Hungarian reduplicated numerals and subatomic event distributivity[1]

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Comments are welcome!

December 15, 2019

1 Introduction

1.1 Reduplicated numeral expressions in Hungarian

Hungarian reduplicated numerals (henceforth: RNs) are morphologically marked numerals formed by the reduplication of a cardinal numeral. RNs can occur in prenominal modifier position, just like unmarked cardinal numerals, as shown in (1). Throughout this paper, I will refer to NPs where the noun is modified by a RN as RN-expressions.

(1) a. *két csavarhúzó* — Unmarked numeral exp.
two screwdriver
'two screwdrivers'

b. ***két-két*** *csavarhúzó* — RN-expression
two-two screwdriver

The most striking difference between unmarked numerals and RNs from a semantic point of view is that while unmarked cardinal numerals are compatible with a cumulative interpretation, i.e. they can give the total number of entities in the denotation of the noun they combine with, RNs are not. As a consequence, sentences where an argument is modified by an unmarked numeral can be interpreted cumulatively, and, given the appropriate context, distributively (see (2)). RNs, however, force a distributive interpretation of the sentence they occur in (see (3)). That is, RNs can be treated as distributive numerals (Gil 1982, 2013).

(2) *A professzor-ok hoztak két csavarhúzó-t.*
the professor-PL bring.PST.3PL two screwdriver-ACC

a. 'The professors brought two screwdrivers in total' — cumulative

b. 'The professors brought two screwdrivers each' — distributive

[1]Glosses: 3 – third person; ACC – accusative case; COM – comitative case; ILL – illative case; INF – infinitive; PL – plural; PST – past tense; SG – singular; SUP – superessive case.

(3) *A professzor-ok hoztak* ***két-két*** *csavarhúzó-t.*
the professor-PL bring.PST.3PL **two-two** screwdriver-ACC
a. #'The professors brought two screwdrivers in total' cumulative
b. 'The professors brought two screwdrivers each' distributive

The distributive interpretation of a sentence is assumed to involve universal quantification – even in cases where there is no overt determiner in the sentence, like in (2) and (3) (see Roberts 1987, Link 1991, Schwarzschild 1996, a.o.). Following Choe (1987), distributivity is assumed to be a quantificational dependency relation between the set or entity in the restriction of the universal quantifier on the one hand, and the entities in the scope of the quantifier on the other. In Choe's terms, the former is called the sorting key (henceforth: KEY), and the latter the distributed share (henceforth: SHARE). (2b) and (3b) spell out the distributive interpretation of (2) and (3), respectively, where the KEY is the set of professors and the SHARE is two screwdrivers.

RNs are distributivity markers that can only mark the constituent that is interpreted as the SHARE of the distributive relation.[2] This trait of RNs is illustrated in (4): if the intended interpretation of the sentence is the one where the subject denotes the KEY of the distributive relation, and the object denotes the SHARE, the subject cannot be marked by a RN, as opposed to the object. Note that the subject in this construction can be marked by an RN (i.e. all versions of (4) are grammatical), but then the interpretation of the sentence is different from the one that is intended in (4).

(4) [*Négy/#**Négy-négy** professzor*]$_{\text{KEY}}$ *hozott* [*két/**két-két** csavarhúzó-t*]$_{\text{SHARE}}$
four/**four-four** professor bring.PST.3SG two/**two-two** screwdriver-ACC
'Four professors each brought two screwdrivers'

RN-expressions can give rise to the so-called event distributive interpretation (Oh 2001, 2005), where the KEY of the distributive relation is from the domain of events or time intervals.[3] The event distributive interpretation of the sentence in (3) is in (5). This kind of interpretation is supposed to be available only if the sentence is uttered in a context where there is a salient plurality of events that can play the role of the KEY in the distributive relation established by the RN. The event distributive interpretation is not available for sentences with unmarked numerals, so (2) cannot be interpreted as in (5).

[2]Such distributivity markers are sometimes called anti-quantifiers (Choe 1987), dependent indefinites (Farkas 1997), distance distributivity elements (Zimmermann 2002). The different terms are associated with specific language phenomena, or specific analyses, so I refrain from adopting any of these terms in this paper.

