Two Kinds of Quantificational Domains: Mandarin *mei* with or without *dou*

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1 Introduction

A quick translation: *mei* → 'every', *dou* → 'all'
What is Mandarin *mei* ('every')?
- a determiner that always takes a Numeral-Classifier NP sequence: *mei* 1-ge xiaohai 'every child';
- must co-occur with an adverb *dou* 'all' unless there is an indefinite in the predicate (Huang 1995, 1996):

(1) a. mei 1-ge xiaohai *(dou) zao-le chuan.
MEI 1-CL child DOU build-PERF raft
'Every child did raft-building.'

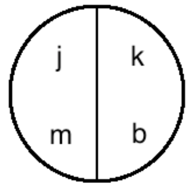
b. mei 1-ge xiaohai (dou) zao-le 1-sou chuan.
MEI 1-CL child DOU build-PERF 1-CL raft
'Every child built one raft.'

Tons of literature about *mei* 'every' and *dou* 'all':
- *mei* is a (distributive) quantifier, *dou* is a sum operator on events (Huang 1996) or *iota* operator exerting domain restriction (Giannakidou and Cheng 2006, Cheng 2009) or maximality operator (Xiang 2008) or pre-exhaustification exhaustifier (Xiang 2016) .
- *dou* is a generalized distributivity operator, *mei* is a sum operator on individuals (Lin 1998).
- both *mei* and *dou* are quantifiers and *mei* type-shifts to a distributive determiner when it co-occurs with *dou* (Luo 2011).

But today we focus on the following data:

(2) a. *mei* 2-CL[1] child built 1-CL raft
b. *mei* 2-CL child *dou* built 1-CL raft

Initial observation: under scenario 1, (3a) is true but (3b) is false!
- Scenario 1: There are four children John, Mary, Kim, and Bill in the context. John and Mary built a raft together. Bill and Kim built a raft together.



(3) a. mei 2-ge xiaohai zao-le 1-sou chuan.
MEI 2-CL child build-PERF 1-CL raft
'Every two children built one raft.'

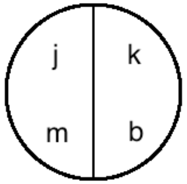
b. mei 2-ge xiaohai dou zao-le 1-sou chuan.
MEI 2-CL child DOU build-PERF 1-CL raft
'Every two children built one raft.'

- This is not predicted by previous analysis: Huang(1996) does not deal with the "2-CL child" case, according to her analysis, every possible pair of boys co-varies either with an event variable of 'build 1-CL raft' (3b) or with an indefinite '1-CL raft' but both would predict six events in total.

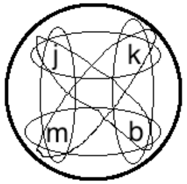
<u>Proposal:</u> Two kinds of quantificational domain - Partition vs. Exhaustive.

(4) a. *mei* 2-CL child built 1-CL raft (Partition)
b. *mei* 2-CL child *dou* built 1-CL raft (Exhaustive)

[1]An anonymous reviewer pointed out that in Huang and Jiang (2009), they argue '*mei*+num(⩾2)+CL' denotes an indeterminate domain, which is not compatible with the *iota* operator *dou* that expects a domain with stable elements. See Appendix A for some corpus as counterexamples.



4a.



4b.

Today's goal:
- Add several observations about the differences between (4a) and (4b).
- Propose a possible compositional analysis.
- Advantages and implications of the new proposal.

2 More observations

[1] Observation 1: *mei* with *dou* sentence requires the occurrence of more events than *mei* without *dou* sentence.

[Scenario] There are 4 children building rafts near the river, if (5a)/(5b):

(5) a. mei 2-ge xiaohai zao-le 1-sou chuan.
MEI 2-CL child build-PERF 1-CL raft
'Every two children built one raft.'

b. mei 2-ge xiaohai dou zao-le 1-sou chuan.
MEI 2-CL child DOU build-PERF 1-CL raft
'Every two children built one raft.'

Then, how many rafts were built in total?
Answer: (5a) → 2 rafts (two pairs); (5b) → 6 rafts (every possible pair)

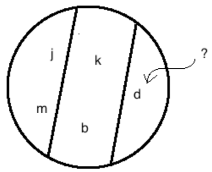
Observation 2: *mei* without *dou* sentence is sensitive to Divisible/Indivisible domain while *mei* with *dou* sentence is not.

