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

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1   Introduction

Huang (1996) observed[1] that the seemingly Mandarin lexical counterparts of English universal quantifiers: *mei* (syntactically as a determiner) and *dou* (syntactically as an adverb), behave very differently from *every* and *all*. When there is no indefinite phrase in the predicate, *mei* obligatorily co-occurs with *dou*, as in (1a)[2]; when there is an indefinite phrase like *yi shou ge* 'a/one song' in the predicate, Mandarin *mei* optionally co-occurs with *dou* (1b). This is puzzling since in English *every* and *all* can never co-occur (1c).

(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.'

       c.   *Every child all did raft-building/built one raft.

Based on this distribution, previous studies debate on whether *mei* or *dou* is the quantifier because according to the Bijection Principle (Koopman & Sportiche 1982) there cannot be two operators binding the same variable. Some representative views include: (i) *mei* is a (distributive) quantifier, *dou* is not a quantifier but a sum operator on events (Huang 1996) or *iota* operator exerting domain restriction (Giannakidou & Cheng 2006, Cheng 2009) or maximality operator (Xiang 2008) or pre-exhaustification exhaustifier (Xiang 2016); (ii) *dou* is a generalized distributivity operator, *mei* is a sum operator on individuals (Lin & Landman 1998); (iii) both *mei* and *dou* are quantifiers and *mei* type-shifts to a distributive determiner when it co-occurs with *dou* (Luo 2011).

This paper looks at some new data, which is an extension of Huang's observation to cases where the numeral following *mei* is larger than one (e.g. two); and I consider it sheds light on our understanding about *mei* and *dou*. The initial observation is that under scenario 1 in (2), only (2a) but not (2b) is true, while both of them are grammatical.

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[1] Huang (1996) was reprinted as Huang (2005) but in this paper to save space I only cite the earlier version.

[2] The notations in this paper: CL=classifier, PERF=perfective, num=numeral.

(2) [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.

    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 contrast is not discussed in most of the previous analyses of *mei* and *dou* and although Huang (1996) did consider *mei*-sentences with or without *dou* are different, this truth-conditional difference between (2a) and (2b) is not predicted from her analysis, as I will show later.

The paper is organized as follows. In the next section I discuss in detail why Huang (1996)'s analysis failed to predict the new data and also give some responses to the judgments of the new data [3]. In Section 3 I propose that the crucial difference between (2a) and (2b), or more generally *mei*-sentence without and with *dou*, is about how their quantificational domains are built and give more empirical observations to establish the difference. In Section 4 I give the compositional analysis for the two kinds of quantificational domains and discuss how the analysis sheds light on the long-term debate about *mei* and *dou*. Section 5 discusses some potential advantages following from the current analysis. Section 6 concludes.

2 Previous accounts
2.1 Huang (1996)'s analysis revisited

Huang(1996) proposed that *mei* is a distributive universal quantifier EVERY that is always associated with a skolem function, which requires morphologically/lexically licensed variables in the scope. Either indefinite phrases or *dou* introduce variables to license the skolem function [4]. As in (3-4), her analysis will predict, when *mei* occurs without *dou* like in (2a), every possible pair of children co-varies with an indefinite 'one raft; when *mei* co-occurs with *dou* like in (2b), both the indefinite variable and an event variable of building one raft are available, so every possible pair of boys can co-vary with either.

(3) 'EVERY(P, f(P)) is true iff for every P'⊂P, P' is a subset of f(P'), where f(P) is constructed from P by a total skolem function.'

                                                                 Huang (1996: 25)

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[3] An anonymous reviewer pointed out that Huang and Jiang (2009) argue '*mei*+num+CL' denotes an indeterminate domain when the numeral (num) is equal to or larger than 2, which is not compatible with the *iota* operator *dou* that expects a domain with stable elements. I will give some corpus as counterexamples in section 2.

[4] According to Huang (1996: 2) "A skolem function links two variables by making the choice of a value for one variable depend on the choice of a value for the other". In this paper when we say X co-varies with Y we mean the choice of a value of Y depends on the choice of a value for X.

(4) '{x: DOU Pred(x)} = {x: AT^5((Pred(x,e)) and DOU(e, Pred)} where DOU(e, Pred) is true iff e is an event of minimum size consistent with the semantics of Pred.'

<div align="right">Huang (1996: 39)</div>

Since both of the two co-variations will entail 6 events occur (or 6 rafts are built) in total, with 4 children in the context for instance (thus making 6 possible pair), it fails to explain the observation in (2). A potential way to defend the account is to apply an implicit domain restriction so that the quantificational domain does not need to contain every possible pair, but rather two non-overlapping pairs of children (e.g. John and Mary, Bill and Kim). In this way it may explain why (2a) is possible under the scenario but why (2b) is never possible under it remains a mystery: in principle nothing should prohibit such a domain restriction.