[3]This interpretation is sometimes called the 'event key reading' (Balusu 2006), or the 'occasion reading' (Champollion 2016).

(5) 'The professors brought two screwdrivers each time' event dist.

1.2 The focus of this paper

This paper focuses on the event distributive interpretation of sentences with RN-expressions that specifically arises in reciprocal sentences[4] where the RN-expression provides the antecedent of the reciprocal pronoun. Based on such sentences, the paper argues that RN-expressions cannot be analyzed as narrow-scope indefinites (cf. Farkas 1997, Oh 2001, Zimmermann 2002, Balusu 2006, Champollion 2016, a.o.). The main claim of the paper, however, is that RN-expressions in reciprocal sentences can give rise to subatomic event distributive interpretations, where the entities involved in the distributive relation as members of the KEY are subatomic parts of the plurality of events denoted by the sentence.

The paper is structured as follows: Section 2 discusses reciprocal sentences with RN-expressions, and shows that such sentences allow for two kinds of event distributive interpretations: one where the KEY is a plurality of reciprocal events, and another where the KEY is a plurality of unidirectional events.[5] Section 3 provides an overview of the mereological approach to atoms and pluralities in different domains. Then, Section 4 shows that the relation between reciprocal events and the unidirectional events entailed by them is different from the relation between pluralities and their atomic parts, and argues that unidirectional events are subatomic parts of reciprocal events. Section 5 lays out our analysis of RN-expressions which is based on the analysis in Cable (2014), except that it relies on a relation that can capture the relation between reciprocal events and unidirectional events. Finally, Section 6 summarizes the main points of the paper.

2 Reduplicated numerals in reciprocal sentences

The key observation of the paper is that RN-expressions can occur in reciprocal sentences as the antecedent of a reciprocal pronoun. A naturally occurring example is in (6).

(6) *Az erőpróbá-n egyszerre **egy-egy** csapat versengett egymás-sal.*[6]
the tournament-SUP at.a.time **one-one** team compete.PST.3SG each.other-COM

[4] I use the term *reciprocal sentence* to refer to sentences where the source of the reciprocal interpretation is the reciprocal pronoun, and 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.

[5] *Unidirectional events*, unlike reciprocal events, are events where participants are clearly differentiated by the thematic roles they bear in the event (Winter 2018).

First, let us discuss the interpretation of reciprocal sentences with RN-expressions, and then I turn to the theoretical implications of the interpretation identified.

2.1 The interpretation of reciprocal sentences with RN-expressions

In (6), there is no plural expression in the sentence referring to a plurality of individuals, so the sentence cannot have the distributive interpretation where the KEY is from the domain of individuals. That is, (6) can only have an event distributive interpretation.

The event distributive interpretation of a sentence with distributive numerals involves a plurality of events described by the sentence that plays the role of the KEY in the distributive relation. The sentence in (6) describes one or more reciprocal competing events[7], however, the interpretation of (6) does not involve a distribution over this plurality of reciprocal events. If it did, the interpretation we would assign to (6) is the one in (7).

(7) #'At the tournament, each time one team competed with each other'

The interpretation in (7) is not only nonsensical, it is also incorrect. The actual interpretation of (6) involves distribution over a plurality of unidirectional competing events entailed by the reciprocal event(s) described by the sentence. However, the RN does not signal the total number of teams involved in each unidirectional competing event, but the number of teams bearing the thematic role of AGENT and that of the THEME[8] in those unidirectional events.[9] The interpretation of (6) is spelled out in (8).

(8) 'At the tournament, each time one team competed with another (and vice versa)'

At this point, we could assume the RNs in reciprocal sentences always signal the number of entities associated with unidirectional events. However, this can be easily shown that it is not the case: if we replace the RN *egy-egy*, lit. 'one-one' in (6) with *két-két*, lit. 'two-two', see (9), the resulting sentence has both kinds of event distributive interpretations we have already considered for (6). (9) has the interpretation where the RN signals the number of teams in

[6]`https://www.mohacsiujsag.hu/mohacs/hir/helyi-hireink/szombaton-sarkanyhajoverseny-nevezoket-jelentkezoket-varnak`. Last accessed: December 9, 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.

