Hungarian reduplicated numerals and distributive counting[1]

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In this talk, I will present some **new data** with Hungarian reduplicated numerals (henceforth: RNS) and propose a **novel semantic analysis** for these elements.

1 RNS: the first encounter

1.1 The formation of RNS

RNS are a special class of numerals in Hungarian (Finno-Ugric); they are formed by the **reduplication of a cardinal numeral**; see Table 1.

Table 1: Unmarked numerals and RNS

Numerical value	Cardinal numeral		RN
1	*egy*		***egy-egy***
2	*két/kettő*		***két-két / kettő-kettő***
3	*három*	⇒	***három-három***
4	*négy*		***négy-négy***
...	...		...

– Numeral reduplication in Hungarian is **productive**, however, complex cardinals formed by compounding multiple numerals sound odd when reduplicated; see (1).

(1) a. ***hatvanhét-hatvanhét***
sixty.seven-sixty.seven

b. ?***ötezerkilencszázhatvan-ötezerkilencszázhatvan***
five.thousand.nine.hundred.sixty-five.thousand.nine.hundred.sixty

[1] Glosses: 3 – third person; ACC – accusative case; COM – comitative case; DAT – dative case; DEL – delative case; ELA – elative case; ILL – illative case; INF – infinitive; PL – plural; POSS – possessive marker; PRT – verbal particle/prefix; PST – past tense; SG – singular.

∗ The weirdness of (1-b) is probably due a constraint on production, and is not grammatical in nature.

When a RN combines with a noun, they form a **RN-expression**.

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

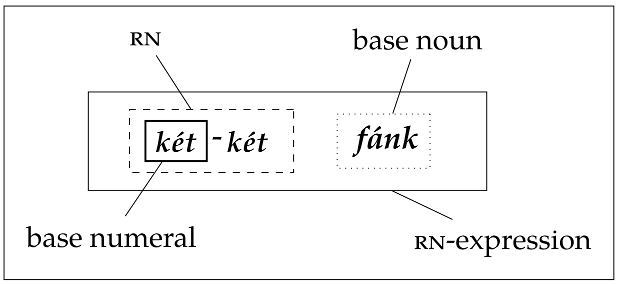


Figure 1: The anatomy of a Hungarian reduplicated numeral expression
BASE CARDINAL: a cardinal numeral
RN: the base numeral reduplicated
BASE NOUN: the NP in the complement of the reduplicated numeral
RN-expression: RN+ base noun

1.2 The syntactic distribution of RNS

The syntactic distribution of RNS is **more restricted** than that of cardinal numerals (for the distribution of cardinals see Rothstein 2015, 2017).

a) As prenominal modifiers: ✓ RNS ✓ cardinals

(2) *Amélia vett két/**két-két** fánk-ot.*
Amelia buy.PST.3SG two/**two-two** doughnut-ACC
Amelia bought two(-two) doughnuts.

(3) *A két/**két-két** fánk, ami-t Amelia vett…*
the two/**two-two** doughnut, that-ACC Amelia buy.PST.3SG…
The two(-two) doughnuts that Amelia bought…

b) As predicates: ✓ RNS ✓ cardinals

(4) *A bicikli-k és a roller-ek szám-a kettő/**kettő-kettő**.*
the bicycle-PL and the scooter-PL number-POSS.3SG two/**two-two**
The number of the bicycles and the scooters is two(-two)

∗ Note that RNS are very odd in constructions like (4) if the subject is a simple plural expression; see (5).

(5) *#A bicikli-k szám-a* ***kettő-kettő***.
the bicycle-PL number-POSS.3SG **two-two**
The number of the bicycles is two-two

c) As arguments: ✗ RNS ✓ cardinals

(6) *Kettő/****Kettő-kettő*** *meg három egyenlő öt-tel.*
two/**two-two** plus three equal five-COM
Two(-two) plus three equals five

d) As determiners of complex numerals: ✗ RNS ✓ cardinals

(7) *Kétszáz/****Két-kétszáz*** *ember állt sor-ba.*
Two-two.hundred/Two.hundred person stand.PST.3SG line-ILL
Two(-two) hundred people stood in line

– Based on (2)–(7), RNS cannot be used as singular terms referring to numbers of type *n*.

– Syntactically, **RNS pattern with numerals as predicates**.

1.3 The core semantic contribution of RNS

The semantic contribution of RNS is radically different from that of cardinals.

e) Cumulative interpretation: ✗ RNS ✓ cardinals

(8) *Amélia és Valentina vett két fánk-ot.*
Amelia and Valentina buy.PST.3SG two doughnut-ACC
'Amelia and Valentina bought two doughnuts in total' non-dist.

(9) *Amélia és Valentina vett* ***két-két*** *fánk-ot.*
Amelia and Valentina buy.PST.3SG **two-two** doughnut-ACC
%'Amelia and Valentina bought two doughnuts in total' %non-dist.

∗ RNS **force a distributive interpretation** of the sentence they occur in (Farkas 1997, 2002, 2015, a.o.).

