Exploring the meaning of Hungarian reduplicated numerals

Kata Wohlmuth

Universitat Pompeu Fabra

katawohl@gmail.com

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What are Hungarian reduplicated numerals?

Reduplicated numerals 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

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

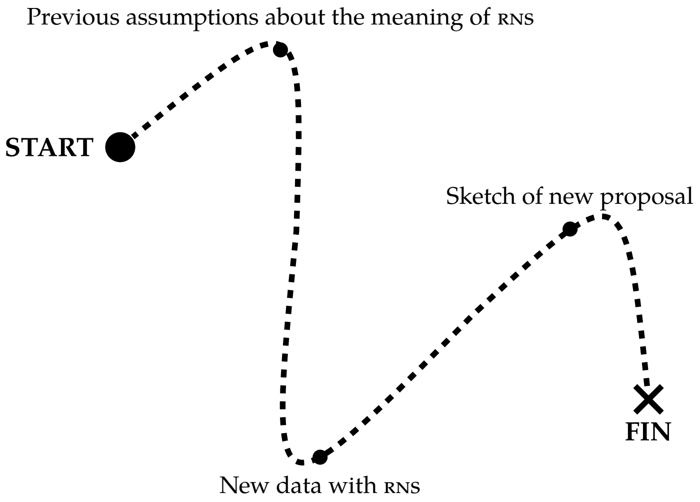
- The weirdness of (1b) is probably due a constraint on production, and is not grammatical in nature.

In this talk

Our central question is: **what is the semantic contribution of RNS** to the meaning of the sentences they occur in?

Glosses: 3 – third person; ACC – accusative case; ADJ – adjectivizer suffix;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 sketch of our road map



RNS as we know them

RNS and distributivity

Typical syntactic position of RNS: **prenominal modifier**; see (3).

(2) *Amélia és Valentina vett két fánk-ot.*
Amelia and Valentina buy.PST.3SG two doughnut-ACC
a. ‘Amelia and Valentina bought two doughnuts in total’
b. ‘Amelia and Valentina bought two doughnuts each’

(3) *Amélia és Valentina vett* ***két-két*** *fánk-ot.*
Amelia and Valentina buy.PST.3SG **two-two** doughnut-ACC
a. %‘Amelia and Valentina bought two doughnuts in total’
b. ‘Amelia and Valentina bought two doughnuts each’

Sentences with RNS are incompatible with cumulative interpretation; RNS **force a distributive interpretation** of the sentence they occur in.

Farkas (1997), Szabolcsi (2010), Csirmaz and Szabolcsi (2012), and Dékány and Csirmaz (2018), a.o.

The relational concept of distributivity (Choe 1987)

The distributive interpretation of a sentence involves **universal quantification**.

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

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

(4) a. The professors (each) bought two doughnuts.

b. | | | | |
|---|---|---|---|
| $\forall$ | KEY | $\exists$ | SHARE |
| | PROFESSOR | | TWO-DOUGHNUT |

Further characteristics of RNS – SHARE-marking

RNS can **only mark the SHARE** of the distributive relation.

(5) [*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'

Choe (1987), Zimmermann (2002), Gil (2013), and Cable (2014), a.o.

Further characteristics of RNS – Event distributivity

KEY from the domain other than individuals.

(6) 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 at least twice, 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**, whereas unmarked cardinals cannot.
* Event distributive interpretations with RNS are **only available if there is a salient plurality of events in the context**.

Gil (1982), Zimmermann (2002), Oh (2005), Balusu (2006), and Champollion (2016), a.o.

Previous semantic analyses for RNS

Based on data like (3) and (5)–(6), there are two types of analyses available for RNS.

1. Narrow-scope analyses
2. Scopeless analyses

Narrow-scope analyses

NPs modified by RNS are interpreted effectively as narrow-scope indefinites; i.e. the whole nominal is interpreted at a lower/embedded level.

Sentences with RNS are understood as in (7).

(7) 'For every element in the KEY there are *n* entities denoted by the noun the RN combines with' (where *n* corresponds to the numerical value expressed by the base cardinal of the RN).

Choe (1987), Farkas (1997), Farkas (2002), Zimmermann (2002), Oh (2005), Balusu (2006), Henderson (2012), Farkas (2015), and Champollion (2016), a.o.