[Scenario] There are 5 children who are going to build some rafts. Their teacher makes a command that (6a)/(6b):

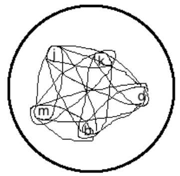
(6) a. mei 2-ge xiaohai zao 1-sou chuan.
MEI 2-CL child build 1-CL raft
'Every two children (should) build one raft.'

b. mei 2-ge xiaohai dou zao 1-sou chuan.
MEI 2-CL child DOU build 1-CL raft
'Every two children (should) build one raft.'

Then, whether the command can be carried out exactly as the teacher wants?
Answer:
(6a) → the command cannot be finished, what happens to the last child?
(6b) → the command can be finished (the domain allows overlapping covers)!



6a.



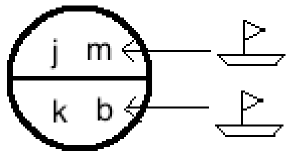
6b.

Observation 3: *mei*-with-*dou* sentence is not very compatible with average semantics.

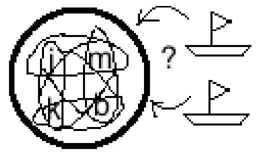
[Scenario] After a survey, we find that 4 children in total built 2 rafts in total.

(7) a. pingjun mei 2-ge xiaohai zao-le 1-sou chuan.
on.average MEI 2-CL child build-PERF 1-CL raft
'On average every two children built one raft.'

b. ??pingjun mei 2-ge xiaohai dou zao-le 1-sou chuan.
on.average MEI 2-CL child DOU build-PERF 1-CL raft
'On average every two children built one raft.'



7a.



7b.

[1]See Appendix B the results from a pilot study to test observations 1-3.

the sum of rafts to be divided by the sum of children: 2 rafts / 4 children = 1/2

The contrast is clearer if we say 'each child built 0.5 raft' under this scenario:

(8) a. pingjun mei 1-ge xiaohai zao-le 0.5-sou chuan.
on.average MEI 1-CL child build-PERF 0.5-CL raft
'On average each child built 0.5 raft.'

b. *pingjun mei 1-ge xiaohai dou zao-le 0.5-sou chuan.
on.average MEI 2-CL child DOU build-PERF 0.5-CL raft
'On average each child built 0.5 raft.'

- Partition domain captures the non-overlapping quantity of children in the context because it keeps track of different individuals → should be compatible with average meaning;
- Exhaustive domain allows overlapping covers → should not be that compatible!

Observation 4: *mei*-without-*dou* sentence emphasizes a semantics of ratio (a relation between two quantities) while *mei*-with-*dou* does not.

[Scenario] The Linguistics Department is discussing the policy for students' hosting tea:

(9) a. qunian, mei 2-ge xuesheng ban-le 1-ci Ling.xiawucha.
last.year MEI 2-CL student host-PERF 1-CL Ling.Tea
'Last year every two students hosted one LingTea.'
√That's too tiring! (The quantity of) hosting one Ling-tea is too much for (the quantity of) two students! We need more people per Tea.

b. qunian mei 2-ge xuesheng dou ban-le 1-ci Ling.xiawucha.
last.year MEI 2-CL student DOU host-PERF 1-CL Ling.Tea
'Last year every two students host one LingTea.'
#That's too tiring! (The quantity of) hosting one Ling-tea is too much for (the quantity of) two students! We need more people per Tea.

(9a) → emphasizes the information of a ratio!
(9b) → emphasizes the exhaustiveness of this situation!

Relevantly, only (9a) but not (9b) can be used to answer to a *how*-question like "How was the Lingtea usually hosted in your department last year? "

3 A compositional analysis

What we want to achieve:
mei without *dou* sentence distributes over a partition.
mei with *dou* sentence distributes over all the possible pairs.