The ingredients of distributivity (terminology)

Following Choe (1987): the distributive interpretation of a sentence involves **universal quantification**.

- Set/plurality in restriction: **KEY**,
- entities in scope: **SHARE**.

Distributivity is understood as the quantificational **dependency relation between the KEY and the SHARE**.

(10) The neighbors (each) petted two ducks.

a. ∀ KEY SHARE
NEIGHBOR TWO-DUCK

b. $\forall x[x <_{\text{AT}} \bigoplus {}^{*}\text{NEIGHBOR} \rightarrow \exists y[{}^{*}\text{DUCK}(y) \wedge |y| = 2 \wedge \text{PET}(x,y)]]$

f) Can only mark the SHARE of the distributive relation: ✓ RNS ✗ cardinals

(11) [*Két/#**Két-két** professzor*]$_{\text{KEY}}$ *vett* [*egy/**egy-egy** fánk-ot*]$_{\text{SHARE}}$.
two/**two-two** professor buy.PST.3SG one/**one-one** doughnut-ACC
'Two professors (each) bought a doughnut'

g) KEY from the domain other than individuals: ✓ RNS ✗ cardinals

(12) a. SCENARIO: Amelia usually goes to her local bakery several times a day to buy fresh baked goods for herself and her neighbors. This afternoon, she went to the bakery multiple times (two or even more times, not sure), and she bought two doughnuts each time. The baker who sold Amelia the doughnuts can conclude:

b. *Ma délután Amélia #két/**két-két** fánk-ot vett.*
this afternoon Amelia two/**two-two** doughnut-ACC buy.PST.3SG
'This afternoon, Amelia bought two doughnuts each time'

∗ RNS can give rise to so-called **event distributive interpretation** (when the KEY of the distributive relation is from the domain of events), whereas unmarked cardinals cannot.

∗ Event distributive interpretations with RNS are **only available if there is a salient plurality of events in the context**.

1.4 Previous semantic analyses for RNS

So far, the literature has only focused on sentences like (9) and (12), where **the RN appears in prenominal modifier position**, and the sentence must be interpreted distributively.

- There are two types of analyses available for RNS.
- For a more detailed overview of the available analyses, see Appendix A.

1. **Narrow-scope analyses**
   * RN-expressions are interpreted effectively as narrow-scope indefinites.
   * According to these analyses, sentences with RNS are understood as 'for every element in the KEY there are *n* entities denoted by the base noun'.
   * See different implementations of the idea in Choe (1987), Farkas (1997), Zimmermann (2002), Oh (2005), Balusu (2006), Henderson (2012), Champollion (2016), a.o.
2. **Scopeless analyses**
   * RN-expressions are interpreted as scopeless plural indefinites; the distributivity effect associated with RNS is interpreted at a lower/embedded level.
   * According to these analyses, sentences with RNS are understood as 'there is an entity in the denotation of the base noun, and this entity can be divided up into parts of the cardinality *n*, and such a part is associated with each member of a salient set/plurality'.
   * See Cable (2014), Kuhn (2017), Wohlmuth (2019a), a.o.

However, we have already seen in Section 1.2, **RNS can appear in predicate position**.

- Even if the analyses above get the truth conditions for sentences like (9) and (12) right, they have nothing to say about the meaning of sentences like (4).

2 The meaning contribution of RNS: a closer look

The meaning contribution of RNS in predicate position is different from what previous analyses assume for RNS in prenominal position.

(13) *A bicikli-k és a roller-ek szám-a kettő.* ≈ (4)
the bicycle-PL and the scooter-PL number-POSS.3SG two
a. 'The total number of the bicycles and the scooters is two.'
b. 'The number of both the bicycles and the scooters is two.'

(14) *A bicikli-k és a roller-ek szám-a* ***kettő-kettő****.* ≈ (4)
the bicycle-PL and the scooter-PL number-POSS.3SG **two-two**
a. %'The total number of the bicycles and the scooters is two.'
b. 'The number of both the bicycles and the scooters is two.'

- The contrast between (14) and (13) suggests that unlike cardinal numerals, **RNS cannot signal the total number of entities**.
- RNS **can only provide the number of entities in different sets**.
- The meaning of sentences like (14) does **not involve a distributive relation** in sense of Choe (1987).

This is further supported by (5) (repeated as (15-b) below), which is semantically anomalous out of the blue, but OK if the context makes it clear how the bicycles are grouped together in twos, see (16).

(15) a. OUT OF THE BLUE
b. #*A bicikli-k szám-a* ***kettő-kettő****.* = (5)
the bicycle-PL number-POSS.3SG **two-two**

(16) a. CONTEXT: Amelia works at a bicycle shop where scooters are sold as well. Recently, her boss asked her to keep a daily tally of the number of bicycles and scooters sold, sorted by color (the boss wants to know which color is the most popular). At the end of the today, Amelia checks the tally, and sees that she sold two bikes of each color, and one green scooter. In this situation, Amelia can conclude:
b. *A ma eladott bicikli-k szám-a* ***kettő-kettő****, míg a*
the today sold bicycle-PL number-POSS.3SG **two-two**, while the
roller-ek-é összesen egy.
scooter-PL–POSS.3SG in.total one
'The number of the bicycles sold today is two per color, and that of the scooters is one in total'

- (16) shows that RNS can signal the number of entities in various **subsets** of the denotation of the noun they modify.