Scopeless analyses

NPs modified by RNS are interpreted as scopeless plural indefinites; the distributivity effect associated with RNS is interpreted at a lower/embedded level.

Sentences with RNS are understood as (8).

(8) 'There is an entity in the denotation of the noun the RN combines with, 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' (where *n* corresponds to the numerical value expressed by the base cardinal of the RN).

Cable (2014), Kuhn (2017), and Wohlmuth (2019), a.o.

The common assumption of all previous analyses

The meaning contribution of RNS should be captured in terms of distributivity (i.e. as a relation between (sets of) entities, see Choe 1987).

New data with RNS

Uncharted syntactic distribution of RNS

Previous analyses only consider RNS in prenominal modifier position, but RNS can appear in constructions like (9).

(9) *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)

In (9), the cardinal/RN is in **predicate position**.

The meaning contribution of RNS in predicate position

(10) *A bicikli-k és a roller-ek szám-a kettő.*
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.’

(11) *A bicikli-k és a roller-ek szám-a* ***kettő-kettő****.*
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.’

In predicate position, RNS provide **the number of entities in different sets**.

Further examples – Simple plural subjects

(12) a. OUT OF THE BLUE

b. #*A bicikli-k szám-a* ***kettő-kettő***.

the bicycle-PL number-POSS.3SG **two-two**

(13) a. CONTEXT: Amelia works at a shop where bicycles and scooters are sold. She keeps a daily tally of the number of bicycles and scooters sold, sorted by color (she wants to know which color is the most popular). At the end of 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'

Further examples – RNS in prenominal modifier position

The interpretation observed in (11) is not tied to a specific syntactic position of the RN; see (14).

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

- The RN in (14) is in prenominal modifier position and it provides the cardinality of doughnuts in different sets.
- These sets are expressed by the conjoined adjective modifying the noun *fánk*, lit. 'doughnut'.

Problem for the previous analyses

The data in (11)–(14) show that the meaning contribution of RNS **cannot be fully captured in terms of distributivity**.

- The interpretation RNS does not necessarily involve a distributive relation in the sense of Choe (1987).
- Instead, **RNS seem to require that the entities to which they apply 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.

The Distributive Counting Hypothesis

The main idea

Here, I pursue the idea that **RNS are a special kind of numeral that 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 an entity (Landman 2003), RNS are unable to do that.
* Instead, **RNS provide the cardinality of parts of an entity**, where there are different, contextually salient properties, and **each of these properties apply to one of these parts**.

I call this approach to the meaning of RNS the **Distributive Counting Hypothesis** (henceforth: DCH).

Pluralities

Applying the theory of **mereology**, we can model the difference between singularities/atoms and pluralities as a structural property of entities (Link 1983).

* This structural property is based the reflexive, anti-symmetric and transitive **part-of** relation ($\leq$).

(15) $\textsc{at}(x) \leftrightarrow \neg\exists y[y \leq x \ \wedge \ y \neq x]$ Singularities/Atoms

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

Enriched 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** $\leq$.

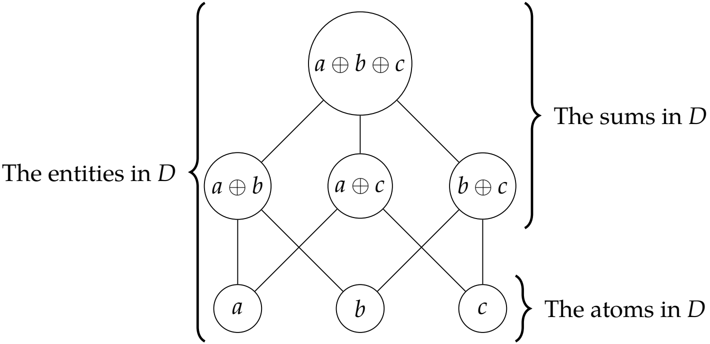
(17) a. $\forall x, y[x, y \in D_e \rightarrow x \oplus y \in D_e]$
b. $\forall e, e'[e, e' \in D_v \rightarrow e \oplus e' \in D_v]$
c. $\forall t, t'[t, t' \in D_t \rightarrow t \oplus t' \in D_t]$

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

Link (1983), Bach (1986), and Krifka (1989); a.o.

The structure of enriched domains

Figure 1: The semi lattice formed by the entities in D, where the atoms are a, b, c, represented as a Hasse-diagram.