[7]The number of events denoted by (6) is not specified by the sentence itself.

[8]Here I assume that the verb *compete* (and its Hungarian counterpart, *verseng*) assigns the thematic role AGENT to its subject, and the thematic role THEME to its object.

[9]Distributive numerals in reciprocal sentences give rise to similar interpretations in Mandarin Chinese (Kobayashi & Chen 2018) and in Telugu (Rahul Balusu, p.c.).

each reciprocal competing event, see (9a); and the interpretation, where the RN signals the number of teams as AGENT and as THEME in each unidirectional competing event; see (9b).

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

The interpretation in (9a) is available for (9) because even if the RN-expression *két-két csapat*, lit. 'two-two team' is understood as *two teams* having obligatory narrow scope, it still denotes a plurality, and hence can refer to the sole participant of a reciprocal event.

2.2 Theoretical implications

The theoretical implications of the interpretations we identified for (6) and (9) are twofold. First, these sentences show that RN-expressions can be the antecedent of a reciprocal pronoun regardless of the cardinality expressed by the base cardinal of the RN. This is a strong argument against treating RN-expressions as narrow-scope indefinites (as in Farkas 1997, Oh 2001, Zimmermann 2002, Balusu 2006, Farkas 2015, Champollion 2016, a.o.). The antecedent of a reciprocal pronoun must be referentially plural. If we assume that RN-expressions are interpreted as narrow-scope indefinites, we predict that the RN-expressions with the RN *egy-egy*, lit. 'one-one' are referentially singular narrow-scope indefinites, hence cannot be the antecedent of a reciprocal pronoun. However, as we have seen in (6), RN-expressions with the RN *egy-egy*, lit. 'one-one' can in fact be the antecedent of a reciprocal pronoun, hence they should not be analyzed as narrow-scope indefinites.

Second, the sentences in (6) and (9) show that the interpretation of reciprocal sentences with RNs can involve quantification over two different kinds of event, as the KEY of the distributive relation can be a plurality of reciprocal events or a plurality of corresponding unidirectional events. Since we assume that the event distributive interpretation of a sentence with RN involve a plurality of events described by the sentence, (6) and (9) suggest that reciprocal sentences are able to describe a plurality of events that has both reciprocal and unidirectional events as its members. This immediately raises the question how these two kinds of events are related to each other, and how RN-expressions can access both kinds of events. In order to answer this question, first I discuss how singularities and pluralities are defined in different domains, and then I turn to the events described by reciprocal sentences and the relation between reciprocal and unidirectional events.

3 Atoms and pluralities in different domains

Since Link (1983), it is quite standard to assume in formal semantics that there are structurally simple and structurally complex entities in our ontology. This structural complexity is captured in terms of the reflexive, anti-symmetric and transitive part-of relation ($\leq$) between entities. Since the theory studying this notion of parthood is called mereology (formally defined by Leśniewski 1916 and Leonard & Goodman 1940), the $\leq$ relation is called the mereological part-of relation.

Based on the mereological part-of relation, singularities or atoms are structurally simple entities that have no proper parts (parts other than themselves); see (10). In turn, pluralities are entities that are structurally complex, i.e. have parts other than themselves; see (11). Pluralities can be referred to as the sum of their parts: the sum $x \oplus y$ is the entity consisting of the entities x and y.[10]

(10) $\text{AT}(x) \leftrightarrow \neg\exists y[y \leq x \wedge y \neq x] \leftrightarrow \neg\exists y[y < x]$ Singularities/Atoms

(11) $\text{PL}(x) \leftrightarrow \exists y[y \leq x \wedge y \neq x] \leftrightarrow \exists y[y < x]$ Pluralities

Following Link (1983), Bach (1986), Krifka (1989) and others, we assume that the respective domains of individuals (D_e), events (D_v), and time intervals (D_t) are closed under sum-formation $\oplus$, and the entities are ordered by the mereological part-of relation $\leq$; see (12).

