A rate analysis of binominal *each*

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Apart from apparent semantic similarities between adverbial *each* sentences and binominal *each* sentences, binominal *each* sentences have many special properties both in syntax and in semantics. In this poster, I would like to 1) show some syntactic and semantic properties of binominal *each* sentences, 2) argue that the existing distributivity analysis (e.g. Balusu 2005, Champollion, 2011) applicable for adverbial *each* sentences is not applicable for binominal *each* sentences, and 3) propose that an analogy can be drawn between binominal *each* constructions and such speed constructions as "200 km/h" and adopt a rate analysis to account for these constructions in a unified way.

As the contrast in (1) shows, the most prominent property of the binominal use of *each* is the counting quantifier requirement (see Szabolcsi 2010, Ch.8.4).

(1a) The boys saw {**one** / **three** / *the / *a / *every / *- / *no / *cute} monkey(s) each.

(1b) The boys each saw {one / three / the / a / every / no / cute} monkey(s).

Actually, even the counting quantifier requirement is not sufficient. Suppose there is a scenario: a cook was baking hams and used thermometers to read the temperature of hams. The contrast in (2) shows that only monotonic measure functions are compatible with the binominal use of *each*.

(2a) The hams weighed 20 pounds each.

(2b) *The hams read 350 degrees each. (cf. The hams each read 350 degrees.)

Another related fact is that as the examples (3a) and (3b) show, both the cardinal reading and the individual reading are available for adverbial *each* sentences, while only the cardinal reading is available for binominal *each* sentences.

(3a) John and Mary should each invite 2 celebrities.

cardinal reading: the number of celebrities that J should invite is 2, and the number for M is also 2.

individual reading: there are 2 celebrities that J should invite, and there are also 2 for M.

(3b) J and M should invite 2 celebrities each. cardinal reading: $\surd$; individual reading: $\times$.

Obviously, all these facts show that there are indeed syntactic and semantic differences between the binominal use of *each* and the adverbial use of *each*. The differences imply that an account good for the adverbial use of *each* might not be equally applicable for the binominal use of *each*.

Balusu 2005 and Champollion 2011 adopted a distributivity analysis to account for the reduplicated number construction in Telugu and the adverbial use of *each* in English respectively. The basic idea of the distributivity analysis is to view an event as a sum of the subevents and the subevents are defined on the atomicity of a certain thematic role. If a similar analysis could be extended to account for the binominal use of *each*, then we would need some very unnatural stipulations to block the individual reading as well as quantifier phrases other than counting quantifier phrases of a monotonic measure function.

However, if we compare binominal *each* sentences and speed constructions (such as (4)), then we can see some striking coincidences: all the generalizations with regard to special properties of binominal *each* sentences also fit speed constructions.

(4) The car goes 200 km per hour.

The common point between both binominal *each* constructions and speed constructions is that in both cases, there is a rate expression telling the proportional relationship between two monotonic measure functions with regard to a same event. Both *each* (which means *one* X) and *per hour* (which means *one hour*) can be considered as the denominator, and *3 monkeys* and *200km* the numerator. The whole construction can be taken as a property of an event, and it modifies the event by expressing a non-monotonic measure function of the event.

Here is a compositional analysis of a binominal *each* sentence: The boys saw 3 monkeys each.

LF: $[_{(ix)}$ $\exists$ $[_{(viii)}$ the boys $[_{(vii)}$ [ag] $[_{(vi)}$ $[_{(v)}$ see $[_{(iv)}$ [th] monkeys]] $[_{(iii)}$ 3 $[_{(ii)}$ u_{th} $[_{(i)}$ each u_{ag}]]]]]]]

$[[u_{ag}]]_{<vn>} = \lambda e_{<v>}|{*}ag(e)|$

$[[u_{th}]]_{<vn>} = \lambda e_{<v>}|{*}th(e)|$

$[[each]]_{<vn,<vn,<n,vt>>>} = \lambda u_{ag<vn>}\lambda u_{th<vn>}\lambda n_{<n>}\lambda e_{<v>}[u_{th}(e)/u_{ag}(e) = n]$

(i) function application result: $\lambda u_{th<vn>}\lambda n_{<n>}\lambda e_{<v>}[u_{th}(e)/|{*}ag(e)| = n]$

(ii) function application result: $\lambda n_{<n>}\lambda e_{<v>}[|{*}th(e)|/|{*}ag(e)| = n]$