– This is further supported by (17), where the RN modifies a noun that is already modified by a conjoined adjective.

(17) *Amélia* ***négy-négy*** *csoki-s és lekvár-os fánk-ot*
Amelia **four-four** chocolate-ADJ and jam-ADJ doughnut-ACC
vett.
buy.PST.3SG

a. %'Amelia bought four doughnuts in total, either chocolate or jam flavored'
b. 'Amelia bought four chocolate and four jam doughnuts'

– Even though they cannot signal the total number of entities, RNS can be modified by *összesen*, lit. 'in total'.

  * Even in these cases, the RN cannot signal the total number of entities in the denotation of noun they modify; see (18).

(18) *A két repülőgép-hordozó-ba* *összesen* ***két-két*** *gázturbina került.*[2]
the two aircraft.carrier-ILL in.total **two.two** gas.turbine put.PST.3SG

a. %'The two aircraft carriers are equipped with two gas turbines in total'
b. 'The two aircraft carriers are equipped with two gas turbines each'

The data in (14)–(17) show that the meaning contribution of RNS **cannot be fully captured in terms of distributivity**.

– The interpretation RNS does not involve a distributive relation in the sense of Choe (1987). Instead, **RNS seem to require that the entities in the denotation of the base noun to be in multiple sets**.

– This is a problem for all previous analyses available for RNS that analyze these elements in terms of establishing a relation between sets of entities.

Additional intriguing data

RNS can serve as the antecedent of a reciprocal pronoun even if the base cardinal of the RN is 'one'; see (19) (see also Wohlmuth 2019a and Wohlmuth 2019b).

[2]Based on the sentence found here: https://tinyurl.com/y5quah3a. Last accessed: Sep 30, 2019.

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

(19) shows that **RN-expressions are not narrow-scope indefinites**.

- The interpretation we could assign to (19) if RN-expressions were to be analyzed as narrow-scope indefinites is in (20).

  (20) %'At the tournament, each time one team competed with each other'

- The interpretation in (20) is **not only nonsensical, it is also incorrect**.
- The actual interpretation we can assign to (19) is in (21).

  (21) 'At the tournament, each time two teams competed, one with the other'

  * (19) is true as long as there was at least one reciprocal competing event,
  * and in each reciprocal competing event exactly two teams competed.

Sentences like (19) **are problematic for any analysis that captures the meaning of sentences with RNs as a relation between sets entities**.

- In (19), the RN signals **the cardinality of both participants (agent and theme) of non-reciprocal competing events** associated with the reciprocal competing event denoted by the sentence.

[3] `https://tinyurl.com/yxecnko8`. Last accessed: Sep 30, 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.

3 The Distributive Counting Hypothesis

Here, I pursue the idea that **the only relevant characteristic of RNs is that they are incompatible with cumulative interpretation**.

- RNS are much like unmarked cardinal numerals in that they provide the cardinality of some entity.
- But while unmarked cardinal numerals provide the cardinality of the entity they combine with (Landman 2003), RNS are unable to do that.
- Instead, **RNS provide the cardinality of parts of the entity they combine with**, where there are different, contextually salient properties, and **each of these properties apply to one of these parts**.
- I call this approach to the semantics of RNS the **Distributive Counting Hypothesis** (henceforth: DCH).

3.1 The analysis of RNS

3.1.1 Some technical background

I) Pluralities of entities

Applying the theory of **mereology**, we can model the difference between singularities (entities that are one) and pluralities (entities that are more than one) as a structural property of entities (Link 1983).

- This structural property is based on a specific relation between entities.
- This relation is the reflexive, anti-symmetric and transitive **part-of** relation ($\leq$).
- Singularities (**atoms**) are entities that have no parts other than themselves.

(22) $\textsc{at}(x) \leftrightarrow \neg\exists y[y \leq x \wedge y \neq x]$

- Pluralities are entities that have parts other than themselves.

(23) $\textsc{pl}(x) \leftrightarrow \exists y[y \leq x \wedge y \neq x]$

In order to make use of the notion of singularities and pluralities, we have to have pluralities in our domains.