(12) 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. $\forall t, t'[t, t' \in D_t \rightarrow t \oplus t' \in D_t]$

According to the definitions in (10) and (11), every entity in our model is either an atom or a plurality, that is, being an atom or a plurality is a structural property of every entity. However, these structural notions have proven to be quite limiting in formal semantics, as it can often be the case that the same entity appears to be an atom with respect to one property and as a sum with respect to another.[11] Thus, we will employ the relative notion atom and plurality. A relative atom or P-atom is a singularity with respect to the property P (Krifka 1989); see (13). In turn, pluralities are understood as sums of relative atoms.

[10] For a full definition of a mereological sum, and a review of possible definitions, see Champollion & Krifka (2016), and the references therein.

[11] To illustrate such a case, we can think about a bouquet of flowers. On the one hand, one bouquet is an atom, an arrangement of flowers. On the other hand, a bouquet is a plurality as it consists of multiple flowers.

(13) $\text{AT}_\text{P}(x) \stackrel{\text{def}}{=} P(x) \wedge \neg\exists y[y < x \wedge P(y)]$ *P*-atom

We further assume, in line with Krifka (1989), that natural language predicates and properties that correspond to linguistic descriptions of entities[12] can be semantically singular or plural, depending on how they refer to entities. Semantically singular predicates denote a set of entities that are atomic with respect to the property expressed by the predicate; see (14).

(14) $SG(P) \leftrightarrow \forall x[P(x) \wedge \text{AT}_P(x)]$

Semantically plural predicates, on the other hand, denote a set of atomic entities and all the possible sums formed by the atomic entities. Semantically plural predicates are formed of semantically singular predicates by closing the denotation of the semantically singular predicate under sum formation (Link 1983). Formally, the semantic pluralization of predicates is done by the *-operator which is defined in (15).

(15) $*P$ 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)

3.1 The denotation of nominals

In the case of nominal predicates in English, morphologically singular count nouns are typically translated into semantically singular predicates, and semantic pluralization might correspond to the morphological plural marking on count nouns; see (16).

(16) a. $[\![\text{screwdriver}]\!] = \lambda x[\text{SCREWDRIVER}(x)]$

b. $[\![\text{screwdrivers }]\!] = \lambda x[*\text{SCREWDRIVER}(x)]$

In Hungarian, count nouns do not have to be morphologically marked as plural in order to have plural interpretation, as illustrated in (17).

(17) *egy/minden/három/néhány/sok csavarhúzó(*-k)*
one/every/three/some/many screwdriver(-PL)
'one/every screwdriver/three/some/many screwdrivers'

In order to represent that singular count nouns in Hungarian can be understood as semantically plural, I distinguish between strong and weak singular versions of singular count nouns

[12]For the sake of readability, from now on I will omit "properties that correspond to linguistic descriptions of entities", and just write "predicates".

in Hungarian (inspired by Farkas & de Swart 2010). The strong singular version of a morphologically singular noun is the noun as a semantically singular predicate; see (18a). In turn, the weak singular version of a morphologically singular noun is the noun as a semantically plural predicate. That is, the denotation of weak singular predicates is the same as that of morphologically plural count nouns; see (18b). Following Farkas & de Swart (2010), I assume the interpretation of the noun depends on the determiner that takes the noun as its complement: universal determiners like *minden*, 'every' select strong singular predicates, whereas numerals like *három*, 'three' select weak singular predicates.

(18) a. $[\![\text{csavarhúzó}_{\text{STRONG-SG}}]\!] = \lambda x[\text{SCREWDRIVER}(x)]$

b. $[\![\text{csavarhúzó}_{\text{WEAK-SG}}]\!] = [\![\text{csavarhúzók}]\!] = \lambda x[^*\text{SCREWDRIVER}(x)]$

3.2 Atomic events and linguistic descriptions

Verbs denote both events and their sums[13], that is, their denotation is closed under the sum formation. This is a common assumption (see Lasersohn 1989, Kratzer 2008, Champollion 2017, among others), based on observations like if e_1 chasing and e_2 is chasing then $e_1 \oplus e_2$ is chasing is a valid inference. I will refer to this property of verbs as lexical cumulativity, following Kratzer (2008).

