Hungarian reduplicated numerals and subatomic event distributivity[1]

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ICSH14, Potsdam

1 This talk

In this talk, I am going to focus on the event distributive interpretations that arise with Hungarian reduplicated numeral expressions (henceforth: RN-expressions), specifically in reciprocal sentences.

KEY OBSERVATION: RN-expressions can be the antecedent of a reciprocal pronoun.

I will argue for two things:

1. RN-expressions can give rise to interpretations that involve distribution over subatomic parts of a plurality of events.
2. RN-expressions are compatible with plural reference, and that should be represented in their analysis.

2 Quick introduction to RN-expressions

RN-expressions are **morphologically marked indefinite NPs** that are formed by the reduplication of the cardinal numeral heading a common noun.

(1) *hat facsemete* — Unmarked numeral exp.
six sapling
'six saplings'

[1]Many thanks to Louise McNally, Giorgos Spathas and Berit Gehrke for the helpful discussions and comments. I gratefully acknowledge the financial support from the grants FFI2016-76045-P (AEI/MINEICO/FEDER, UE) and BES-2014-069070, the ICREA Foundation, AGAUR grants 2014SGR698 and 2017SGR1478.

(2) ***hat-hat*** *facsemete* RN-expression
six-six sapling

I will refer to different parts of RN-expressions as in Figure 1.

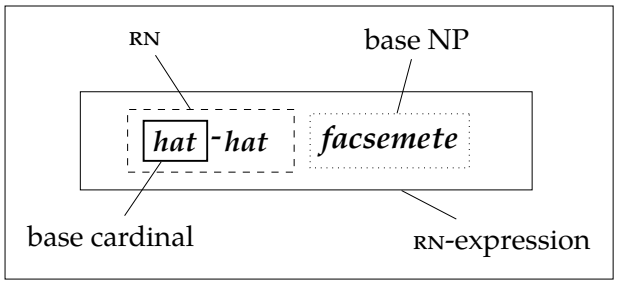


Figure 1: The anatomy of a Hungarian reduplicated numeral expression
BASE CARDINAL: the cardinal numeral determiner/prenominal adjective
RN: the base cardinal reduplicated
BASE NP: the NP in the complement of the reduplicated numeral
RN-expression: RN+ base NP

RNs are distributive numerals: they **force a distributive interpretation** of the sentence they occur in (Gil 1982, Gil 2013); see (3).

(3) *Az önkéntes-ek el-ültettek* ***három-három*** *facsemeté-t.*
the volunteer-PL PRT-plant.PST.3PL **three-three** sapling-ACC
a. %'The volunteers planted three saplings in total'
b. 'The volunteers planted three saplings each'
c. 'The volunteers planted three saplings on each (salient) occasion'

- RN-expressions **do not have a cumulative interpretation** where the RN signals the total number of entities denoted by the base NP; see (3-a).
- RNs signal the number of entities associated with **each atomic part of a plurality** (**distributive interpretation**).
- This plurality can be from the domain of
  - individuals: **individual distributive interpretation**, as in (3-b); or
  - events: **event distributive interpretation**, as in (3-c).

3 RN-expressions in reciprocal sentences

KEY OBSERVATION: RN-expressions can occur in **reciprocal sentences**[2] as the antecedent of the reciprocal pronoun; see a naturally occurring example in (4).

(4) *Az erőpróbá-n egyszerre **egy-egy** csapat versengett egymás-sal.*[3]
the tournament-SUPE at.a.time **one-one** team compete.PST.3SG each.other-COM
a. %'At the tournament, one team competed with each other at a time'
b. 'At the tournament, two teams competed at a time, one with the other'

(4) has an event distributive interpretation.

- (4) denotes a plurality of reciprocal competing events.
- EXPECTATION: the RN *egy-egy*, lit. 'one-one' signals the number of teams associated with each atomic part of the plurality of reciprocal competing events: **nonsensical truth conditions**; (4-a).
- INSTEAD: the RN-expression targets a plurality of **unidirectional subevents associated with reciprocal events**:
  - The RN signals **the number of both the agent and the theme** in each unidirectional subevent; (4-b).[4]

Contrast (4) with (5).