(iii) function application result: $\lambda e_{<v>}[|{*}th(e)|/|{*}ag(e)| = 3]$

$[[monkeys]]_{<et>} = \lambda x[{*}monkey(x)]$

$[[\ [th]\ ]]_{<ve>} = \lambda e_{<v>}[{*}th(e)]$

Type shifter: $\lambda\theta_{<ve>}\lambda P_{<et>}\lambda V_{<vt>}\lambda e_{<v>}[P(\theta(e)) \wedge V(e)]$

(iv) type shifting result: $\lambda V_{<vt>}\lambda e_{<v>}[{*}monkey({*}th(e)) \wedge V(e)]$

$[[see]]_{<vt>} = \lambda e[{*}see(e)]$

(v) function application result: $\lambda e_{<v>}[{*}monkey({*}th(e)) \wedge {*}see(e)]$

(vi) predicate modification result: $\lambda e_{<v>}[{*}see(e) \wedge {*}monkey({*}th(e)) \wedge [|{*}th(e)|/|{*}ag(e)| = 3]$

Type shifter: $\lambda\theta_{<ve>}\lambda V_{<vt>}\lambda x_{<e>}\lambda e_{<v>}[\theta(e) = x \wedge V(e)]$

$[[\ [ag]\ ]]_{<ve>} = \lambda e_{<v>}[{*}ag(e)]$

(vii) type shifting result:

$\lambda x_{<e>}\lambda e_{<v>}[{*}ag(e) = x \wedge {*}see(e) \wedge {*}monkey({*}th(e)) \wedge [|{*}th(e)|/|{*}ag(e)| = 3]$

$[[the\ boys]]_{<e>} = \oplus boy$

(viii) function application result:

$\lambda e_{<v>}[{*}ag(e) = \oplus boy \wedge {*}see(e) \wedge {*}monkey({*}th(e)) \wedge [|{*}th(e)|/|{*}ag(e)| = 3]$

(ix) existential closure result:

$\exists e_{<v>}[{*}ag(e) = \oplus boy \wedge {*}see(e) \wedge {*}monkey({*}th(e)) \wedge [|{*}th(e)|/|{*}ag(e)| = 3]$

Moreover, there are at least two presuppositions not included in this derivation.

The first presupposition is the monotonicity requirement: the measure functions in the dimension of agent and in the dimension of theme are monotonic.

The second presupposition is the homogeneity assumption, which guarantees that the property $|{*}th(e)|/|{*}ag(e)| = 3$ holds homogeneously through all parts of the event e. Here is the formal expression of this assumption: for any x_1, $x_2 \leq {*}ag(e) = \oplus boy$, define e_1 as $\oplus\{e'|{*}ag(e')\leq x_1\}$, e_2 as $\oplus\{e'|{*}ag(e')\leq x_2\}$, then $|{*}th(e_1)|/|{*}ag(e_1)| = |{*}th(e_2)|/|{*}ag(e_2)|$.

Not only this rate analysis can account for the (monotonic) counting quantifier requirement and the unavailability of individual readings in the binominal use of *each*, but also it predicts other interesting facts.

For example, the rate construction in (5a) and the distributivity construction in (5b) cause the two sentences to behave differently when there is a sentence modifier *on average*:

(5a) On average, the boys saw three monkeys each.

[[the boys saw three monkeys each]] =

$\exists e[{*}see(e) \wedge {*}ag(e) = \oplus boy \wedge {*}monkey({*}th(e)) \wedge |{*}th(e)|/|{*}ag(e)| = 3]$

(5b) ?? On average, the boys each saw three monkeys.

[[the boys each saw three monkeys]] =

$\exists e[\ {*}ag(e) = \oplus boy \wedge e = \oplus\{e'|atom(ag(e')) \wedge {*}see(e') \wedge |{*}monkey({*}th(e'))| = 3\}]$

Presumably, in (5a), *on average* modifies the property $|{*}th(e)|/|{*}ag(e)| = 3$, while in (5b), *3* is a property which tells the amount of themes in each subevent, thus *3* is too embedded to be modified by the sentence level modifier *on average*, and since there is no other number property for the sentence modifier *on average* to modify, *on average* cannot be compatible with this adverbial *each* sentence.

References: Balusu, Rahul. 2005. Distributive reduplication in Telugu. In *NELS* 36, 39 - 52. | Champollion, Lucas. 2011. *Each* vs. *jeweils*: a cover-based view on distance-distributivity. In *Proceedings of the 18th Amsterdam Colloquium*. | Szabolcsi, Anna. 2010. *Quantification*. Cambridge University Press.