Lexical cumulativity captures the observation that there is no such morphological distinction between singular and plural forms in the case of verbs[14] as we have seen in case of count nouns in English. Since the same verbal predicate can be used to refer to a singular event and a plurality of events, we can assume that the denotation of verbal predicates is inherently closed under the sum formation; see (19). Following Krifka (1992, 1998) and Champollion (2017), a.o., I assume the same for thematic role functions (see (20)) and temporal trace functions (see (21)).

(19) $[\![V]\!] = [\![^*V]\!]$ (20) $[\![\theta(e)]\!] = [\![^*\theta(e)]\!]$ (21) $[\![\tau(e)]\!] = [\![^*\tau(e)]\!]$

I assume that an atomic event is always bounded on its temporal dimension, that is, it must have a starting point and an endpoint in time in order to be counted as one event. Having a starting point and an endpoint in time entails that the event occurred within those two points of time. More specifically, it entails that the event started to exist at its starting point and

[13] 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).

[14] This is only true in the case of verb roots.

ceased to exist at its endpoint, and it continuously existed during the time interval defined by the starting point and the endpoint.[15]

In our system, atomic events are the ones whose runtime is assigned by the function τ_{max} that assigns the time interval defined by the starting point and the endpoint of the event. Events which have their runtime assigned by τ_{max} might have parts whose runtime is part of the runtime picked out by τ_{max}, but those parts cannot be counted in our system. This way we can differentiate between countable and uncountable parts of an event. For example, if Amelia ran this week twice, then there is a plurality of running events that has two parts whose runtimes are assigned by τ_{max}. The plurality of events may have other parts whose runtime is part of the sum of the time intervals assigned by τ_{max} – many parts of a plural running event are themselves running events –, but those parts are not atomic thus cannot be counted. According to this approach, whether an event is atomic or not cannot be fully determined by verbal predicates themselves (still, an event can be atomic only with respect to a predicate), but atomic events are independently introduced in our model.

Sentences with a verbal predicate and all of its arguments describe either atomic events, or a plural event. If an event e is associated only with atomic individuals via the thematic role functions, then e is atomic, i.e. its runtime is assigned by τ_{max} function, as in (22).[16]

(22) A professor looked for a screwdriver. *sg. event*

If an event e described by a sentence is associated with a plurality of individuals x by any of the thematic role functions θ, as in (23), then e is atomic if it does not have any proper parts e' such that the individual y assigned by θ to e' is a proper part of x.

(23) Two professors looked for a screwdriver. *sg. or pl. event*

Finally, if an event e described by a sentence is associated with a plurality of time intervals t by the temporal trace function τ, as in (24), then e is atomic if it does not have any proper parts e' such that the time interval t' is assigned by τ_{max} to e', and t' is a proper part of t. I assume that if e is not atomic (based of any types of entities it is associated with) then in e is a plurality of events.

(24) A professor looked for a screwdriver on two consecutive days. *sg. or pl. event*

Having discussed atomicity of events, I turn to the discussion of reciprocal sentences and the

[15]For the purposes of this paper we can set aside the issue of pauses and events that are scattered over time.
[16]Here we only consider the episodic interpretations of the sentences in (22), (23) and (24).

events they describe.

4 Reciprocal sentences and events

Reciprocal sentences describe events that are always associated with a plurality of individuals as one of its thematic roles, since the constituent that serves as the antecedent of the reciprocal pronoun must refer to a plurality. This straightforwardly raises the question whether reciprocal sentences describe atomic events or a plurality of events. In this section, I argue that reciprocal sentences describe a (sum of) reciprocal events, and the relation between reciprocal events and the unidirectional events they entail cannot be captured in terms of the mereological part-of relation.

4.1 Reciprocal sentences and the events they describe

According to Carlson (1998), Dimitriadis (2008), and others, reciprocal sentences always describe a plurality of unidirectional events. This assumption is based on the following observation: if the sentence in (25) is true, it must be the case that Amelia wrote Valentina and Valentina wrote Amelia. Since those are two distinct events, it follows that reciprocal sentences like (25) describe a plurality of events.

(25) Amelia and Valentina wrote each other.