(5) *Az erőpróbá-n egyszerre **két-két** csapat versengett egymás-sal.*
the tournament-SUPE at.a.time **two-two** team compete.PST.3SG each.other-COM
a. 'At the tournament, two teams competed with each other at a time'
b. 'At the tournament, four teams competed with each other at a time, two with two'

[2] I use the term *reciprocal sentence* to refer to sentences where the main predicate is part of the reciprocal construction. That is, a sentence like *The dogs saw each other* is treated as a reciprocal sentence, but *The dogs ate each other's dinner* is not.

[3] `https://www.mohacsiujsag.hu/mohacs/hir/helyi-hireink/szombaton-sarkanyhajoverseny-nevezoket-jelentkezoket-varnak`. Last accessed: 3 Jan, 2019. In the original example, the verb is in present tense; changing it to past tense should not affect any substantial claims made in relation to the sentence.

[4] Similar interaction between distributive numerals and reciprocals happens in Mandarin Chinese (Kobayashi & Chen 2018) and Telugu (Rahul Balusu, p.c.).

- In (5), the RN can signal the number of teams in each reciprocal competing event.

RN-expressions in reciprocal sentences show:

1. **RNs can break down reciprocal events into unidirectional subevents they are associated with**.

   - Based on (4) and (5), we can argue that RNs access two different sets of pluralities of events.
   - I argue that the events denoted by reciprocals are not mere sums of unidirectional events; unidirectional events are subatomic parts of reciprocal events.
   - Thus RNs can be involved in **subatomic event distributivity**.

2. The **RN-expression can be the antecedent of the reciprocal pronoun** regardless the cardinality expressed by the base cardinal.

   - The antecedent of the reciprocal pronoun must be referentially plural.
   - RN-expressions should be represented as their denotation is compatible with plural reference.

4 Singularities and pluralities in different domains

ASSUMPTION: The respective domains of individuals D_e, of events D_v, and of time intervals D_t are closed under the sum-formation $\oplus$ and the entities therein are ordered by the mereological part-of relation $\leq$ (Link 1983, Bach 1986, Krifka 1989, a.o.).

(6) a. $\forall x, y[x, y \in D_e \rightarrow x \oplus y \in D_e]$
b. $\forall e, e'[e, e' \in D_v \rightarrow e \oplus e' \in D_v]$
c. $\forall t, t'[t, t' \in D_t \rightarrow t \oplus t' \in D_t]$

(7) $\forall x, y[x \leq y \leftrightarrow x \oplus y = y]$

Singularities and pluralities on the respective domains are understood relative to a property or a linguistic description.

- Singularities are atomic entities with respect to a property (Krifka 1989).

(8) $\textsc{at}_P(x) \stackrel{\text{def}}{=} P(x) \wedge \neg\exists y[y < x \wedge P(y)]$ **Relative atom**

- Pluralities are sums of singularities.

Natural language predicates can be semantically singular or plural.

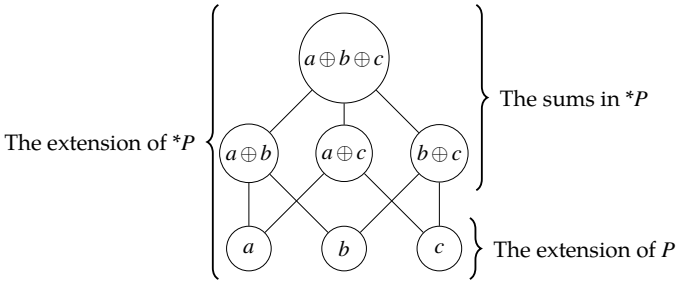
- Semantically singular predicates denote a set of atomic entities.

(9) $SG(P) \leftrightarrow \forall x[P(x) \wedge \textsc{at}_P(x)]$

- Semantically plural predicates denote a set of atomic entities and all the possible sums formed by the atomic entities.
- Formally, pluralization of predicates is done by the ***-operator** (Link 1983).

(10) $^*P$ is the smallest set, such that:
  a. $P \subseteq {}^*P$
  b. $\forall x, y[x, y \in {}^*P \rightarrow x \oplus y \in {}^*P]$ (Sternefeld 1998 and Nouwen 2016)

Figure 2: The semilattice formed of the extension of a plural predicate $^*P$, where $P = \{a, b, c\}$, represented as a Hasse-diagram.



In the case of nominal predicates, semantic pluralization might correspond to the morphological plural marking on count nouns; see (11).

