Each **vs.** ***jeweils*****: A cover-based view on distance-distributivity**

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Abstract. Zimmermann (2002) identifies two kinds of distance-distributive items. 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 D operator) and Schwarzschild (cover-based operator), which I reformulate in a Neo-Davidsonian event-based framework.

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. I will call adnominal and adverbial *each* distance-distributive items (DD items).

In German, adnominal and adverbial *each* are translated by one word, *jeweils*. Determiner *each* 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* Kind hat zwei Affen gesehen.
Each.sg.n child has two monkeys seen.

[⋆] I am grateful to Anna Szabolcsi and to the audience of the 2011 Stuttgart workshop on quantification for helpful discussion.

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.

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, chunks of time or space).

The best way to illustrate Zimmermann's generalization is to start by considering languages like German and Telugu, a Dravidian language. Both have DD items which look different from the distributive determiner. These DD items can distribute over individuals, but also (unlike in English) 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 pattern. Sentences (3) and (4) are ambiguous between a reading that distributes over individuals – the ones of which their plural subject consists, (3a)-(4a) – and one that distributes over occasions (3b)-(4b). While the former reading is always available, the latter requires a supporting context. That is, when (3) and (4) are uttered out of the blue, they only have the readings (3a)-(4a), while the readings (3b)-(4b) are 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.

(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.'

[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 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 documented in Chapter 5 of Zimmermann (2002), 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, it distributes over occasions, not over individuals.

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

b. ‘The children have seen two monkeys each time.’

(4) pilla-lu1 renDu renDu kootu-lu-ni cuus-ee-ru. *(Telugu)*
kid-Pl two two monkey-Pl-Acc see-Past-3PPl.

a. ‘Each of the children has seen two monkeys.’
b. ‘The children have seen two monkeys on each occasion.’

Sentences (5) and (6) have singular subjects and only have an occasion reading.[2] These sentences are odd out of the blue and require supporting context in the same way as readings (3b) and (4b) do. The Telugu sentences (4) and (6) are taken from Balusu (2005), who uses the terms *participant key readings* for distribution over individuals.

(5) Hans hat jeweils zwei Affen gesehen. *(German)*
Hans has DIST two monkeys seen.
‘Hans has seen two monkeys on each occasion.’

(6) Raamu renDu renDu kootu-lu-ni cuus-ee-Du. *(Telugu)*
Ram two two monkey-Pl-Acc see-Past-3PSg.
‘Ram has seen two monkeys on each occasion.’

While DD items in German and Telugu allow distribution both over individuals and over salient occasions, this is not the case for all DD items crosslinguistically. In many languages, adnominal DD items can only distribute over individuals. One example is English, where (7) can only mean (7a), not (7b).

(7) 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 like (8), whose subject is singular, distribution over individuals is not possible. Even with supporting context, no occasion reading surfaces, and the sentence as a whole is unacceptable.

(8) *John has seen two monkeys each.

Why does English *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. Zimmermann (2002) looks at a range of languages – French, Dutch, Norwegian, Icelandic, Italian, and Russian – in which an adnominal DD item can also be used as a determiner, and finds that the DD item lacks the occasion reading in all these languages.[3] Based on this, he postulates a generalization which can be put as follows:

[2] Their other reading would involve vacuous distribution over only one individual and is presumably blocked through the Gricean maxim of manner “Be brief”.

[3] 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.

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

There are many languages besides German and Telugu whose DD items have occasion readings and cannot be used as determiners. Examples are Czech, Bulgarian, Korean, and Romanian (Zimmermann, 2002). However, the generalization goes only one way (the "if" cannot be strengthened to "if and only if"). In Japanese, the DD item *sorezore* cannot be used as a determiner and does not have an occasion reading (see Zimmermann (2002) for discussion). In Hungarian, distance-distributivity is expressed by reduplication (this is a common pattern across languages, see Gil (1982)), and determiners cannot be reduplicated. But unlike in Telugu, reduplication in Hungarian does not allow the occasion reading (Szabolcsi, 2010):

(10) A gyerekek két-két majmot láttak. *(Hungarian)*
The children two-two monkey.acc saw.3pl

a. *Available:* 'Each of the children saw two monkeys.'
b. *Unavailable:* 'The children saw two monkeys on each occasion.'

The following requirements for a semantic analysis of distance-distributivity emerge. 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 DD items across all languages share some part of their semantics (namely the individual-distributive readings) should be represented, as well as the fact that some of them can additionally have occasion readings. Third, the analysis should clarify the connections between DD items and distributivity theory. Finally, there should be a way to capture the correlation expressed in (9). I now propose an analysis that fulfills these requirements. Section 3 presents distributivity operators; Section 4 relates them to DD items.