A conceptual picture:

| selects two to construct an non-overlapping partition to distribute over |

(without *dou*)⇑

$[\![$mei 2-CL boy$]\!]$ = {a⊕b, a⊕c, a⊕d, b⊕c, b⊕d, c⊕d}

(with *dou*)⇓

| *dou* exhausts all the elements to distribute over |

The difference between partition and exhaustive domain:

(10) a. $[\![\text{dou VP}]\!] = \lambda Q.\ \forall z \in Q: [\![\text{VP}]\!](z)$ [1]

b. $[\![\emptyset\ \text{VP}]\!] = \lambda Q. \exists Y \in \wp_{NO}(Q). \forall z \in Y: [\![\text{VP}]\!](z)$ where $\wp_{NO}(Q)$ is a powerset of all the maximal non-overlapping subsets of Q.
For Q = {a⊕b, a⊕c, a⊕d, b⊕c, b⊕d, c⊕d},
one maximal non-overlapping subset would be:
√ {a⊕c, b⊕d} (which is a partition)
√ {a⊕d, b⊕c} (which is a partition)
× {a⊕c} (not maximal!)
× {a⊕c, a⊕d} (not non-overlapping!)
× {a⊕b, c⊕d, b⊕d} (not non-overlapping!)

How to make $[\![$mei 2-CL boy$]\!]$ denote {a⊕b, a⊕c, a⊕d, b⊕c, b⊕d, c⊕d}?
- One possible way is treat cardinals as modifiers (Ionin&Matushanksy 2006, Landman 2003):

(11) $[\![\text{2-CL}]\!] = \lambda P.\ \lambda x.\ \exists S\ [\Pi(S)(x) \wedge |S|=2 \wedge \forall s \in S\ P(s)]$.
$\Pi(S)(x) = 1$ iff S is a non-overlapping cover of a plural individual x, e.g. {a, b} is a non-overlapping cover S of a plural individual a⊕b.

[1] A recent paper (Xiang 2016) gives a uniform semantics to capture *dou*'s multiple uses as quantifier-distributor, free choice licenser, and the scalar marker: *dou* is a pre-exhaustification exhaustifier that operates on sub-alternatives. I consider our analysis here is compatible with it.

If there are 4 boys a, b, c, d in the domain:
$[\![\text{2-CL boy}]\!] = \lambda x.\ \exists S\ [\Pi(S)(x) \wedge |S|{=}2 \wedge \forall s{\in}S\ [\![\text{boy}]\!](s)]$
$\rightarrow \{a{\oplus}b, a{\oplus}c, a{\oplus}d, b{\oplus}c, b{\oplus}d, c{\oplus}d\}$

(12) a. $[\![(\exists)\text{2-CL boy}]\!] = \exists x\ \exists S\ [\Pi(S)(x) \wedge |S|{=}2 \wedge \forall s{\in}S\ [\![\text{boy}]\!](s)] \rightarrow a{\oplus}b$

b. *mei*'s distributive/universal strength is shown by blocking this existential closure and presupposing the input set is plural:
$[\![\text{mei}]\!] = \lambda P{:}|P|{\geqslant}2.\ P$
$[\![\text{mei 2-CL boy}]\!] = \lambda x.\ \exists S\ [\Pi(S)(x) \wedge |S|{=}2 \wedge \forall s{\in}S\ [\![\text{boy}]\!](s)]$ and this set contains at least 2 elements.
e.g. If there are only 2 boys in context, it is odd to say '*mei* 2-CL boy'!

Summary:
- Numerals (or NumP) can do more things than we thought!
- *mei* is not a quantifier only in terms of its ability to establish a subset relation between two sets → but I am not saying it is NOT distributive or universal!
- *dou* is a quantifier only in the sense that it can establish a subset relation between two sets → but I am not saying it is just simply a quantifier!

4 Potential advantages

Advantage 1: With a null operator ∅, it is possible to encode *mei*'s requirement for either *dou* or an indefinite here:
- the null operator, which relates to the semantics of a ratio (observation 4), is available only when there are two quantities in the sentence.

(13) a. $*[\![\text{MEI 2-CL boy}]\!]_{<e,t>} + [\![\text{arrived}]\!]_{<e,t>}$
→ ungrammatical because cannot composite!

b. $[\![\text{MEI 2-CL boy}]\!]_{<e,t>} + [\![\text{DOU build 1-CL raft}]\!]_{<et,t>}$
→ quantifier *dou* blocks the null operator and distributes over every possible pairs.

c. $[\![\text{MEI 2-CL boy}]\!]_{<e,t>} + [\![\emptyset_R \text{ built 1-CL raft}]\!]_{<et,t>}$
→ null operator $\emptyset_R$ is only available when there are two quantities.