(11) a. sapling $\rightsquigarrow \lambda x[\textsc{sapling}(x)]$
  b. saplings $\rightsquigarrow \lambda x[{}^*\textsc{sapling}(x)]$

- In Hungarian, count nouns do not have to be marked morphologically as plural in order to have plural interpretation.
- Here I distinguish between **strong and weak singular denotation of singular count nouns in Hungarian**; the interpretation of the whole NP depends on the determiner (see also Farkas & de Swart 2010).

(12) a. $\text{facsemete}_{\text{STRONG-SG}} \rightsquigarrow \lambda x[\textsc{sapling}(x)]$
b. $\text{facsemete}_{\text{WEAK-SG}} \rightsquigarrow \lambda x[{}^{*}\textsc{sapling}(x)]$

(13) a. $\text{minden facsemete}_{\text{STRONG-SG}} \rightsquigarrow \lambda P \forall x[\textsc{sapling}(x) \rightarrow P(x)]$
b. $\text{három facsemete}_{\text{WEAK-SG}} \rightsquigarrow \lambda P \exists x[{}^{*}\textsc{sapling}(x) \wedge |x| = 3 \wedge P(x)]$

- Plural count nouns are interpreted as plural predicates.

(14) $\text{facsemeték} \rightsquigarrow \lambda x[{}^{*}\textsc{sapling}(e)]$

In the case of verbal predicates, the denotation of verbs[5] (or at least verb roots) is closed under sum formation (see **lexical cumulativity** in Kratzer 2008), and so is that of thematic roles and temporal traces.

(15) $[\![V]\!] = [\![{}^{*}V]\!]$ (16) $[\![\theta(e)]\!] = [\![{}^{*}\theta(e)]\!]$ (17) $[\![\tau(e)]\!] = [\![{}^{*}\tau(e)]\!]$

- Events can be atomic with respect to their thematic roles and their temporal traces (**multidimensionality of events**, see Moltmann 1997, Zimmermann 2002, a.o.).

(18) a. A volunteer planted a sapling. *sg. event*
b. Two volunteers planted a sapling. *sg. or pl. event*
c. A volunteer planted a sapling on two consecutive days. *sg. or pl. event*

- (Considering the episodic interpretations of the sentences in (18).)

[5] I adopt the Neo-Davidsonian approach (Parsons 1990) and assume that verbs denote sets of events; events are related to individuals via thematic role functions θ and are are related to time intervals via temporal trace functions (τ) (Krifka 1992).

Hypothesis about the atomicity of events

(19) An event e is atomic V-event iff $V(e)$ and
- a. both $\theta(e)$ and $\tau(e)$ is atomic[6], or
- b. (i) if $\theta(e)$ is a plurality, and e does not have any proper part e', such that $\theta(e') < \theta(e)$ and $V(e')$, and
  (ii) if $\tau(e)$ is a plurality, and e does not have any proper part e' such that $\tau(e') < \tau(e)$ and $V(e')$.

If e is not an atomic V-event then e is a plurality of V-events.

5 Reciprocal sentences and events

CANONICAL ASSUMPTION: reciprocal sentences, where the source of reciprocity is the reciprocal pronoun, denote sums of events (see Carlson 1998, Dimitriadis 2008).

(20) Amelia and Valentina wrote each other.
- a. e: `Amelia and Valentina wrote each other`
- b. e': `Amelia wrote Valentina`
- c. e'': `Valentina wrote Amelia`
- d. $e = e' \oplus e''$

- Sentences like (20) are assumed to involve distributivity (Heim, Lasnik & May 1991).

The **distributivity in reciprocal sentences must be very local** (see Moltmann 1992 and Dotlačil 2010).

- In (proper) distributive predication, the scope of distributivity can involve any constituent below the predicate; (21). Cf. (22).

[6]Caveats for (19): atomicity is usually not defined with respect to time intervals (Krifka 1998, Champollion 2017, a.o.). Here *atomic time interval* it is used as a shorthand for non-overlapping intervals of time that can be referred to, albeit most often vaguely, by linguistic expressions (e.g. *from 10 AM to 12.00 PM*, *this morning*, or *the morning of May 27, 2019 AD*, etc.) and are associated with events that are individuated as atomic in a given context.

(21) Amelia and Valentina (each) wrote a letter on two rainy days. ⇒
`Amelia wrote a letter on two rainy days, and Valentina wrote a letter on (potentially different) two rainy days`

(22) Amelia and Valentina wrote each other on two rainy days. ⇏
`Amelia wrote Valentina on two rainy days, and Valentina wrote Amelia on (potentially different) two rainy days`

- The contrast between (21) and (22), the distributivity involved in reciprocal sentences does not affect the event denoted by the sentence.