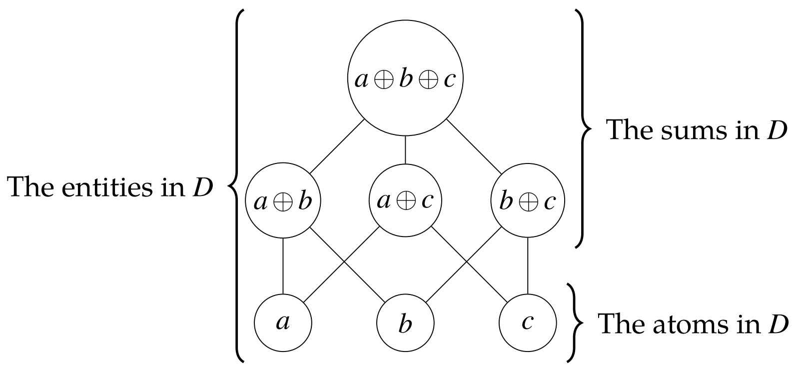
Two-dimensional domains

The respective domains of individuals D_e, of events D_v, and of time intervals D_t (etc.) 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.).

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

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

Figure 2: The semi lattice formed by the entities in D, where the atoms are a, b, c, represented as a Hasse-diagram.



II) <u>Semantically singular and plural predicates</u>

Natural language predicates can be distinguished as semantically singular or plural based on how they refer to entities.

(i) **Semantically singular predicates** can be used to refer to entities, but not to refer to sums of these entities.

∗ They denote a set of entities atomic with respect to the property expressed by the predicate; see (26).

(26) a. $\textsc{sg}(P) \leftrightarrow \forall x[P(x) \wedge \textsc{at}_P(x)]$
b. $\textsc{at}_P(x) \leftrightarrow P(x) \wedge \neg\exists y[y < x \wedge P(y)]$ (Krifka 1989)

(ii) **Semantically plural predicates** can be used to refer to entities and also to sums of these entities.

- They 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).

(27) $*P$ 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, Nouwen 2016)

- Semantically plural predicates are properties that have plural entities in their denotations.

– In the case of nominal predicates, semantic pluralization might correspond to the morphological plural marking on count nouns; see (28).

(28) a. doughnut $\rightsquigarrow \lambda x[\textsc{doughnut}(x)]$

b. doughnuts $\rightsquigarrow \lambda x[*\textsc{doughnut}(x)]$

– In the case of verbal predicates, the denotation of verbs[4] (or at least verb roots) is closed under sum formation (see **lexical cumulativity** in Kratzer 2008), so semantic pluralization does not have an effect on their denotation; see (29).

(29) $[\![V]\!] = [\![*V]\!]$

III) Cumulation of properties

Other than plural properties that hold of entities and their sums, I assume that there are **cumulated properties** – different[5] properties that hold of entities cumulatively; see (31).

(31) $P(x) \wedge Q(y) \rightarrow P \sqcup Q(x \oplus y)$

If a property P applies to x and a property Q applies to y, then a cumulated property $P \sqcup Q$ applies to $x \oplus y$.

[4]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).

[5]What I mean by 'same' and 'different' in relation with properties might be best captured in terms of their intension:

(30) a. P and Q are the same properties ($P = Q$) iff in every world w : $[\![P]\!]^w = [\![Q]\!]^w$

b. P and Q are the different properties ($P \neq Q$) iff there is a world w : $[\![P]\!]^w \neq [\![Q]\!]^w$

– This rule can be observed at work in natural language in examples like (32).

(32) a. These things are bicycles and those things are scooters. $\rightarrow$
b. These things and those things are bicycles and scooters.

There are some very weak requirements to meet for a cumulated property $P \sqcup Q$ to hold of x:

(33) $P \sqcup Q(x) \leftrightarrow \forall y[y \leq x \rightarrow \exists z[y \leq z \wedge z \leq x \wedge P(z) \vee Q(z)]]$
A cumulated property $P \sqcup Q$ holds of an entity x iff every part y of x is part of some z, such that z is part of x and either P or Q holds of z.

I assume that the operation that forms cumulated predicates ($\sqcup$) has the property of idempotence; see (34):

(34) $P \sqcup P = P$

Finally, I define a relation that stands between cumulated properties and its non-cumulated parts ($\sqsubset$); see (35).

(35) $Q \sqsubset P \leftrightarrow Q \sqcup P = P \wedge \exists S[S \neq Q \wedge Q \sqcup S = P]$
Q is (a proper) part of P iff the cumulated property $Q \sqcup P$ is identical to P and there is a property S different from Q such that the cumulated property $Q \sqcup S$ is identical to P.

3.1.2 The semantics of RNS

Based on their syntactic distribution (see Section 1.2), I assume that **the semantic type of RNS is the same that of unmarked cardinal numerals** in prenominal modifier position.

– Following Landman (2003) and Rothstein (2017), unmarked cardinal numerals are treated as **predicates of entities**; see (36).

(36) $[\![n]\!] = \lambda x[|x| = n]$

– According to (36), **unmarked cardinal numerals are predicates that hold of entities with a given cardinality**.

– The cardinality of an entity x is the cardinality of the set of all the parts of the entity such that these parts are atomic with respect to a predicate P where P holds of x; see (36) (based on Rothstein 2017).

(37) $|x| = n \leftrightarrow |\{y : y \leq x \wedge \exists P[P(x) \wedge \textsc{at}_P(y)]\}| = n$, where P is a non-cumulated property

RNS are predicates that hold of entities which have some special parts of a certain cardinality; see (38).