3 Distributivity Operators in Event Semantics

The following analysis is placed in the context of the general theory of distributivity developed in the work of Link (1987) and Schwarzschild (1996) on distributivity operators. Link postulates a silent VP-level operator that shifts a VP to a distributive interpretation, i.e. one that holds of any individual whose atomic parts each satisfy the unshifted VP. This so-called D operator is defined as in (11). The variable x is resolved to a plural entity, the subject, and y ranges over its atomic parts, i.e. the singular individuals of which it consists.

(11) $[\![\text{D}]\!] = \lambda P_{\langle et\rangle} \lambda x \forall y[y \leq x \wedge \text{Atom}(y) \rightarrow P(y)]$

The optional presence of the D operator derives the ambiguity between distributive and scopeless readings. For example, (12a) represents a scopeless reading and (12b) 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.

(12) 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 lacks the occasion reading). Clearly, Link's D operator and *each* are similar, as can be seen from the paraphrase of (12b). I take adverbial *each* and similar DD items (e.g. Hungarian reduplication) to be D operators. As for DD items like *jeweils* and Balusu reduplication, we have seen that in special contexts, 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 the 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 (rather than each shoe) costs $50. 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. In this case, C partitions the sum of shoes into pairs. Schwarzschild refers to his own version of the D operator as Part.

(13) $[\![\text{Part}_C]\!] = \lambda P_{\langle et \rangle} \lambda x \forall y [y \leq x \wedge \text{C}(y) \rightarrow P(y)]$

This operator optionally applies to a VP and shifts it to a nonatomic distributive reading, as follows:

(14) The shoes Part cost $50.
≈ Each salient set 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 crosslinguistic relatives across languages has a wider range of readings than *each* does.

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 (Champollion, 2010). Here we find once again that the readings in question are available given appropriate contextual information or world knowledge. Example (15) 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 (16) is from Deo and Piñango (2011), and is acceptable because it is clear that snowmen are typically built in winter.

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

(16) 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 (15) and (16) are, it is plausible to assume that a temporal version of Part is responsible for the distributive interpretation of these sentences (Champollion, 2010). The meaning of this temporal version can be paraphrased as *daily* in (15) and *yearly* in (16).

The original formulations of the operators in (11) and (13) can only "target" (i.e. distribute over parts of) the subject. Examples like (15) and (16) 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, see Champollion (2010). This will allow us to capture the fact that DD items can also target different thematic roles (Zimmermann, 2002). For example, (17) can either involve two stories per boy or two stories per girl, depending on which noun phrase is targeted by *each*.

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

In the following, I assume a Neo-Davidsonian system loosely based on Carlson (1984) and Krifka (1989). 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.

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

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 of which P holds. It can be easily generalized to n-ary predicates and functions.

Noun phrases can be interpreted in situ (we will not need quantifier raising). Silent thematic role heads, which denote functions of type $\langle ve \rangle$ (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 shifter applies first to the thematic role head, then to the noun phrase, and finally to the verbal projection.

(19) Type shifter: $\lambda\theta_{\langle ve\rangle}\lambda P_{\langle et\rangle}\lambda V_{\langle vt\rangle}\lambda e[V(e) \wedge P(\theta(e))]$

This type shifter assumes that the noun phrase is of predicative type $\langle et\rangle$, which is appropriate for indefinites. Definites are first shifted from type e to type $\langle et\rangle$ by the standard *ident* type shifter ($\lambda x \lambda y[y = x]$) so that (19) can apply. The type shifter (19) combines the noun phrase with its thematic role head and forms an event predicate modifier (type $\langle vt, vt\rangle$). For example, after the noun phrases *the children* and *two monkeys* combine via (19) with the thematic roles *ag* and *th* respectively, their denotation is as follows. I write $\bigoplus$ child for the sum of all children. I will write *2M* as a shorthand for $\lambda e[|{}^*\text{th}(e)| = 2 \wedge {}^*\text{monkey}({}^*\text{th}(e))]$.

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

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

After the verb has combined with all its arguments, the event variable can be existentially bound if the sentence is uttered out of the blue. (If the sentence is understood with reference to a specific event, the event variable can instead be resolved to that event.) If the noun phrases combine directly with the verb, we get a scopeless reading:

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

To get a distributive reading, 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 entry is as follows:[4]

(23) $[\![\text{D}_\theta]\!] = \lambda V_{\langle vt\rangle} \lambda e[e \in {}^*\lambda e'[V(e') \;\wedge\; \text{Atom}(\theta(e'))]]$[5]

As an example, the distributive reading of (22) is derived like this:

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

This formula is true iff 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] This definition is taken from Champollion (2010), except that *PureAtom* has been changed to *Atom*. This change is immaterial because we do not use impure atoms.