Advantage 2: It explains that *mei* sometimes (when there is no perfective marker) can be freely omitted:

(14) (mei) 2-ge xiaohai zao 1-sou chuan.
MEI 2-CL child build 1-CL raft
'Every two children (should) build one raft.'

Advantage 3: The fact that Mandarin *mei* can modify an VP directly seems to be compatible with the analysis of *mei* as a modifier type <et, et>:

(15) a. wo (mei) xi 5-ge wan zheng 10-kuai qian.
I MEI wash 5-CL bowl earn 10-CL money
'Every *(time) I wash 5 bowls I earn 10 CNY.'

Advantage 4: *mei* in object place does not need *dou* or indefinites to license it because '*mei* 1-CL NP' in (16) might be able to become type e in object position (but not an option for '*mei* 2-CL NP' because semantically odd!)
- $[\![\text{mei 1-CL boy}]\!]$: $\{a, b, c, d\} \Rightarrow a{\oplus}b{\oplus}c{\oplus}d$ (type e)
- $[\![\text{mei 2-CL boy}]\!]$: $\{a{\oplus}b, a{\oplus}c, a{\oplus}d, b{\oplus}c, b{\oplus}d, c{\oplus}d\}$
$\Rightarrow a{\oplus}b{\oplus}a{\oplus}c{\oplus}a{\oplus}d{\oplus}b{\oplus}c{\oplus}b{\oplus}d{\oplus}c{\oplus}d$ (type e but an odd one!)

(16) a. wo xihuan mei 1-ge jiangzuo.
I like MEI 1-CL talk
'I like every talk (of the conference).'

b. *wo xihuan mei 2-ge jiangzuo.
I like MEI 2-CL talk
Lit.'I like every two talks (of the conference).'

5 Conclusions

In this talk:
◦ Establish a difference between '*mei* with/without *dou* by 4 observations.
◦ Propose a possible compositional analysis:

$[\![(\exists)\text{2-CL boy}]\!] = \exists x\ \exists S\ [\Pi(S)(x) \wedge |S|{=}2$
$[\![\text{mei}]\!] = \lambda P{:}|P|{\geqslant}2.\ P$

$[\![\text{mei 2-CL boy}]\!] = \lambda x.\ \exists S\ [\Pi(S)(x) \wedge |S|=2 \wedge \forall s \in S\ [\![\text{boy}]\!](s)]$ and this set contains at least 2 elements.

$[\![\text{dou VP}]\!] = \lambda Q.\ \forall z \in Q\text{: } [\![\text{VP}]\!](z)$

$[\![\emptyset_R \text{ VP}]\!] = \lambda Q. \exists Y \in \wp_{NO}(Q). \forall z \in Y\text{: } [\![\text{VP}]\!](z)$ where $\wp_{NO}(Q)$ is a powerset of all the maximal non-overlapping subsets of Q.

○ Such an analysis can:

→ explain such a difference between partition and exhaustive

→ explain why '*mei* 2-CL child' always needs *dou* or an indefinite in the predicate

Acknowledgments I am grateful to Karlos Arregi, Lucas Champollion, Itamar Francez, Anastasia Giannakidou, Chris Kennedy, Qiongpeng Luo, Line Mikkelsen, Xiang Ming, and the three anonymous *CLS* reviewers for their comments and feedback; and to Laura Casasanto and Geoff Brookshire for their help with experimental design and data analysis. Thanks also go to Huanqing Chen, Jackie Lai, Mengxiang Lin, Chang Liu, Anisia Popescu, Eszter Ronai, Amara Sankhagowit, Laura Stigliano, Michael Tabatowski, and Han Yang for their judgements and/or encouragement. Any inadequacies in this work are solely mine.

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Appendix A

Response to Huang&Jiang (2009, p305-306)[1]:

- For *mei* with *dou*, when the number ⩾2, is ungrammatical?

(17) *mei liang-ge xuesheng dou chi yi-kuai dangao.
MEI 2-CL student DOU eat 1-CL cake
Intended: 'Every two students eat one piece of cake.'