The DC-analysis of RNS

(38) $[\![n-n]\!] = \lambda x[C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = n \wedge Q(y)]]]$, where C is a contextually salient cumulated property.

A RN *n-n* holds of an entity x iff a contextually salient cumulated property C holds of x such that for each property Q part of C there is a y such that y is part of x and the cardinality of y is n and Q holds of y.

– RNS are analyzed effectively as a special kind of cardinal numerals – which they actually are.

3.2 In action

With the analysis in (38), we can account the data with RNS we have seen so far.

3.2.1 The new data

We can account for RNS in predicate position:

(39) a. *A bicikli-k és a roller-ek szám-a* ***kettő-kettő****.* = (14)
the bicycle-PL and the scooter-PL number-POSS.3SG **two-two**

b. $C(\sigma x[{}^*\textsc{bicycle}(x)] \oplus \sigma y[{}^*\textsc{scooter}(y)]) \wedge \forall Q[Q \sqsubset C \rightarrow \exists z[z \leq \sigma x[{}^*\textsc{bicycle}(x)] \oplus \sigma y[{}^*\textsc{scooter}(y)] \wedge |z| = 2 \wedge Q(z)]]$

(39-a) is true as long as a contextually salient property C applies to the sum of the bicycles and the scooters, and for every property Q such that Q is part of C, there is an entity z such that z is part of the bicycles and the scooters and the cardinality of z is two, and Q holds of z.

– In the case (39-a), C can be resolved as $^*\textsc{bicycle} \sqcup {}^*\textsc{scooter}$.

– I discuss other possible interpretations in Section 4.1.

We predict very similar truth conditions for (5):

(40) a. *A bicikli-k szám-a **kettő-kettő**.* = (5)
the bicycle-PL number-POSS.3SG **two-two**

b. $C(\sigma x[{}^*\textsc{bicycle}(x)]) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq \sigma x[{}^*\textsc{bicycle}(x)] \wedge |y| = 2 \wedge Q(y)]]$

– (40-a) will receive an interpretation only in contexts where C is resolved.

– According to the context in (16-a), C can be resolved as $\textsc{color}_1 \sqcup \textsc{color}_2 \sqcup \ldots \sqcup \textsc{color}_m$ (where m is the total number of colors).

We can also account for cases where the sentence denotes an event:

(41) a. *Amélia **négy-négy** csoki-s és lekvár-os fánk-ot vett.* = (17)
Amelia **four-four** chocolate-ADJ and jam-ADJ doughnut-ACC buy.PST.3SG

b. $\exists e \exists x[\textsc{buy}(e) \wedge \textsc{ag}(e) = \text{a} \wedge {}^*\textsc{doughnut}(x) \wedge {}^*\textsc{choc} \sqcup {}^*\textsc{jam}(x) \wedge \textsc{th}(e) = x \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 4 \wedge Q(y)]]$

– In (41-b), C can be resolved as $^*\textsc{choc} \sqcup {}^*\textsc{jam}$.

– Again, I discuss other possible interpretations in Section 4.1.

3.2.2 The "classic" examples

By "classic", I mean cases where the interpretation of the sentence can be modeled in terms of distributivity.

– The interpretation of these sentences arises exactly the same way as the interpretation where no entities are involved.

– This kind of interpretation arises as a **byproduct of the salient properties entailing the existence of entities**.

* I assume that for **any entity associated with an event** (via thematic roles, temporal trace functions, etc.) **there is a property that holds of that entity corresponding to the event description**.

(42) a. There is an event of Amelia walking at $t_1 \leftrightarrow$
b. Amelia has the property of being the agent of a walking event at t_1
c. t_1 has the property of being the runtime of a walking event by Amelia

* The properties that correspond to a specific event description **entail the existence of entities** associated with the event.

* Moreover, if the event is associated with a plurality of entities, there might be a cumulated property formed by **the properties corresponding to events associated with parts** of these plural entities.

(43) a. There is an event of Amelia and Valentina buying a doughnut $\leftrightarrow$
b. Amelia and Valentina have the property of being the agent of an event of buying a doughnut $\rightsquigarrow$
(i) Amelia has the property of being the agent of an event of buying a doughnut AND Valentina has the property of being the agent of an event of buying a doughnut

We analyze the (9) and (12), the two examples that can potentially be understood distributively, as (44-b) and (45-b), respectively:

(44) a. *Amélia és Valentina vett* ***két-két*** *fánk-ot.* = (9)
Amelia and Valentina buy.PRT.3SG **two-two** doughnut-ACC
b. $\exists e \exists x[\text{BUY}(e) \wedge \text{AG}(e) = \mathsf{a} \oplus \mathsf{v} \wedge {}^{*}\text{DOUGHNUT}(x) \wedge \text{TH}(e) = x \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 2 \wedge Q(y)]]$

(45) a. *Amélia* ***két-két*** *fánk-ot vett.* ≈ (12)
Amelia **two-two** doughnut-ACC buy.PST.3SG
b. $\exists e \exists x[\text{BUY}(e) \wedge \text{AG}(e) = \mathsf{a} \wedge {}^{*}\text{DOUGHNUT}(x) \wedge \text{TH}(e) = x \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 2 \wedge Q(y)]]$

– In both cases, C can be resolved as a cumulated property consisting of regular properties (i.e. the properties do not entail the existence of entities, like BLUE⊔RED or LIGHT⊔HEAVY).