Semantically singular predicates

Semantically singular predicates denote a set of entities atomic with respect to the property expressed by the predicate; see (19).

(19) 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)

Morphologically singular count nouns are typically semantically singular predicates.

Semantically plural predicates

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).

(20) $^*P$ 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)

- In the case of nominal predicates, semantic pluralization might correspond to the morphological plural marking on count nouns; see (21).

(21) a. $[\![\text{doughnut}]\!] = \lambda x[\textsc{doughnut}(x)]$

b. $[\![\text{doughnuts}]\!] = \lambda x[{}^*\textsc{doughnut}(x)]$

Complex properties

Complex properties are formed of properties with different senses that hold of entities cumulatively; see (22).

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

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

(22) can be observed at work in natural language in examples like (23).

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

Some relevant definitions

(24) $P \sqcup Q(x) \leftrightarrow \exists y, y'[y, y' \leq x \ \wedge \ P(y) \ \wedge \ Q(y')] \ \wedge \ \forall z[z < x \rightarrow \exists z'[z \leq z' \ \wedge \ z' \leq x \ \wedge \ P(z') \ \vee \ Q(z')]]$

A complex property $P \sqcup Q$ holds of an entity x iff both P and Q holds of some parts of x, and every proper part of x is part of some z', and z' is in P or Q.

(25) $P \sqcup P = P$

(26) $Q \sqsubset P \leftrightarrow Q \neq P \ \wedge \ Q \sqcup P = P$

Q is (a proper) part of P iff Q is different from P and the sum of Q and P is P.

The DC-analysis of RNS

RNS are analyzed effectively as a special kind of cardinal numerals (for the semantics of cardinals see Landman (2003) and Rothstein (2017)).

The semantics of RNS

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

A RN *n*-*n* holds of an entity x iff a contextually salient complex 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.

(28) $|x| = n \leftrightarrow |\{y : y \leq x \wedge \exists P[P(x) \wedge \text{AT}_P(y)]\}| = n$, where P is a simple property

The analysis of the new data

RN in predicate position (for now without a close syntactic analysis of constructions like (11)):

(29) a. *A bicikli-k és a roller-ek szám-a* ***kettő-kettő.*** = (11)
the bicycle-PL and the scooter-PL number-POSS.3SG **two-two**

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

- In (29b), C can be resolved as $^*\text{BICYCLE} \sqcup {}^*\text{SCOOTER}$.

The analysis of the new data II.

RN in predicate position with a simple plural subject:

(30) a. *A bicikli-k szám-a* ***kettő-kettő.*** = (12b)
the bicycle-PL number-POSS.3SG **two-two**

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

- (30a) will receive an interpretation only in contexts where C is resolved.
- According to the context in (13a), C can be resolved as $\text{COLOR}_1 \sqcup \text{COLOR}_2 \sqcup \ldots \sqcup \text{COLOR}_m$ (where m is the total number of colors).

The analysis of the new data III.

(31) a. *Amélia* ***négy-négy*** *csoki-s és lekvár-os fánk-ot vett.* = (14)
Amelia **four-four** chocolate-ADJ and jam-ADJ doughnut-ACC buy.PST.3SG

b. $\exists e \exists x[\text{BUY}(e) \wedge \text{AG}(e) = \text{a} \wedge \text{TH}(e) = x \wedge {}^{*}\text{DOUGHNUT}(x) \wedge {}^{*}\text{CHOC} \sqcup {}^{*}\text{JAM}(x) \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 4 \wedge Q(y)]]$

- In (31b), C is resolved as ${}^{*}\text{CHOC} \sqcup {}^{*}\text{JAM}$.

Distributive interpretation with RNS – Assumptions

RNS in sentences whose interpretation can be modeled in terms of distributivity are analyzed exactly like in (27).

* The distributive interpretation is a **byproduct** of the salient properties entailing the existence of entities.
* If an entity is 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; see (32).

(32) 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 AND
c. t_1 has the property of being the runtime of a walking event by Amelia

Distributive interpretation with RNS – Assumptions II.

If the event is associated with a plurality of entities, there might be a complex property that holds of the plurality, where this complex property is formed by properties corresponding to events associated with parts of the plurality; see (33).

