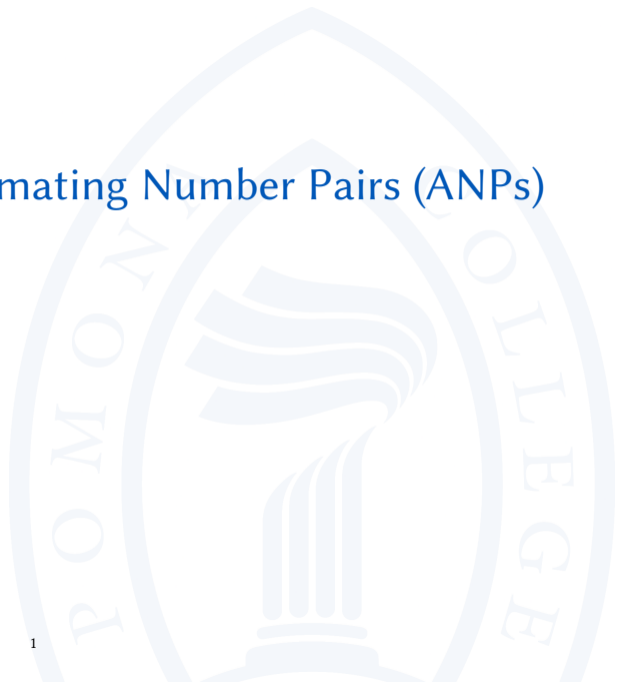


# The Grammar of Approximating Number Pairs (ANPs) in Mandarin Chinese

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## *Agenda:*

- What are approximating number pairs (ANPs)?
- Empirical features of Mandarin ANPs
- Structures of well-formed Mandarin ANPs
- Meaning of Mandarin ANPs

## *Approximating number pairs (ANPs)*

## Approximating number pairs

(1) There were **twenty or thirty** people in the hallway.

- Not the same as  $20 \vee 30$  or *between 20 and 30!*
- In Mandarin, expressions like 二三十 ‘twenty or thirty’, 六七百万 ‘six or seven million’ present similar effects.

### Definition

Approximating number pairs (ANPs) is a kind of range-approximation-like expression which takes a pair of numbers and **expresses a quantity close to the pair.**

Can we just add an ‘or’ between any two numbers and make them approximative?

## Approximating number pairs

Not all number pairs work!

(2) # He ate maybe **eleven or fifty** biscuits.

Natural questions: What are the rules? Why?

Empirical observations: **Are these well-formed ANPs?**

- six or seven hundred books
- twenty- or thirty-six cats
- thirty or forty-five biscuits
- eighty or seventy cat biscuits

**good!**

**trailing 'six' is ??**

**gap of 15 is ??**

**descending is ??**

## What's been said about ANPs

Pollmann and Jansen (1996) summarized the following rules about the construction of ANPs based on English, French, German and Dutch that worked on >90% tokens:

1. the two numbers must be in **ascending** order;
  2. the gap between them must be a **divisor** of both values;
  3. the gap must be a **so-called favored number**, being of the form  $\{1/2/2.5/5\} \times 10$ ;
  4. the gap must be at least **5%** of the second value.
- Mathematical characterization rather than grammatical
  - All in number-marking languages (Scontras, 2013) and not classifier languages

### Question of interest

What are the features of ANPs in Mandarin Chinese, an analytic, classifier language?

## ANPs have grammar

- Mathematically equivalent numbers do not necessarily produce the same meaning:
  - (3) a. ANPs have approximative effects:  
*There were **twenty or thirty** people.*
  - b. Sentential disjunctions do not have approximative effects:  
*There were twenty people or there were thirty people*

### Question of interest

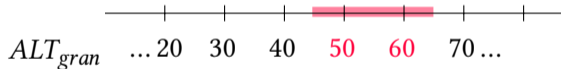
What is the grammatical structure of well-formed ANPs?

## Meanings of ANPs

“A quantity close to the pair” is vague...

Solt (2018): “*or* as a disjunction” and “the Ruler Model”. (Handout [16-17] & appendix 9.2)

“Fifty or sixty”  $gran = 10$  by “social convention”



$$\llbracket 50 \text{ or } 60 \rrbracket = \{ \text{numbers closer to 50 than any alternatives} \} \\ \cup \{ \text{numbers closer to 60 than any alternatives} \}^1$$

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<sup>1</sup>Informal notation, for demonstration purpose only

## Meanings of ANPs

- Justifications for how the unit *gran* is chosen?
- Conjunctions missing in many other languages
  - (4) ‘三四十, 八九万’

san-si-shi, ba-jiu-wan  
three-four-10, eight-nine-10<sup>4</sup>

Thirty or forty, eighty or ninety thousand

### Question of interest

What do ANPs mean and what are the formal denotations of them?

