Are adnominal and adverbial distributive numerals the same? Perspectives from Mandarin Chinese*

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1 Introduction

- **Distributive numerals** are morphosyntactic constructions containing a numeral whereby
  - the sentence as a whole receives a distributive reading, and
  - the numeral is interpreted as if within the scope of a distributive operator. (Cable 2014)
- Mandarin distributive numerals (NumNums): formed by reduplicating a numeral+classifier.

(1) Haizi-men **liang-ge.liang-ge-de** dao le.
child-PL two-CL.two-CL.DE arrive PERF
'The children arrived in twos/two by two.'

- NumNums come in two flavours, adnominal and adverbial, distinguished by
  - their word order with respect to the noun, and
  - orthographically distinct markers for adnominals and adverbials.

(2) a. Yanhua **liang-duo-liang-duo-de** zai kong-zhong zhanfang.
firework two-CL.two-CL-DE$_{adv}$ at sky-in explode
'The fireworks explode in twos/in groups of two/two by two.' *Adverbial*

b. **Liang-duo-liang-duo-de** yanhua zai kong-zhong zhanfang.
two-CL.two-CL-DE$_{adn}$ firework at sky-in explode
'The fireworks explode in twos/in groups of two/two by two.' *Adnominal*

- **Today's talk**: some novel data with the hope to shed light on the following questions:
  - How can we provide an adequate compositional analysis for NumNum?
  - Do adverbial and adnominal NumNums ever differ? If so, how?

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2 Basic properties & framework

2.1 *Basic properties of (adverbial) NumNum*

- NumNum is an event modifier that:
  - breaks the topical event down into non-overlapping subevents, and
  - distributes a plural target over these subevents.
- Not only must NumNum's target be plural, but it must also satisfy the classifier's restriction:

(3) Haizi-men liang-**ge**-liang-**ge**-de/*liang-**zhi**-liang-**zhi**-de dao le.
child-PL two-CL.two-CL-DE$_{adv}$/RED-two-CL-DE$_{adv}$ arrive PERF
'The children arrived two by two/in twos/in groups of two.'
→ *where* ge *is the general classifier and* zhi *is used for small, round and fluffy/cute things.*

- Ambiguity: NumNum can in principle target either the agent or the theme of the sentence.

(4) Haizi-men **liang-ge.liang-ge-de** chi-wan le huashendou
child-PL two-CL.two-CL-DE$_{adv}$ eat-finish PERF peanut
'The children ate the peanuts two by two.' (Donazzan & Müller 2014)
a. For each occasion/location, there is an event of two children eating peanuts.
b. For each occasion/location, there is an event of children eating two peanuts.

2.2 *Framework & Toy analysis*

- **The domain**: The domain of individuals D_e and the domain of events D_v are composed of singularities and pluralities (i.e, sums of singularities).
- These domains are closed under sum formation and they are partially ordered by a 'plural-part' relation ($\sqsubseteq_{\text{PL}}$), induced by the sum formation operation.

(5) a. $\forall x \forall y (x, y \in D_e \rightarrow x \oplus y \in D_e)$ b. $\forall e \forall e' (e, e' \in D_v \rightarrow e \oplus e' \in D_v)$

(6) $\forall x \forall y (x \sqsubseteq_{\text{PL}} y \leftrightarrow x \oplus y = y)$

(7) $x = \bigoplus P =_{\text{def}} \forall y (P(y) \rightarrow y \sqsubseteq_{\text{PL}} x) \wedge \forall z (z \sqsubseteq_{\text{PL}} x \rightarrow \exists z' (P(z') \wedge z \circ z'))$
'An entity x is the sum of a set of entities P if and only if everything in P is a plural-part of x and every plural-part of x overlaps with something in P.' (Champollion 2016)

- **Neo-Davidsonian syntax**: Verbs are predicates of events, and verbal arguments are stitched into sentences via thematic roles.

(8) $[\![\text{explode}]\!] = \lambda e_v .\, \text{explode}(e)$ (9) $[\![\text{TH}]\!] = \lambda x_e \lambda e_v .\, \text{th}(e) = x$

- **Lexical Cumulativity**: Verbs are cumulative, and so are thematic roles (Kratzer 2007):

(10) $^*P = \{x : P' \subseteq P[x = \oplus P']\}$

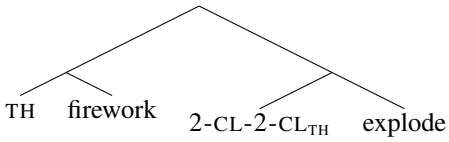
(11) a. $V(e_1) \wedge V(e_2) \rightarrow {}^*V(e_1 \oplus e_2)$
b. $\theta(e_1) = x_1 \wedge \theta(e_2) = x_2 \rightarrow {}^*\theta(e_1 \oplus e_2) = x_1 \oplus x_2$