The assumption in Carlson (1998) and Dimitriadis (2008) is in line with the assumption in Heim, Lasnik & May (1991) that sentences like (25) involve distributive predication, where the source of the distributivity is the reciprocal pronoun itself. According to this approach, in reciprocal sentences the distribution is over the entities denoted by the antecedent of the reciprocal pronoun, that is, (25) is interpreted as 'Amelia and Valentina each wrote the other', and this interpretation entails that there is a plurality of writing events, one with Amelia as the agent, and another with Valentina.

Moltmann (1992), Dotlačil (2010) and others point out that the distributive interpretation of reciprocal sentences might be very local compared to the distributive interpretation of sentences without the reciprocal pronoun. In those sentences, the scope of distributivity can involve any constituent below the predicate, as illustrated by (26), where there is a temporal modifier in a post-verbal position in the scope of the distributive operator. In reciprocal sentences, however, it is harder to get the interpretation where the post-verbal modifier is

understood as being in the scope of a distributive operator, as shown in (27). This suggests that the distributive interpretation does not affect the event described by the sentence.

(26) 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`

(27) Amelia and Valentina wrote each other on two rainy days. $^{?}\Rightarrow$
`Amelia wrote Valentina on two rainy days, and Valentina wrote Amelia on (potentially different) two rainy days`

Moreover, according to our approach to atomicity of events discussed in Section 3, (27) describes a plurality of reciprocal events. This plurality of events has two proper parts along its temporal properties: there is a reciprocal writing event between Amelia and Valentina on each of the two rainy days. These subevents have the sum of Amelia and Valentina as their agents. However, these subevents themselves have no further parts e' such that a proper part of the plurality a $\oplus$ v is the agent of e'.

This assumption is supported by the observation that reciprocal sentences, unlike sentences without a reciprocal pronoun, do not display the properties of cumulativity of thematic roles and cumulativity of temporal traces. These are properties of the thematic role function θ and temporal trace function τ, respectively, according to which if they relate an entity (individual or time interval) x to e and an entity y to e' then they relate the sum of x and y to the sum of e and e' (Krifka 1992, Krifka 1998, Champollion 2017).

Given the properties of cumulativity of thematic roles, and temporal trace functions we can assume that if an event e is related to a plurality of individuals x by θ, and a plurality of time intervals t by τ, e can be the sum of events e', such that e' is associated to a proper part of x by θ and a proper part of t by τ. For example, the non-reciprocal sentence (28) can be understood as describing an event which is the sum of the events of Amelia playing solitaire this morning on the one hand, and Valentina playing solitaire this afternoon on the other. However, the reciprocal sentence in (29), event though it is related to a plurality both by θ and τ, cannot be understood as Amelia writing Valentina this morning and Valentina writing Amelia this afternoon. That is, (29) cannot be understood as describing a sum of unidirectional events.

(28) Amelia and Valentina played solitaire this morning and this afternoon (respectively).

(29) Amelia and Valentina wrote each other this morning and this afternoon (#respec-

tively).

In sum, based on (26)–(29), I will treat reciprocal sentences as sentences that describe (a sum of) atomic reciprocal events, and not sums of unidirectional events.

4.2 The relation between reciprocal events and unidirectional events

Given that we assume that the events described by reciprocal sentences are (sums of) atomic reciprocal events, the relation between them and the unidirectional events they entail should not be captured by the mereological part-of relation. The mereological part-of relation models the relation between sums and the atoms they consist of, but this is not the kind of relationship that we can assume between reciprocal and unidirectional events. Yet, we still want to capture the relation between these two kinds of events, as the event distributive interpretation of sentences with Hungarian RNs can involve quantification either over reciprocal events or unidirectional events.

I assume that reciprocal and unidirectional events are related to each other indirectly, via the mereological part-of relation holding between their participants on the one hand, and their runtimes on the other. I call this relation *containment*, defined formally as in (30).

(30) $e' \trianglelefteq e \stackrel{\text{def}}{=} \exists V[V(e) \wedge V(e') \wedge \tau(e') \leq \tau(e) \wedge \theta(e') \leq \theta(e)]$

According to (30), 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. That is, the containment relation can describe the relation between an event and its subatomic parts like in the case of reciprocal events and unidirectional events.