## Other approximative numeral expressions

ANPs are far from the only form of approximative numeral expressions!

(5) a. *Thousands* of people

b. 七百多

qi bai duo  
seven  $10^2$  DUO

More than 700 (e.g.  $747 \in \llbracket qi\ bai\ duo \rrbracket$ )

- Current analyses of ANPs are idiosyncratic to them and not connected with other approximative expressions.

### Question of interest

Do ANPs have grammatical commonalities with other approximative numeral expressions?

*Empirical features of Mandarin Chinese ANPs*

# Number system and the Numeral-Classifier-NP structure of Mandarin

(More details: handout [25-27])

Decimal counting system with additive and multiplicative numerals:

(6) 四千三百五十八

si qian san bai wu shi ba

4  $10^3$  3  $10^2$  5  $10$  8

four thousand three hundred and fifty-eight ( $4358 = 4 \times 10^3 + 3 \times 10^2 + 5 \times 10 + 8$ )

# Number system and the Numeral-Classifier-NP structure of Mandarin

Chinese: *Classifier language* (More details: handout [28-34])

- All nouns need **nominal classifiers!** e.g. 三滴水 ‘three drops of water’
- Nouns in these languages denote **kinds**, and nominal classifiers are **functions** that convert *kinds* to atomic predicates (Chierchia, 1998).
- Classifiers could also internally encode a quantity, which functions as a **multiplicand** like a base:

(7) 二十打鸡蛋

er-shi da jidan

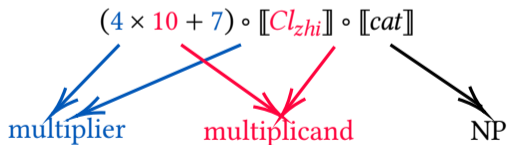
two-10 dozen egg

twenty dozens of eggs ( $2 \times 10 \times 12 = 240$  eggs!)

Table: Features of simple digits, bases and nominal classifiers in Mandarin

	simple digits	bases	nominal classifiers
Multiplier	√	×	×
Multiplicand	×	√	√
Type conversion	×	×	√

四十七只猫



## Base reduplication constraint

(More details: handout [35-38])

(8) 两三百只猫

liang-san-bai zhi mao  
two-three-10<sup>2</sup> CL cat

Two (hundred) or three hundred cats.

(9) \* 两百三百只猫

\*liang-bai san-bai zhi mao  
two-10<sup>2</sup> three-10<sup>2</sup> CL cat

Intended: Two (hundred) or three hundred cats.

## Base reduplication constraint

(10) 两百或三百只猫

liang-bai huo san-bai zhi mao  
two-10<sup>2</sup> or three-10<sup>2</sup> CL cat

(Precisely, either) two hundred or three hundred cats.

- No longer an ANP! Precise meaning instead, well-formed.

The two simple digits in ANPs need to be immediately concatenated without conjunctions.

### Definition

We henceforth call the concatenated simple numerals (e.g. 两三, 五六) **concatenated pairs**.

## Choice of simple numerals: the 1-increment rule

(More details: handout [39-40])

(11) \* 五四个人

\*wu-si ge ren  
five-four CL people

Intended: four or five people

(12) \* 五七个人

\*wu-qi ge ren  
five-seven CL people

Intended: (around) five or seven people

Has to be in the form of  $(n, n + 1)$  with order.

## The 'last summand' constraint

(More details: handout [41-44])

- (13) a. 一亿两三千万  
yi yi liang-san-qian wan  
one  $10^8$  two-three- $10^3$   $10^4$   
a hundred twenty or thirty million
- b. \* 两三百二十一  
\*liang-san-bai er-shi yi  
two-three- $10^2$  two-10 one  
\*two or three hundred twenty one

What makes the first a valid ANP and the second unnatural?

# The 'last summand' constraint

Let's do some math!

Recall the base-final multiplicative & additive number generation in Mandarin:

- Number in (13a):  $1 \times 10^8 + \llbracket(2, 3)\rrbracket \times 10^3 \times 10^4$
- Number in (13b):  $\ast \llbracket(2, 3)\rrbracket \times 10^2 + 2 \times 10^1 + 1 \times 10^0$
  
- Does not work if the concatenated pair is not on the **last summand** of the number.

*Structures of well-formed Mandarin ANPs*

## Hypothesis 1: no underlying disjunctions in ANPs

- The meanings of the ‘or’-inserted concatenated pair and the ‘or’-absent pair are contrastive, with only the ‘or’-absent pair having the approximative meaning.