(12) $[\![\text{explode}]\!] = \lambda e_v.\ *\text{explode}(e)$ (13) $[\![\text{TH}]\!] = \lambda x_e \lambda e_v.\ *\text{th}(e) = x$

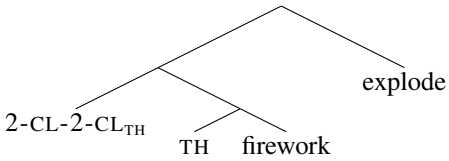
- **Theta-indexing**: We follow Champollion (2016) in assuming that distance distributive items target an NP via 'θ-indexing.' Nothing here hinges on this assumption.
- Toy analysis for NumNum & truth conditions of (2):

(14) $[\![\text{NumNum}_\theta]\!]^C = \lambda e : \text{CL-RESTRICTION}(\theta(e)).\ e \in *\lambda e'(|\theta(e')| = n \wedge C(e'))$
where C is a contextually given cover on e

(15) a.



b.

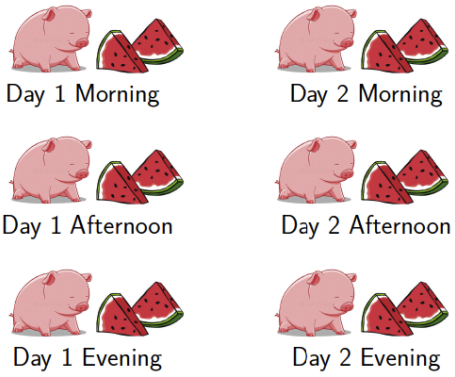


c. $\exists e(*\text{th}(e) = \bigoplus\text{firework} \wedge *\text{explode} \wedge e \in *\lambda e'(|*\text{th}(e')| = 2 \wedge C(e')))$

3 The Puzzle

- Adnominal and adverbial NumNums appear to be truth conditionally equivalent.
  - The data in (2a-b) seems to be in line with this idea.
  - We are not aware of any existing empirical observation against this.
- Here, we report novel observations regarding this matter. Specifically, differences between adnominal and adverbial NumNums can be observed in sentences with two NumNums.
- Consider the following scenario:

(16) *There was a two-day festival, with a total of 6 pigs and 12 pieces of watermelons.*



- There are two salient ways to break down the "topical event", i.e. the festival, into subevents:
  - By *day*: Agent = 3 pigs, Theme = 6 pieces of watermelon
  - By *meal*: Agent = 1 pig, Theme = 2 pieces of watermelon

- When using one adverbial NumNum:
  - Either of these two salient ways can be accessed: by *day* in (17), by *meal* in (18)
  - Our toy analysis can easily handle these cases by using different covers.

(17) a. Zhu **san-tou.san-tou-de** ba xigua chi-wan le.
pig three-CL.three-CL_{AG}-DE BA watermelon eat-finish PERF
'The pigs, three by three, ate up the watermelons.' (True)

b. $\exists e(*\text{ag}(e) = \bigoplus\text{pig} \wedge *\text{eat} \wedge *\text{th}(e) = \bigoplus\text{wtml} \wedge e \in *\lambda e'(|*\text{ag}(e')| = 3 \wedge \text{day}(e')))$

(18) a. Zhu ba xigua **liang-kuai.liang-kuai-de** chi-wan le.
pig BA watermelon two-CL.two-CL_{TH}-DE eat-finish PERF
'The pigs ate up the watermelons, two pieces at a time.' (True)

b. $\exists e(*\text{ag}(e) = \bigoplus\text{pig} \wedge *\text{eat} \wedge *\text{th}(e) = \bigoplus\text{wtml} \wedge e \in *\lambda e'(|*\text{th}(e')| = 3 \wedge \text{meal}(e')))$

- When using two adverbial NumNums:
  - Each NumNum can have its own way of decomposing the topical event.
  - However, the contrast between (19a) and (20a) suggests that the two adverbial NumNums must decompose the topical event in the same way. Our toy analysis in (20b) overgenerates!