5 The analysis of RNs

Here I adopt the analysis in Cable (2014) for RNs, not only because it offers a compositional analysis of distributive numerals, but also because it does not assume that the RN-expression is interpreted as a narrow-scope indefinite (cf. Oh 2001, Zimmermann 2002, Balusu 2006, Henderson 2012, Farkas 2015, and Champollion 2016 a.o.). The main reason in Cable (2014) to not to treat NPs modified by distributive numerals as narrow-scope indefinites is to account for the intuition that sentences with distributive numerals are not ambiguous as to which domain the KEY is from, merely underspecified. For us, the reason lies in the observation that RN-expressions can be the antecedent of reciprocal pronouns. But unlike the analysis

in Cable (2014), ours relies on the containment relation, instead of the mereological part-of relation between events.

5.1 The ingredients of the analysis in Cable (2014)

Before turning to the actual analysis, I introduce the ingredients of the analysis in Cable (2014): the metalanguage predicate PARTICIPANT, the *Partition*-function, and the binary maximality (σ) operator. The definitions below rely on the original definitions from Cable (2014), except that they utilize the containment relation defined in (30), and not the mereological part-of relation.

The first ingredient, the PARTICIPANT predicate, is defined as 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; see (31).

(31) 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)

The second ingredient, the *Partition*-function, is defined in (32). According to this definition, the *Partition*-function is a function that maps an event to a set of its subevents. The subevents in this set fulfill the following requirements: each subevent is related to the event by containment, and the sum of all subevents in the set equals the event, and none of the subevents in the set overlaps in terms of containment. I follow Balusu (2006) and Cable (2014), and assume that the *Partition*-function has to be contextually salient and yields a cognitively natural partition over the event it is applied to.

(32) $Partition(e) = \{e' : e' \trianglelefteq e\}$, such that

a. $\bigoplus Partition(e) = e$, and

b. $\forall e' \forall e'' [e', e'' \in Partition(e) \wedge \neg \exists e''' [e''' \lhd e' \wedge e''' \lhd e'']]$ (based on (71) in Cable 2014)

The last ingredient of our analysis is the binary σ-operator, defined in (33). This operator is the maximality operator defined for pairs, which applies to a two-place relation $Q(x)(y)$, and 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.

(33) 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 $\delta \trianglelefteq \beta$

Now that we have the ingredients of Cable (2014) defined, we can turn to the semantic analysis of RNs.

5.2 The semantics of RNs

The lexical entry of RNs is in (34), where n should be substituted with the numerical value expressed by the base numeral of the RN. According to (34), a RN 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'.

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

Based on (34), the contribution of RNs to the interpretation of the sentence they occur in is that they require there to be a contextually salient partition over the event e described by the sentence such that in each subevent in that partition, n number of individuals participated, and these individuals are described by the NP modified by the RN. Since RN-expressions seem to be always compatible with plural interpretation, we furthermore assume that this NP has weak singular denotation, i.e. Q in (34) is a plural predicate.

5.3 The semantics of the reciprocal pronoun

Before we turn to the analysis of the sentences in (6) and (9), I give our definition of the reciprocal pronoun. Here I only consider the reciprocal pronoun in direct object position, see the definition in (35). According to this definition, 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.

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

In our approach, reciprocity is treated as a restricted version of reflexivity (Murray 2008): on the one hand, the reciprocal pronoun requires that the event e described by the sentence assigns two thematic roles to the same individual. In this sense, it is like a reflexive pronoun. On the other hand, it requires e to have multiple contained parts, such that the set of these parts is in Rec_V^x. This Rec_V^x, as defined in (36), is a set of sets of events consistent with the reciprocal interpretation of V given the entity x. A crucial property of the events in Rec_V^x is that none of them can assign different thematic roles to the same individual.

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

Now we have all the assumptions and definitions that we need in order to give the truth conditions to the reciprocal sentences with RNs.

5.4 The analysis of reciprocal sentences with RN-expressions

The truth conditions for (6), repeated as (37) below, are in (38).[17]

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

(38) $\exists e\exists x\exists y[{*}\text{TEAM}(x) \wedge \text{COMPETE}(e) \wedge \text{AG}(e) = x \wedge \text{TH}(e) = y \wedge x = y \wedge \exists e', e'' \trianglelefteq e[\{e', e''\} \in Rec^x_{\text{COMPETE}}] \wedge \langle e, x\rangle = \sigma_{\langle e''', x'''\rangle}[x''' \leq x \wedge |x'''| = 1 \wedge e''' \in Partition(e) \wedge \text{PARTICIPANT}(e''', x''')]]$

According to (38), the sentence in (37) 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. These contained parts are 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. And finally, 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.