Moreover, (22) describes a sum of two atomic events according to (19).

- The event described by the (22) has two proper parts along its temporal properties: there is a reciprocal writing event between Amelia and Valentina for each atomic part of the two rainy days.
- These subevents have a plurality as one of their thematic roles (AMELIA $\oplus$ VALENTINA).
- However, the subevents themselves have no proper parts based on their participants, where for each atomic part of AMELIA $\oplus$ VALENTINA there is an reciprocal writing event.

Reciprocal sentences **do not display cumulativity of thematic roles and temporal traces** (Krifka 1998, Champollion 2017).

(23) Amelia and Valentina played solitaire this morning and this afternoon (respectively).
   a. e: `Amelia and Valentina played solitaire this morning and this afternoon`
   b. e': `Amelia played solitaire this morning`
   c. e'': `Valentina played solitaire this afternoon`
   d. $e = e' \oplus e''$

(24) Amelia and Valentina wrote each other this morning and this afternoon (#respectively).
   a. e: `Amelia and Valentina wrote each other this morning and this afternoon`
   b. e': `Amelia wrote Valentina this morning`
   c. e'': `Valentina wrote Amelia this afternoon`
   d. $e \neq e' \oplus e''$

Based on (21)–(24) we can conclude that **reciprocal sentences refer to atomic reciprocal events** and not sums of unidirectional events.

- The relation between them **should not be captured by the mereological part-of relation** as is between atomic events and their sums.

Assumption: the relation between reciprocal events and unidirectional events is based on the mereological relation between their participants and their runtime, but not the events themselves.

(25) $e' \trianglelefteq e \stackrel{\text{def}}{=} \exists V[V(e) \wedge V(e') \wedge \tau(e') \leq \tau(e) \wedge \theta(e') \leq \theta(e)]$ **Containment**
An event e' is contained by an event e iff e and e' are in the denotation of the same verbal predicate V, and $\theta(e')$ is part of $\theta(e)$, $\tau(e')$ is part of $\tau(e)$.

Containment relates events to each other that **form a mereological structure given the predicate V, yet might not form a mereological structure given another description**.

6 The analysis of RNS

RNS relate events based on the containment relation (instead of the mereological part-of relation).

Here I adopt the account in Cable (2014) to analyze RNS.

- It is a **compositional analysis** for distributive numerals in Tlingit.
- Does not rely on quantificational dependency.
  - **Other analyses treat RNS as having obligatory narrow scope** with respect to another expression (see Oh 2001, Zimmermann 2002, Balusu 2006, Henderson 2012, Farkas 2015, and Champollion 2016 a.o.).
- Distributive numerals are represented as having **plural denotation**.

6.1 The ingredients of the analysis in Cable (2014)

The account in Cable (2014) relies on three special definitions: the metalanguage predicate PARTICIPANT; the ***Partition*-function**, and the **binary maximality (σ) operator**.

- I give the re-definitions of these ingredients below: instead of the mereological part-of relation ($\leq$) between events, I utilize the containment-relation $\trianglelefteq$.

1. PARTICIPANT: a relation that holds between an event and any individual that participates in that event by bearing any of the thematic roles associated with the event.

(26) PARTICIPANT$(e,x) \stackrel{\text{def}}{=} x$ bears a thematic relation to $e \leftrightarrow x$ is Agent of e, or x is Theme of e, x is Goal of e... ((52) in Cable 2014)

2. *Partition*-function:

(27) $Partition(e) = \{e' : e' \trianglelefteq e\}$, such that
   a. $\bigoplus Partition(e) = e$, and
   b. $\forall e' \forall e'' [e', e'' \in Partition(e) \wedge \neg \exists e''' [e''' \triangleleft e' \wedge e''' \triangleleft e'']]$

   Partition maps an event e to a set of events e', such that every e' is contained by e; moreover, the sum of all elements in the set equals e, and none of the events in the set overlaps in terms of containment.

- The *Partition*-function has to be contextually salient and yields a cognitively natural partition over the event it is applied to (Balusu 2006, Cable 2014).