(19) a. Zhu **yi-tou.yi-tou-de** ba xigua **liang-kuai.liang-kuai-de** chi-wan le.
pig RED.one-CL_{AG}-DE BA watermelon RED.two-CL_{TH}-DE eat-finish PERF
'The pigs, one by one, ate up the watermelons, two pieces at a time.' (True)

b. $\exists e(*\text{ag}(e) = \bigoplus\text{pig} \wedge *\text{eat} \wedge *\text{th}(e) = \bigoplus\text{wtml} \wedge e \in *\lambda e'(|*\text{ag}(e')| = 1 \wedge \text{meal}(e'))$
$\wedge\, e \in *\lambda e'(|*\text{th}(e')| = 3 \wedge \text{meal}(e')))$

(20) a. Zhu **san-tou.san-tou-de** ba xigua **liang-kuai.liang-kuai-de** chi-wan le.
pig RED.three-CL_{AG}-DE BA watermelon RED.two-CL_{TH}-DE eat-finish PERF
'The pigs, three by three, ate up the watermelons, two pieces at a time.' (False)

b. $\exists e(*\text{ag}(e) = \bigoplus\text{pig} \wedge *\text{eat} \wedge *\text{th}(e) = \bigoplus\text{wtml} \wedge e \in *\lambda e'(|*\text{ag}(e')| = 3 \wedge \text{day}(e'))$
$\wedge\, e \in *\lambda e'(|*\text{th}(e')| = 3 \wedge \text{meal}(e')))$

- The problem we face right now is the following:
  - NumNums are being treated as specifying the cardinality of individuals that participate in subevents of the topical event.
  - NumNums have their own partition, and thus each NumNum is independently responsible for decomposing the topical event into subevents,
  - This predicts that if a sentence contains two NumNums, they should be able to decompose the topical event in different ways, an unwelcome result.
- Note that the same problem is faced by the approaches developed in Balusu (2006) and Cable (2014).

▷ *Proposal #1*: Multiple NumNums must share the same cover.

- However, the problem is more complicated as soon as we start looking at data that involves one adnominal and one adverbial NumNum.
- When using one adnominal and one adverbial NumNum to describe the scenario in (16):
  - (20a) vs (21): the first NumNum is adverbial vs. adnominal.
  - Contrary to (20a), the two NumNums in (21) do *not* need to distribute over the same subevent.

(21) **San-tou.san-tou-de** zhu ba xigua **liang-kuai.liang-kuai-de** chi-wan le.
three-CL.three-CL_{AG}-DE pig BA watermelon two-CL.two-CL_{TH}-DE eat-finish PERF
'The pigs in threes ate up the watermelons, two pieces at a time.' (True)

- If we are to further entertain Proposal #1, we will need a more complex version of the story, namely something like the following:

(22) CONSTRAINT ON NUMNUM COVERS
The covers of adverbial NumNums have to match, but the covers of an adnominal and an adverbial NumNum don't.

- Issues with this proposal:
  - This constraint is descriptively accurate but not explanatory.
  - In fact, it's hard to see how such a constraint on NumNum's covers should be incorporated into the grammar.

4 Analysis

4.1 Sentences with two adverbial NumNums

- When two adverbial NumNums modify the same event, they have to break it down into subevents with the same *granularity*.
- Rather than assuming that this is achieved via a constraint on covers, we'll argue for the following:

▷ *Proposal #2*: NumNum breaks down the topical event into subevents that are singularities.

(23) $[\![\text{NumNum}_\theta]\!] = \lambda e.\, e \in {}^*\lambda e'(|\theta(e')| = n \wedge \text{SG}(e'))$

(24) $\forall e(\text{SG}(e) \leftrightarrow \neg\exists e'(e' \neq e \wedge e' \sqsubseteq_{\text{PL}} e))$

- Event singularities:
  - Nothing in definition in (24) implies that event singularities don't mereologically overlap.
  - This is so because it is based on the 'plural-part', rather than the mereological 'part-of', relation.
  - Thus, the event e' of John moving his right leg is a mereological part – but not a plural part – of the singular event e of John running.

- We propose that in the festival scenario sketched above, there are in fact 9 salient singular events: 6 meals, 2 days, and 1 festival.
- To the extent that certain nouns can denote predicate events, this assumption is supported by the fact that descriptions like *the meal* and *the day* refer to singular events that temporally overlap.[1]
- Accounting for the falsity of (20a), repeated in (25a):

(25) a. Zhu **san-tou.san-tou-de** ba xigua **liang-kuai.liang-kuai-de** chi-wan le.
pig RED.three-CL_{AG}-DE BA watermelon RED.two-CL_{TH}-DE eat-finish PERF
'The pigs, three by three, ate up the watermelons, two pieces at a time.' (False)

b. $\exists e(*\text{ag}(e) = \bigoplus \text{pig} \wedge *\text{eat}(e) \wedge *\text{th}(e) = \bigoplus \text{wtml}$
$\wedge e \in *\lambda e'(|*\text{ag}(e')| = 3 \wedge \text{SG}(e')) \wedge e \in *\lambda e'(|*\text{th}(e')| = 2 \wedge \text{SG}(e')))$

- The agent NumNum is true of the sum of the days, but the theme NumNum isn't:

(26) a. $\bigoplus\text{day} \in *\lambda e'(|\text{agent}(e')| = 3 \wedge \text{SG}(e'))$
b. $\bigoplus\text{day} \notin *\lambda e'(|\text{theme}(e')| = 2 \wedge \text{SG}(e'))$

- The theme NumNum is true of the sum of the meals, but the agent NumNum isn't:

(27) a. $\bigoplus\text{meal} \in *\lambda e'(|\text{theme}(e')| = 2 \wedge \text{SG}(e'))$
b. $\bigoplus\text{meal} \notin *\lambda e'(|\text{agent}(e')| = 3 \wedge \text{SG}(e'))$

- (25a) is false because there is no single witness to both NumNums.