– *C* can also be resolved as a cumulated property that consists of properties corresponding to an event description.

  ∗ In both cases, *C* can be resolved as in (46).

    (46) $C =$ BEING-BOUGHT-AT-$t_1 \sqcup$ BEING-BOUGHT-AT-$t_2 \sqcup \ldots \sqcup$ BEING-BOUGHT-AT-t_n

    ◦ In this case, the interpretation of the sentences is equivalent to the interpretation where the KEY is a plurality of runtimes associated with different events.

  ∗ In the case of (44), *C* can be resolved also as in (47).

    (47) $C =$ BEING-BOUGHT-BY-A $\sqcup$ BEING-BOUGHT-BY-V

    ◦ In this case, the interpretation of the sentence will be equivalent to the interpretation where the KEY is a $\oplus$ v.
    ◦ The main difference between (44) and (45) is that the event in (45) is associated with an atomic individual Amelia via the thematic role AGENT, so *C* cannot be resolved as a cumulated property formed by properties holding of parts of Amelia.

The biggest advantage of **the DC-analysis** is that it **can account for the different kinds of interpretations** of sentences like (44-a) and (45-a):

– It can account for the interpretation where the RN-expression is interpreted as if it was in the scope of a universal quantifier (distributivity).

  ∗ The analysis can also account for the observation that many sentences with RNS can have individual and event distributive interpretations (see Gil 1982, Zimmermann 2002, Cable 2014, Champollion 2016, a.o.).

– It can also account for the interpretation that cannot be modeled in terms of distributivity.

– Previous analyses can only for the interpretation that can be modeled in terms of distributivity.

4 Loose ends

The DCH seems to work fine, but there are some problematic cases.

4.1 The relevant properties are overt in the sentence

The DC-analysis predicts that in sentences like (39-a) and (41-a) (repeated below), *C* does not have to be is resolved as the overt properties cumulated.

(48) a. *A bicikli-k és a roller-ek szám-a* ***kettő-kettő.*** = (39-a)
the bicycle-PL and the scooter-PL number-POSS.3SG **two-two**

b. $C(\sigma x[{}^*\textsc{bicycle}(x)] \oplus \sigma y[{}^*\textsc{scooter}(y)]) \wedge \forall Q[Q \sqsubset C \rightarrow \exists z[z \leq \sigma x[{}^*\textsc{bicycle}(x)] \oplus \sigma y[{}^*\textsc{scooter}(y)] \wedge |z| = 2 \wedge Q(z)]]$

– According to (48-b), we predict that (48-a) is true in a situation like (49):

(49) a. C = BLUE⊔RED, and
b. $[\![\textsc{blue}]\!] = \{\text{scooter}_1, \text{bicycle}_1\}$
$[\![\textsc{red}]\!] = \{\text{scooter}_2, \text{scooter}_3\}$

– Whether (48-a) is true in a context in (49) has to be tested empirically, nonetheless, the prediction is there in our system.

(50) a. *Amélia* ***négy-négy*** *csoki-s és lekvár-os fánk-ot vett.* = (41-a)
Amelia **four-four** chocolate-ADJ and jam-ADJ doughnut-ACC buy.PST.3SG

b. $\exists e \exists x[\textsc{buy}(e) \wedge \textsc{ag}(e) = \text{a} \wedge {}^*\textsc{doughnut}(x) \wedge {}^*\textsc{choc}(x) \wedge {}^*\textsc{jam}(x) \wedge \textsc{th}(e) = x \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 4 \wedge Q(y)]]$

– Sentences like (50-a) pose a more serious problem for the analysis: they **might not have any other possible interpretation** other than the one where *C* is resolved as the cumulated property formed by the ones modifying the main nominal predicate.

– However, we predict (50-a) to be true in situations like in (51) and (52) (and many-many other situations).

(51) a. C = BIG⊔SMALL, and
b. $[\![\textsc{big}]\!] = \{\text{choc}_1, \text{choc}_2, \text{choc}_3, \text{jam}_1\}$
$[\![\textsc{small}]\!] = \{\text{choc}_4, \text{choc}_5, \text{jam}_2, \text{jam}_3\}$

(52) a. C = BEING-BOUGHT-IN-e_1⊔BEING-BOUGHT-IN-e_2, and
b. $[\![\textsc{being-bought-in-}e_1]\!] = \{\text{choc}_1, \text{choc}_2, \text{choc}_3, \text{jam}_1\}$
$[\![\textsc{being-bought-in-}e_2]\!] = \{\text{choc}_4, \text{choc}_5, \text{jam}_2, \text{jam}_3\}$

Sentences like (48-a) and (50-a) suggest that **contextual saliency might not be the only requirement** that has to be fulfilled by the cumulated property involved in the interpretation of sentences with RNS.