(33) 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

(ii) Valentina has the property of being the agent of an event of buying a doughnut

Distributive interpretation with RNS – Analysis

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

b. $\exists e \exists x[\text{BUY}(e) \wedge \text{AG}(e) = \text{a} \oplus \text{v} \wedge \text{TH}(e) = x \wedge {}^*\text{DOUGHNUT}(x) \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 2 \wedge Q(y)]]$

- In (34b), C can be resolved as:
  - a complex property consisting of regular properties (i.e. the properties do not entail the existence of entities, like $^*\text{CHOC} \sqcup {}^*\text{JAM}$), or
  - as a complex property that consists of properties corresponding to an event description; see (35).

(35) a. $C = \text{BEING-BOUGHT-AT-}t_1 \sqcup \text{BEING-BOUGHT-AT-}t_2 \sqcup \ldots \sqcup \text{BEING-BOUGHT-AT-}t_m$

b. $C = \text{BEING-BOUGHT-BY-a} \sqcup \text{BEING-BOUGHT-BY-v}$

Distributive interpretation with RNS – Analysis II.

(36) a. *Amélia **két-két** fánk-ot vett.* $\approx$ (6)
Amelia **two-two** doughnut-ACC buy.PST.3SG

b. $\exists e \exists x[\textsc{buy}(e) \wedge \textsc{ag}(e) = \text{a} \wedge \textsc{th}(e) = x \wedge {}^{*}\textsc{doughnut}(x) \wedge C(x) \wedge \forall Q[Q \sqsubset C \rightarrow \exists y[y \leq x \wedge |y| = 2 \wedge Q(y)]]$

* In (36b), C can be resolved as in (34b), except for (35b).
  - C cannot be resolved as a complex property formed by properties holding of parts of Amelia.

Loose ends

NPs modified by RNS can occur in the (surface) scope of a universal determiner; see (37).

(37) *Minden professzor **két-két** fánk-ot vett.*
every professor **two-two** doughnut-ACC buy.PST.3SG
Every professor bought two-two doughnuts

- In these cases, the RN+NP can be interpreted as a narrow-scope indefinite.
- The DC-analysis cannot account for this interpretation (yet).

(38) $\forall x[\textsc{prof}(x) \rightarrow \exists e \exists y[\textsc{buy}(e) \wedge \textsc{ag}(e) = x \wedge {}^{*}\textsc{doughnut}(y) \wedge \textsc{th}(e) = y \wedge C(y) \wedge \forall Q[Q \sqsubset C \rightarrow \exists z[z \leq y \wedge |z| = 2 \wedge Q(z)]]]]$

Conclusions

Summary

In this talk, I argued

* that the meaning contribution of RNS cannot be fully captured in terms of distributivity (i.e. establishing a relation between (sets of) entities);
* rather, RNS provide the cardinality of entities in different sets.

The intuition about the meaning contribution of RNS (**Distributive Counting Hypothesis**) was formalized as the DC-analysis in (27) which can account for:

* the interpretation of sentences with RNS that can be modeled in terms of distributivity, and
* the interpretation of sentences with RNS that does not involve a relation between (sets of) entities.

Future directions

1. Numeral reduplication as a proper morphosyntactic operation.

Future directions (cont.)

2. Exploration of the syntactic distribution of RNS.
   - Unmarked cardinals and RNS in Hungarian cannot be used as predicates proper (see Rothstein 2015, 2017 on the predicate use of numerals).
   - RNS **can occur in measure constructions**.

(39) *Amélia két/**két-két** kiló fánk-ot vett.*
Amelia two/**two-two** kilogram doughnut-ACC buy.PST.3SG
Amelia bought two(-two) kilograms of doughnut

(40) *A sör-ök nyolc/**nyolc-nyolc** fok-os-ak.*
the beer-PL eight/**eight-eight** degree-ADJ-PL
The temperature of the beers is eight(-eight) degrees

   - RNS **cannot occur as proper names for numbers**.

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

(42) *A kettő/****kettő-kettő** páros szám.*
The two/**two-two** even number
'Two is an even number'

Zooming out

According to the DCH, **the semantic contribution of RNS is radically different than previously assumed**.

This raises many questions, two of which are:

1. Are there elements in other languages whose meaning contribution can be modeled similarly to that of RNS?
   - Most obvious suspects: distributive numerals (Gil 1982; Gil 2013)
2. How does (proper) distributivity relate to the interpretation arising with RNS?

Thank you!

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