3. The binary σ-operator: the maximality operator defined for pairs.

(28) a. Pair addition: $\langle x', x'' \rangle \oplus \langle y', y'' \rangle \stackrel{\text{def}}{=} \langle x' \oplus y', x'' \oplus y'' \rangle$
   b. $\sigma_{\langle x,y \rangle}[Q(x)(y)] \stackrel{\text{def}}{=}$ the pair $\langle \alpha, \beta \rangle$, such that $\langle \alpha, \beta \rangle \in {}^*\{\langle x,y \rangle : Q(x)(y)\}$, and if $\langle \gamma, \delta \rangle \in {}^*\{\langle x,y \rangle : Q(x)(y)\}$ then $\gamma \leq \alpha$ OR $\gamma \trianglelefteq \alpha$, and $\delta \leq \beta$ OR $\delta \trianglelefteq \beta$

   The binary σ-operator defined in (28-b) applied to a two-place relation $Q(x)(y)$ yields the maximal pair $\langle \alpha, \beta \rangle$ in the denotation of Q such that for every pair $\langle \gamma, \delta \rangle$ in the denotation of Q, γ is part of or contained by α, and δ is part of or contained by β.

- Here, I augmented the original definition ((53) in Cable 2014) with the containment relation which applies if $\alpha, \beta, \gamma, \delta$ are from the domain of events.

6.2 The semantics of RNS

(29) $[\![\text{N-N}]\!] = \lambda Q_{\langle et \rangle} \lambda V_{\langle e, \varepsilon t \rangle} \lambda e_\varepsilon \exists x_e [Q(x) \wedge V(x)(e) \wedge \langle e, x \rangle = \sigma_{\langle e', x' \rangle} [x' \leq x \wedge |x'| = \text{N} \wedge e' \in Partition(e) \wedge \text{PARTICIPANT}(e', x')]]$ (based on (72) in Cable 2014)

N-N takes a predicate Q and a predicate V, where the latter holds of individuals and events, and returns a predicate over events. This predicate of events holds of an event e if there is an individual x such that Q holds of x, and the relation V holds between e and x; and if the pair $\langle e,x\rangle$ is the sum of pairs $\langle e',x'\rangle$ such that x' is part of x and the cardinality of x' is N, and e' is in a salient partition over e and x' is a participant in e'.

- The meaning contribution of RNS based on (29): the sentence they occur in is true as long as there is a contextually salient partition over the event e denoted by the sentence such that in each subevent in that partition N number of individuals (denoted by the base NP) participated.
- EXTRA ASSUMPTION: **the base NP of RNS has weak singular denotation**: Q is a plural predicate.

6.3 The semantics of the reciprocal pronoun

- Here I only consider the reciprocal pronoun in object position.

(30) $[\![\text{each other}_{\text{D-OBJ}}]\!] = \lambda V_{\langle e,\varepsilon t\rangle}\lambda x_e\lambda e_\varepsilon \exists y_e[V(y)(e) \wedge x = y \wedge \exists e', e'' \trianglelefteq e[\{e', e''\} \in Rec_V^x]]$

The reciprocal pronoun in direct object position takes a predicate V that holds between individuals and events, and an entity x, and returns a predicate over events. This predicate holds of an event e if there is an individual y, such that the relation V holds between e and y, and y is equal to x, and the event e contains two subevents, such that the set of those subevents are in the set Rec_V^x.

- Reciprocity is treated as a restricted version of reflexivity (Murray 2008).
  - The reciprocal pronoun requires that the event e denoted by the sentence assigns two thematic roles to the same individual.
  - It also requires e to have multiple contained parts, such that the set of these parts is in Rec_V^x.
- Rec_V^x is a set of sets of events consistent with the reciprocal interpretation of V given the entity x.
  - Rec_V^x can be defined in different ways.
  - A crucial property of the events in Rec_V^x is that none of them can assign different thematic roles to the same individual.

(31) $Rec_V^x \stackrel{\text{def}}{=} \{E : \bigoplus \textsc{participant}(E) = x \ \wedge \ \forall e \in E[V(e)] \ \wedge \ \forall x'[x' \leq x \rightarrow \exists x'' \exists e' \in E \exists \theta[x'' \leq x \wedge x' \leq x'' \wedge \theta(e') = x'']] \wedge \neg \exists e'' \in E[\theta_1(e'') = \theta_2(e'')]$,
and E is consistent with the reciprocal interpretation of $V\}$

6.4 The analysis of reciprocal sentences with RN-expressions

Given all the assumptions and definitions from above, the truth conditions for (4), repeated as (32) below, are in (33).[7]