4.2 Interaction with universal quantifiers

RN-expressions can occur in the (surface) scope of a universal quantifier; see (53).

(53) *Minden professzor* ***négy-négy*** *fánk-ot vett.*
every professor **four-four** doughnut-ACC buy.PST.3SG
Every professor bought four-four doughnuts

- (53) has very similar interpretation to the sentences we have seen so far.
- But, unlike in previous sentences, the RN-expression *négy-négy fánk*, lit. 'four-four doughnut' in (53) **<u>can</u> be understood as 'four doughnuts' having narrow-scope** wrt. the universal quantifier.
- However, we can only assign the truth conditions in (54) for (53).

  (54) $\forall x[\text{PROF}(x) \rightarrow \exists e \exists y[\text{BUY}(e) \wedge \text{AG}(e) = x \wedge {}^{*}\text{DOUGHNUT}(y) \wedge \text{TH}(e) = y \wedge C(y) \wedge \forall Q[Q \sqsubset C \rightarrow \exists z[z \leq y \wedge |z| = 4 \wedge Q(z)]]]]$

  * According to (54), the distributive counting effect associated with the RN is interpreted in the scope of the universal quantifier.
  * That is, (54) can only account for interpretations where for every professor there was a plurality of doughnuts, such that it has parts of four with different properties.
  * The narrow-scope interpretation is not predicted by th DC-analysis.

5 Summary

I presented the DC-analysis for RNS, according to which **the semantic contribution of RNS is radically different than previously assumed**.

- The RNS were assumed to establish a (distributive) relation between (sets of) entities.

– According to the DC-analysis, **RNS count entities in different sets**.

This raises many questions, of which the two most important are:

1. Are similar elements in other languages behave similarly to RNS?
2. How does distributivity relate to the interpretation arising with RNS?

Appendix

A Previous analyses available for RNS

A.1 Narrow-scope analyses

<u>Basic assumption</u>: the interpretation of the sentences with RNS[6] is essentially the same as the interpretation that arises with universal determiners or covert distributivity operators (Roberts 1987, Link 1991, Schwarzschild 1996); see (10-a).

(55) a. *Amélia és Valentina vett **két-két** fánk-ot.* = (9)
Amelia and Valentina buy.PST.3SG **two-two** doughnut-ACC

b. $\forall$ KEY SHARE
a $\oplus$ v **or** $\bigoplus\{e$: contextually salient $e\}$ TWO-DOUGHNUT

Focal points of these analyses:

1. **Compositionality**: the surface position of the RN is different from where the distributivity effect associated with it is interpreted.
   – In (55-a), the distributive effect is associated with the RN ***két-két***, lit. 'two-two'.
   – On the surface, ***két-két*** only has the direct object NP *fánk*, lit. 'doughnut' in its scope.
   – However, the sentence is assumed to be interpreted as the universal quantifier associated with ***két-két*** taking widest scope, scoping over even the subject.

[6]Most of these analyses were not developed for RNS specifically, but for some related phenomena in other languages. Nonetheless, in theory, all of these analyses should be extendable to RNS.

2. Wider range of **possible interpretations**: unlike sentences with RNS, sentences where the distributive interpretation is due to a covert distributivity operator or a universal determiner are not compatible with event distributive interpretations.

– Each of the narrow-scope analyses addresses these issues, and offer different solutions; see a detailed discussion of the account in Champollion (2016) below.

In **Champollion (2016)**, elements like RNS are analyzed as overt manifestations of a special kind of distributivity operator Part (based on the Part operator in Schwarzschild 1996), defined in (56).

(56) $[\![\text{Part}_{\theta,C}]\!] = \lambda V \lambda e[e \in {}^*\lambda e'[V(e') \wedge C(\theta(e'))]]$ ((85) in Champollion (2016))

The Part-operator takes an event predicate V and returns a predicate that holds of any event e which can be divided up into events that are in V and whose θs satisfy the (contextually salient) predicate C.

– Champollion's Part-operator is defined for events, and it has a dimension parameter θ and a granularity parameter C.
– θ (which basically provides the KEY in Choe 1987's terms) can be resolved as a thematic relation (Θ) or as runtime (τ).
  * If θ is resolved as a thematic relation then C must be set to AT.
  * If θ is resolved as the runtime then C is set to a contextually salient event or occasion.

RNS can be treated as are overt manifestations of the Part-operator in (56).

– The semantics of RNS according to this analysis is in (57).
– A type-shift is applied to Part because RNS can only appear in prenominal modifier position.