4.2 Adnominal NumNums

- As it is, our analysis also predicts adnominal and adverbial NumNums to match, contrary to fact.
- A possible solution: give adnominal NumNums a different denotation from adverbial NumNums.
- However, we'd like to pursue a different route.
- Schein (1993), in a different context, suggested the following:
  - each conjunct of a neo-Davidsonian logical form is true of its own event argument, and
  - those events are then glued together by a relation of complete (mereological) overlap.
- Our take:

(28) a. The boys arrived.
b. $\exists e_1 \exists e_2(*\text{ag}(e_1) = \bigoplus \text{boy} \wedge *\text{run}(e_2) \wedge \text{O}(e_1, e_2))$

(29) $\text{O}(e_1, e_2) \Leftrightarrow \forall e(e \circ_{\text{m}} e_1 \leftrightarrow e \circ_{\text{m}} e_2)$

[1] Thanks to Roger Schwarzschild for discussing this matter with us.

- **The idea we'd like to advance**:
  - Adverbial and adnominal NumNums do have the same denotation.
  - Adverbial NumNums modify the event argument of the verb.
  - Adnominal NumNums modify the event of the thematic role of the nominal they adjoin.
- We can thus maintain a uniform semantics for NumNums, and explain away their different behaviours as a matter of where they attach in the structure.
- Truth conditions for a sentence with two adverbial NumNums:

(30) $\exists e_1 \exists e_2 \exists e_3 (*\text{ag}(e_1) = \bigoplus \text{pig} \wedge \text{O}(e_1, e_3) \wedge *\text{eat}(e_3) \wedge *\text{th}(e_2) = \bigoplus \text{wtml} \wedge \text{O}(e_2, e_3)$
$\wedge\, e_3 \in *\lambda e'_3(|*\text{ag}(e'_3)| = 3 \wedge \text{SG}(e'_1)) \wedge e_3 \in *\lambda e'_3(|*\text{th}(e'_3)| = 2 \wedge \text{SG}(e'_3))$

- Truth conditions for a sentence with one adverbial and one adnominal NumNum:

(31) $\exists e_1 \exists e_2 \exists e_3 (*\text{ag}(e_1) = \bigoplus \text{pig} \wedge \text{O}(e_1, e_3) \wedge *\text{eat}(e_3) \wedge *\text{th}(e_2) = \bigoplus \text{wtml} \wedge \text{O}(e_2, e_3)$
$\wedge\, e_1 \in *\lambda e'_1(|*\text{ag}(e'_1)| = 3 \wedge \text{SG}(e'_1)) \wedge e_3 \in *\lambda e'_3(|*\text{th}(e'_3)| = 2 \wedge \text{SG}(e'_3))$

5 More puzzles & future directions

- **Adnominal NumNum as a distributive operator** Our proposal as it is overgenerates:

(32) **Yi-tou.yi-tou-de** zhu ba xigua **liu-kuai.liu-kuai-de** chi-wan le.
one-CL.one-CL_{AG}-DE pig BA watermelon six-CL.six-CL_{TH}-DE eat-finish PERF
'The pigs one by one ate up the watermelons, six pieces at a time.' (False)

  - This data seems to suggest that adnominal NumNum can takes scope. But note that it's not obligatory.

- **NumNums & reciprocals** NumNum has an interesting interaction with reciprocals:

(33) Xuesheng-men **liang-ge.liang-ge-de** quxiao le bici.
student-PL two-CL-two-CL-DE mock PERF each.other
'The students mocked each other in twos.'

  - The sentence above is only true in scenarios in which NumNum breaks down the topical events into subevents with both an agent and a theme that has the cardinality of two.

- **NumNums & *wh*-indefinites** A *wh*-indefinite *ji* 'a few' can be used in NumNum:

(34) Xuesheng-men **ji-ge.ji-ge-de** yiqi zou le
student-PL few-CL-few-CL-DE together left PERF
'The students left, a few at a time.'

  - The cardinality of the participant that NumNum associates with in each subevent doesn't need to be identical, as long as it is a small number.

- **Adnominal vs. Adverbial NumNums crosslinguistically** We'd like to investigate whether the same data we discussed is attested in other languages with adnominal and adverbial NumNums.

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