(18) *mei liang-ge xuesheng dou chi-le yi-kuai dangao.
MEI 2-CL boy DOU eat-PERF 1-CL cake
Intended: 'Every two students ate one piece of cake.'

√ Just pragmatic weirdness, but in some context like a Math problem set, we can find the following corpus [1]:

(19) mei 3-ge yuan dou wu gongtongdian.
MEI 3-CL circle DOU not.have common.point
'Every three circles don't have a common point.'

(20) mei liang-ge dian dou queding yi-tiao zhixian.
MEI 2-CL point DOU determine 1-CL line
'Every two points determine one line.'

√ With perfective marker it is still grammatical! (See Niu&Pan (2015, p15)):

(21) mei san-ge ren dou he-le yi-ping jiu.
MEI 3-CL man DOU drink-PERF 1-CL wine
'Every three men drank one bottle of wine'

Appendix B: Results from a pilot study

<u>Observation 1</u>: *mei* with *dou* sentence requires the occurrence of more events than *mei* without *dou* sentence

► Exp1:

There are 4 boys a, b,c, d building castles on the beach.
Scenario P(partition): a and b built a castle, c and d built a castle.
Scenario E(exhaustive): a and b, a and c, a and d, b and c, b and d, c and d, all possible pairs each built a castle.
Sentence O(without *dou*): *mei* 2-boy built 1-castle. (每两个男孩造了一个城堡)

[1]Thanks to an anonymous reviewer who brought up this proceeding paper to me.

[1]https://www.nowcoder.com/questionTerminal/a8656f58e89f4d0aa6b62a550ce2b2aa?toCommentId=332792

Sentence W(with *dou*): *mei* 2-boy *dou* built 1-castle. (每两个男孩都造了一个城堡)
→ Question: Whether the sentence is true under this scenario?

Predictions for Exp1:

	Scenario P	Scenario E
Sentence without *dou*	True	True(but pragmatically bad)
Sentence with *dou*	False	True

Results for Exp1(Mean ratio of 'True' response):

	P	E
without *dou*	53.3%	37.8%
with *dou*	38.3%	65%

- The effect of P/E is not quite (but almost) significant for sentence with *dou*: F(1, 28) = 4.167, p = 0. 05073.
- For sentence without *dou* there is no significant effect: F(1, 28) = 1.559, p = 0.2221.

Observation 2: *mei* without *dou* sentence is sensitive to Divisible/Indivisible domain while *mei* with *dou* sentence is not.

▶ Exp2:

Scenario D (divisible): There are 7 carpenters doing work together. Their master makes a command that [O/W].
Scenario I (indivisible): There are 6 carpenters doing work together. Their master makes a command that [O/W].
Command O (without *dou*): *mei* 2-carpenter make 1-desk. (每两个木匠做一个桌子)
Command W (with *dou*): *mei* 2-carpenter *dou* make 1-desk. (每两个木匠都做一个桌子)
→ Question: Whether the Command can be carried out exactly under this Scenario (not considering other factors)?

Predictions for Exp2:

	Scenario D	Scenario I
Command without *dou*	Yes	No
Command with *dou*	Yes	Yes

Results for Exp2(Mean ratio of 'Yes' response):

	D	I
without *dou*	90%	68.3%
with *dou*	75%	73.3%

- Significant difference between D and I for sentence without *dou*: F(1, 28) = 4.568, p = 0.04146 < 0.05.
- No significant difference for sentence with *dou*: F(1, 28) = 0.01989, p = 0.8889.

Observation 3: *mei*-with-*dou* sentence is not very compatible with average semantics.

▶ Exp3:

Scenario A(average): 12 students in class own 6 phones in total.
Sentence O: On average *mei* 2-student own 1-phone. (平均每两个学生拥有一部手机)
Sentence W: On average *mei* 2-student *dou* own 1-phone. (平均每两个学生都拥有一部手机)
→ Question: Whether the sentence is true under this Scenario?

Predictions for Exp3:

	Scenario A
Sentence without *dou*	True
Sentence with *dou*	False

Results for Exp3 (Mean ratio of 'True' response):

	A
without *dou*	71.7%
with *dou*	64.2%

- The difference is actually not significant: F(1, 58) = 0.6374, p = 0.4279 → should ask acceptability rather than truth-value judgment!