[17] For the sake of simplicity, I do not analyze 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.

Our analysis of (37) treats the meaning contribution of the reciprocal pronoun and the RN-expression separately. On the one hand, the reciprocal pronoun signals a specific structure associated with the reciprocal event(s) described by the sentence. On the other hand, the RN signals the number of entities bearing a certain thematic role in each contextually salient subevent of the event described by the sentence.

The truth conditions in (40) for (9), repeated as (39) below, are almost identical to that of (38), except for the cardinality expressed by the base numeral: in (37), it is the cardinality one, whereas in (39), it is the cardinality two. Since individuals of cardinality of two are pluralities, they can be involved in reciprocal events and unidirectional events. Thus, based on the context, in the case of (39), the *Partition*-function can yield to a set of reciprocal events or unidirectional events. In the former case, the sentence is interpreted as there were two teams in each reciprocal competing events, and in the latter case it is interpreted as there were two teams for each unidirectional competing event.

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

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

According to our analysis, RNs only require one kind of participant of the relevant subevent to be of the cardinality expressed by the base cardinal numeral. However, RNs can signal the number of two kinds of participants of the unidirectional subevents (agents and themes in our case) when they occur in reciprocal sentences. We rely on pragmatic reasoning to account for this. The assumption is that there is a restriction on the set of the unidirectional subevents in Rec^{x}_{V} that the *Partition*-function can access. This restriction is as follows: 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' is different from e'', and both e' and e'' are in E'). This way we can ensure that *any* thematic role assigned by the events in E' has the cardinality expressed by the base cardinal of the RN. This assumption, however, is not hard-wired into our analysis of RNs, and there is at least one strong argument that it should be. Other distributive elements like the adverb *egyesével*, 'one by one', can also break down reciprocal events into unidirectional events, but cannot signal the cardinality of two different thematic roles; see (41).

(41) *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'

Our analysis, as it is, cannot capture the difference between the interpretation of sentences with RNs, and sentences with adverbs like *egyesével*. Accounting for this difference is, unfortunately, outside of the scope of this paper and left for further research.

6 Conclusions

In this paper, I discussed the interpretation of reciprocal sentences where the antecedent of the reciprocal pronoun is modified by a RN. I argued that these sentences can have two different kinds of event distributive interpretation, one where the KEY is a plurality of reciprocal events, and another where the KEY is a plurality of unidirectional events. I argued that the latter kind of interpretation is a subatomic event distributive interpretation: reciprocal sentences describe reciprocal events, and the unidirectional events they entail are not mereological parts of reciprocal events. This suggests that RNs can access a fine-grained structure of events which I modeled with the relation of containment, a relation that relates events based on the mereological part-of relation between their participants and their runtimes.

The analysis of RNs presented in this paper is based on the one Cable (2014), but relies on the containment-relation, instead of the mereological part-of relation between events. One of the biggest advantages of adapting Cable's analysis of distributive numerals is that it does not assume that RN-expressions are interpreted as narrow-scope indefinites. RN-expressions can be the antecedent of a reciprocal pronoun (regardless of the cardinality expressed by the base cardinal of the reduplicated numeral), which clearly shows that they cannot be interpreted as narrow-scope indefinites. Instead, RN-expressions are interpreted as plural indefinites that are not in necessary scopal relations, where the RN expresses the number of entities in the denotation of the NP associated with each contained part of the event(s) described by the sentence. In reciprocal sentences, these contained parts can be either reciprocal events or unidirectional events, depending on the context.

As RNs are considered to be distributive numerals, and distributive numerals can be found in many unrelated languages, the question immediately follows whether distributive numerals in other languages display similar interactions with reciprocals. At this point, we have very limited understanding about distributive numerals in reciprocal sentences in other languages, so the analysis proposed in this paper provide a hypothesis to test in other languages.

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