(32) *Az erőpróbá-n egyszerre* ***egy-egy*** *csapat versengett egymás-sal.*
the tournament-SUPE at.a.time **one-one** team compete.PST.3SG each.other-COM

(33) $\exists e \exists x \exists y[^*\textsc{team}(x) \ \wedge \ \textsc{compete}(e) \ \wedge \ \textsc{ag}(e) = x \ \wedge \ \textsc{th}(e) = y \ \wedge \ x = y \ \wedge \ \exists e', e'' \trianglelefteq e[\{e', e''\} \in Rec^x_{\textsc{compete}}] \wedge \langle e, x \rangle = \sigma_{\langle e''', x''' \rangle}[x''' \leq x \wedge |x'''| = 1 \wedge e''' \in Partition(e) \wedge \textsc{participant}(e''', x''')]]$

According to (33), (32) is true as long as there is a plurality of teams x and there is a competing event e such that

- x is both the agent and the theme of e,
- and e has various contained parts such that the set of these parts is among the sets of events associated with the verbal predicate *compete* on its reciprocal interpretation holding of x;
- moreover, x can be divided up into single teams such that each of them is assigned a thematic role in some contextually salient subevent of e.

Our analysis treats the meaning contribution of **the reciprocal pronoun and the RN-expression separately**.

- The reciprocal pronoun signals a specific structure associated with the reciprocal event(s) denoted by the sentence.
- The RN signals the number of entities bearing a certain thematic role in each contextually salient subevent of the event denoted by the sentence.

[7] For simplicity, I ignore the word *egyszerre*, lit. 'at a time/at the same time'. This element unambiguously conveys that there were no two simultaneous competing events, and hence implies there were multiple events of reciprocal competing.

The truth conditions for (5), repeated as (34) below, are almost identical to that of (33), except for the cardinality expressed by the base numeral.

(34) *Az erőpróbá-n egyszerre **két-két** csapat versengett egymás-sal.*
the tournament-SUPE at.a.time **two-two** team compete.PST.3SG each.other-COM

(35) $\exists e \exists x \exists y [{}^{*}\textsc{team}(x) \wedge \textsc{compete}(e) \wedge \textsc{ag}(e) = x \wedge \textsc{th}(e) = y \wedge x = y \wedge \exists e', e'' \trianglelefteq e[\{e', e''\} \in Rec^{x}_{\textsc{compete}}] \wedge \langle e, x \rangle = \sigma_{\langle e''', x''' \rangle}[x''' \leq x \wedge |x'''| = 2 \wedge e''' \in Partition(e) \wedge \textsc{participant}(e''', x''')]]$

- Individuals of cardinality of 2 can be involved in reciprocal events and unidirectional events.
- Based on the context, the *Partition*-function can yield to a set of reciprocal events or unidirectional events.

We rely on **pragmatic reasoning** to account for the fact that RN-expressions signal the number of two different thematic roles of the event when associated with unidirectional subevents.

- For now, I assume that there is a restriction on the set of the unidirectional subevents in $Rec^{x}_{\textsc{v}}$ that the *Partition*-function can access.
  - The set E' must be such that for any given individual that bears a thematic role θ_1 of e' then it must bear a thematic role θ_2 of e'' (such that $e' \neq e''$ and e' and e'' are in E').
- However, this assumption is not motivated by the analysis itself.
- It should be hard-wired into the semantics of RNS; most importantly to account for the fact that other elements, like the adverb *egyesével*, can also break down reciprocal events into unidirectional events, but cannot signal the cardinality of two different thematic roles; see (36).

(36) *A csapat-ok **egyesével** versenyeztek egymás-sal.*
the team-PL **one.by.one** compete.PST.3PL each.other-COM
'The teams competed with each other one by one'

7 Conclusions

RNs can occur in reciprocal constructions as the **antecedent of the reciprocal pronoun**, where they can give rise to distributive readings either on the level of reciprocal events or the level of unidirectional events.

- In the latter case, RNs can be in involved **subatomic event distributive** readings.
- To model the relation between events and their subatomic parts, I defined the **containment-relation** that relates events based on the mereological relation between their participants and runtime.

The analysis of RNs is based on Cable (2014), relying on the containment-relation.

- It treats RN-expressions as semantically plural.
- We can also acknowledge that RNs are share-marking elements (Choe 1987): they establish a distributive relation without specifying the plurality over which their denotation is distributed.

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