(8) 两三百只猫

liang-san-bai zhi mao  
two-three-10<sup>2</sup> CL cat

Two (hundred) or three  
hundred cats.

(14) 两或三百只猫

liang huo san-bai zhi mao  
two or three-10<sup>2</sup> CL cat

(Precisely, either) two  
hundred or three hundred  
cats.

## Hypothesis 2: the concatenated pair is an inseparable constituent

- Reduplicating the numeral base would also force us into either syntactic anomaly or the precise disjunction; in fact, we cannot form valid ANPs whenever we try to separate the two simple digits in the number pair.

(14) 两或三百只猫

(Precisely, either) two  
hundred or three hundred  
cats.

(9) \* 两百三百只猫

Intended: Two (hundred) or  
three hundred cats.

- The only valid way to form an ANP is to have the two concatenated simple digits replace the position of a single numeral (i.e. two-10 → two-three-10).
- The concatenated pair functions like a single numeral that could further multiplicatively combine with bases to form the final ANP.

## *Semantics of Mandarin Chinese ANPs*

## Hypothesis 1: the range is independent from specific number

The multiplicands (bases or classifiers) are not approximative, so the approximative meaning is created by the concatenated pair.

By the 1-increment rule, for each  $n \in \{1, \dots, 9\}$ , the only concatenated pair it could form is  $(n, n + 1)$ .

- There is only one available size of the range of approximation by concatenated pairs.
- Denote this range as  $R_{cp}$ .

The precise numbers are converted into a range before multiplying with the multiplicands, so the range magnifies/shifts accordingly.

- 两百二十三十 ‘two hundred twenty or thirty’:  $\{2 \times 10^2 + (2 + r) \times 10 \mid r \in R_{cp}\}$

## Connections with other approximatives: example of *duo*

Luo (2018) observed the puzzle that constructions involving the particle *duo* exhibit different meanings when the particle attached before or after the classifier *bei* ‘cup’, as illustrated in (15):

(15) a. 二十多杯水

er shi duo bei shui  
two 10 (DUO) CL(cup) water

More than twenty cups of water (Between **20 and 30** cups of water)

b. 二十杯多水

er shi bei duo shui  
two 10 CL(cup) (DUO) water

More than twenty cups of water (Between **20 and 21** cups of water)

## Connections with other approximatives: example of *duo*

- Luo (2018): the *duo* particle (circled above) means a *subportion* and could only scope over the single unit-morpheme immediately preceding it. This implies that (15a) means 20 cups plus a *subportion* of 10 cups, while (15b) is 20 cups plus a *subportion* of one unit cup.
- The formulation for ANPs in this paper is compatible: we only need to substitute  $R_{cp}$  with the range of approximation of *duo*  $R_{duo} = [0, 1]$ .

## Hypothesis 2: Formal denotation

For formal derivation in lambda calculus, see handout [60-65].

For demonstration purposes, assume  $R_{cp} = [-\frac{1}{2}, 1\frac{1}{2}]$  by the Ruler Model<sup>2</sup>.

(16) 两百二十三十

liang bai er san shi  
two 10<sup>2</sup> two three 10

Two hundred twenty or thirty

“The quantity of the referent  $x$  is between  $2 \times 100 + (2 - \frac{1}{2}) \times 10 = 215$  and  $2 \times 100 + ((2 + 1) + \frac{1}{2}) \times 10 = 235$ .”

The referent  $x$  here needs to be countable, hence is usually Classifier+NP.

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<sup>2</sup>See appendix in handout for limitations of such assumption.

## To conclude

### Questions of interest

- What are the **features of ANPs** in Mandarin Chinese, an analytic, classifier language?
- What is the **grammatical structure** of well-formed ANPs?
- What do ANPs **mean** and what are the formal denotations of them?
- Do ANPs have grammatical **commonalities** with other approximative numeral expressions?

## To conclude

Where we started: (Handout (10))

Pollmann and Jansen (1996) on English, French, German & Dutch:

1. the two numbers must be in **ascending** order;
2. the gap between them must be a **divisor** of both values;
3. the gap must be a **so-called favored number**, being of the form  $\{1/2/2.5/5\} \times 10$ ;
4. the gap must be at least **5%** of the second value.

Surface forms derived are largely consistent to the statistical generalizations above!

- Underlying grammar for 2-3; consistency with the grammar of numerals in Chinese.
- Generalizations across other approximative expressions.

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## Paper & Handout



My senior thesis paper (long!)



The handout (print copies also available)