(57) $[\![n-n_{\theta,C}]\!] = \lambda P \lambda \Theta \lambda e[[\![\text{Part}_{\theta,C}]\!](\lambda e'[P(\Theta(e')) \wedge |\Theta(e')| = n])(e)]$
$= \lambda P \lambda \Theta \lambda e[e \in {}^*\lambda e'[P(\Theta(e')) \wedge |(\Theta(e'))| = n \wedge C(\theta(e'))]$

A RN *n-n* takes a predicate P, a thematic role Θ, and returns a predicate that holds of thematic role Θ of any e, such that e can be divided up into events e' whose Θ is also in P, and the cardinality of Θ of e' is n (the cardinality expressed by the base numeral of the RN-expression), and the θs of e' satisfy the contextually salient predicate C.

According to (57), we can give the following truth conditions for (55-a):

(58) KEY: $\mathrm{a} \oplus \mathrm{v}$
$\exists e[\textsc{buy}(e) \wedge \textsc{ag}(e) = \mathrm{a} \oplus \mathrm{v} \wedge e \in {}^*\lambda e'[{}^*\textsc{doughnut}(\textsc{th}(e')) \wedge |\textsc{th}(e')| = 2 \wedge \textsc{at}(\textsc{ag}(e'))]]$
There is a buying event *e* whose agent is Amelia and Valentina, and *e* can be divided up into events *e′* whose theme is two doughnuts, and whose agent is atomic.

(59) KEY: $\bigoplus\{e : \text{contextually salient meals}\}$
$\exists e[\textsc{buy}(e) \wedge \textsc{ag}(e) = \mathrm{a} \oplus \mathrm{v} \wedge e \in {}^*\lambda e'[{}^*\textsc{doughnut}(\textsc{th}(e')) \wedge |\textsc{th}(e')| = 2 \wedge \textsc{meal}(\tau(e'))]]$
There is a buying event *e* whose agent is the Amelia and Valentina, and *e* can be divided up into events *e′* whose theme is two doughnuts, and whose runtime is a contextually salient meal.

In (58) and (59) **the KEY is provided by resolving the parameters of the Part-operator** manifested by the RN and it is not represented as the restrictor of a universal quantifier; **the SHARE is represented as properties of each (relevant) subevent** of the main event denoted by the sentence.

A.2 Scopeless analyses

Basic assumption: the interpretation of sentences with RNS[7] is fundamentally different from the interpretation that arises with universal determiners or covert distributivity operators.

- According to Cable (2014), the meaning contribution of RNS is twofold.
  1. They signal **the existence of an entity in the denotation of a plural predicate** which is provided by the NP in their complement.
  2. They mark **the cardinality of the part(s)** of that entity participating **in every relevant part of a (plural) event** denoted by the sentence.
     * This is the **distributive-effect** associated with distributive numerals.
     * The distributive effect of RNS is not represented as a quantificational dependency relation à la Choe (1987), but as a relation between parts of individuals and parts of **events**.

The account in **Cable (2014)** relies on the **three special definitions** in (60)–(62).

[7] The disclaimer in Footnote 6 applies here, too.

(60) $\text{PARTICIPANT}(e,x) \stackrel{\text{def}}{=} x$ 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)

(61) 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 $\gamma \leq \alpha$ and $\delta \leq \beta$ ((53) in Cable 2014)

The binary σ-operator defined in (61-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 α, and δ is part of β.

(62) $Partition(e) = \{e' : e' \leq e\}$, such that

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

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

Partition maps an event e to a set of events e', such that every e' is part of e; moreover, the sum of all elements in the set equals e, and none of the events in the set overlap.

– 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).

With these three extra ingredients we can give the semantics of RNS as in (63).

(63) $[\![n-n]\!] = \lambda P \lambda V \lambda e \exists x[P(x) \wedge V(x)(e) \wedge \langle e,x\rangle = \sigma_{\langle e',x'\rangle}[x' \leq x \wedge |x'| = n \wedge e' \in Partition(e) \wedge \text{PARTICIPANT}(e',x')]]$ (based on (72) in Cable 2014)

N-N takes a predicate P and a predicate V, and returns a predicate over events. This predicate of events holds of an event e if there is an individual x such that P 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'.

– According to (63), **RN-expressions are interpreted as scopeless indefinites**, and the meaning contribution of RNS is as follows:

  ∗ 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.

Analyzing RNS as in (63), we can assign the following truth conditions for (55-a).

(64) $\exists e \exists x[\textsc{buy}(e) \wedge {}^{*}\textsc{doughnut}(x) \wedge \textsc{ag}(e) = \mathsf{a} \oplus \textsc{v} \wedge \textsc{th}(e) = x \wedge \langle e, x\rangle = \sigma_{\langle e', x'\rangle}[x' \leq x \wedge |x'| = 2 \wedge e' \in Partition(e) \wedge \textsc{participant}(e', x')]]$

There is a buying event *e* and plurality of doughnuts *x*, and the agent of *e* is Amelia and Valentina and the theme of *e* is *x*, and *x* can be divided up into pairs of doughnuts such that each of them participated in a contextually salient subevent of *e*.

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