[5] This is not the only way to reformulate the D operator. See Lasersohn (1998) and Dotlačil (2011) for other proposals.

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 (23). Adnominal and determiner *each* need to be type-shifted but both are defined in terms of (23):

(25) Adverbial: $[\![\text{each}_\theta]\!] = [\![D_\theta]\!] = (23)$

(26) Adnominal: $[\![\text{each}_\theta]\!] = \lambda M_{\langle vt,vt\rangle}\lambda V_{\langle vt\rangle}\lambda e\ [[\![D_\theta]\!](M(V))(e)]$

(27) Determiner: $[\![\text{each}]\!] = \lambda P_{\langle et\rangle}\lambda\theta_{\langle ve\rangle}\lambda V_{\langle vt\rangle}\lambda e\ [\theta(e) = \bigoplus P \wedge [\![D_\theta]\!](V)(e)]$

Adnominal *each* combines with a thematic-role-carrying noun phrase like (21). Determiner *each* combines first with a nominal and then with a theta role head. It is not coindexed with anything because it is not a DD item. 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 (28) and (29).

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

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

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

(30) $[\![\text{The children each}_{ag}\ \text{saw two monkeys}]\!]$
$= [\![\text{The children saw two monkeys each}_{ag}]\!]$
$= [\![\text{Each child saw two monkeys}]\!]$
$= (24) = [\![\text{The children D}_{ag}\ \text{saw two monkeys}]\!]$

We now come to the event-based reformulation of the Part operator. We obtain it by replacing *Atom* in (23) with a free variable C, which is assumed to be anaphoric on the context:

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

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 (31) entails that C is a cover over the value that θ maps e to. (31) is also the lexical entry of adverbial *jeweils*. The same type shift as in (33) brings us from (31) to adnominal *jeweils*:

(32) Adverbial: $[\![\text{jeweils}_{\theta,C}]\!] = [\![\text{Part}_{\theta,C}]\!] = (31)$

(33) Adnominal: $[\![\text{jeweils}_{\theta,C}]\!] = \lambda M_{\langle vt,vt\rangle}\lambda V_{\langle vt\rangle}\lambda e\ [[\![\text{Part}_{\theta,C}]\!](M(V))(e)]$

As in the case of the Part operator, the C parameter can be set to *Atom* so long as θ is set to a function whose range is a count domain, such as *agent.* In that case, *jeweils* distributes over individuals and is equivalent to *each.*

(34) ⟦Die Kinder haben jeweils$_{ag,Atom}$ zwei Affen gesehen⟧ = (24)

If – and only if – there is a supporting context, the anaphoric predicate C can be set to a salient antecedent, and in that case θ is free to adopt values like τ (runtime). This leads to occasion readings:

(35) ⟦Die Kinder haben jeweils$_{\tau,C}$ zwei Affen gesehen⟧ =
$^{*}\text{ag}(e_0) = \bigoplus \text{child} \ \wedge \ e_0 \in {}^{*}\lambda e'[^{*}\text{see}(e') \ \wedge \ 2\text{M}(^{*}\text{th}(e')) \ \wedge \ \text{C}(\tau(e'))]$

Suppose for example that (35) is uttered in a context where the children have been to the zoo three times – last Monday, last Wednesday and last Friday. I assume that the predicate that is true of these three times is salient in this context. I also assume that (35) is interpreted as referring to the sum of these three events, call it e_0. I have indicated this by resolving the event variable in (35) to e_0 rather than existentially quantifying over it. Runtime is closed under sum just like other thematic roles (that is, it is a sum homomorphism – see Krifka (1989)). So the runtime $\tau(e_0)$ of this event is the (discontinuous) sum consisting of last Monday, last Wednesday, and last Friday. Now (35) asserts that e_0 has the children as its agents; that it can be divided into subevents, each of whose runtimes is either last Monday, last Wednesday, or last Friday; and that these subevents are seeing-two-monkeys events. This is the occasion reading.

5 Summary and Discussion

The preceding analysis has captured the semantic similarities between DD items across languages, as well as their variation, by relating them to distributivity operators. A given DD item can be given the same lexical entry up to type-shifting regardless of its syntactic position. The parameters provided by our reformulation of the D and Part operators capture the semantic variation: DD items like *each* and Hungarian reduplication are hard-coded for distribution over atoms, which blocks distributivity over a noncount domain like time. DD items like *jeweils* and Telugu reduplication 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 (9). 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 syntactically agree with their complement; DD *each* has a proform as complement, which acquires 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 atomicity requirement can be seen as independent evidence of the atomic distributivity hard-coded in the entry (27) via the D operator (23). In other words, the DD item *each* inherits its atomicity requirement. Both types of explanations are compatible with this framework.

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