2.2 Response to judgment issues

Huang & Jiang (2009) considers '*mei* + num + CL + NP' constructions are ungrammatical with *dou* when the numeral in it is larger than one. The reason, according to them, is that the quantificational domain of '*mei* 2 CL NP' is indeterminate, i.e. what exact pairs in the domain are not decided, which is incompatible with the *iota* operator *dou* (Cheng 2009) that requires a set of stable elements. However, is the data they gave as in (5) and (6), or my example (2b) truly ungrammatical? I argue those sentences, if less acceptable, are only due to pragmatic reasons[6]. As I will point out later, the quantificational domain of '*mei* 2 CL student', when with *dou*, must include every possible combination of two students, which is not common for daily life scenarios.

(5) 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.'

(6) 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.'

<div align="right">Huang&Jiang (2009: 305-306)</div>

To minimize such pragmatic interference, imagine the sentences (5, 6) are uttered as part of the instruction for a mathematical problem set, and followed by a question 'Then how many cakes did they eat in total?'; then they sound much more natural. That's also why much corpus that is found online is about mathematics (7, 8):

(7) 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.'
    (https://zhidao.baidu.com/question/1382981072038513180.html)

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[5] 'AT' is a function stipulated to introduce event variables.

[6] It should be also noticed that all the native speakers I consulted (including myself) consider those claimed ungrammatical sentences are good

(8) mei liang-ge dian dou queding yi-tiao zhixian.
MEI 2-CL point DOU determine 1-CL line

'Every two points determine one line.'
(www.nowcoder.com/questionTerminal/a8656f58e89f4d0aa6b62a550ce2b2aa?toCommentId=332792)

In some other literature (Niu & Pan 2015) we can also find sentence like (9) is judged to be grammatical, even with perfective marker thus clearly episodic. So we think Huang & Jiang (2009)'s judgments about '*mei* 2 CL NP' construction with *dou* and with episodic marker (perfective *le*) need to be re-considered.

(9) 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'   Niu&Pan (2015: 15)

3   The new proposal and more empirical evidence
3.1   New proposal: Two kinds of quantificational domains

Different from Huang's original analysis that *mei* is a generalized universal quantifier plus a skolem function, I propose that in Mandarin the canonical universal quantification is realized by *mei* plus *dou* (so neither of them are true quantifiers like English *every*), and the *mei* sentences without *dou* should be distinguished from the canonical universal quantification in terms of how their quantificational domains are built: as simplified and summarized in (10), structure A's domain is characterized by what I call *one-time partition* (henceforth *Partition*) which means if there are 4 boys in the context, they are divided by the num(assume num is 2 here) into two groups, each group relates to an occurrence of the event "build 1-CL castle"; structure B's domain is characterized by *exhaustive cover building* (henceforth *Exhaustive*), which means if there are 4 boys in the context, all the possible pairs are built to be quantified over and each pair as a cover relates to an occurrence of the event.

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

A visualization of the differences between two ways of building quantificational domains can be illustrated in Fig. 1.
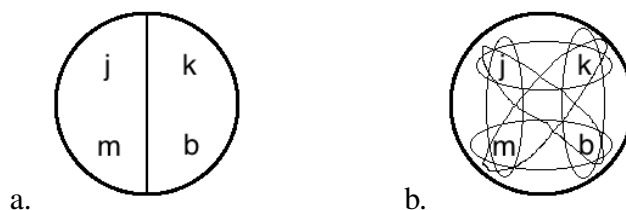

Figure 1: Visualization of *partition*(a.) and *exhaustive*(b.) quantificational domains

To establish the claimed difference between the *mei*-sentence without or with *dou*, I will give four empirical observations in Section 3.2.

3.2 Empirical evidence

Since the speaker judgments of *mei* and *dou* seem to vary a little, it should be noted that the four empirical observations in this section initially come from the author's introspective data; but the first two of them are strengthened by the experimental data of a pilot study, which is not the focus of this paper but can be referred to in Appendix.

3.2.1 Observation 1: *mei*-with-*dou* sentence requires the occurrence of more events than *mei* without *dou* sentence

This observation is an elaboration on the initial contrast we discussed in section 1: in (11) under Scenario 2, if we ask the question 'Then, how many rafts were built in total?' following the utterance of (11a) or (11b) respectively, then for the former the answer is intuitively '2 rafts' (two pairs) while for the latter the answer would be '6 rafts' (every possible pair).

(11) [Scenario 2] There are 4 children building rafts near the river, if (11a)/(11b):

    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.'

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

The second contrast between the two constructions is that, when it is known that there are 5 children in the context, as in Scenario 3 in (12), and someone makes a command using either (12a) or (12b). Then if the question 'Then, whether the command can be carried out exactly as the teacher wants?' is asked, native speakers intuitively consider (12a) impossible to be finished and wonder, 'what happens to the last child?' But (12b) would be considered possible to be finished.

(12) [Scenario 3] There are 5 children who are going to build some rafts. Their teacher makes a command that (12a)/(12b):

    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.'

This can be explained by our proposal that, since the *mei*-sentence with *dou* allows overlapping in the quantificational domain, it is not sensitive to the divisibility of the domain (i.e. whether the sum of boys as 5 is divisible by the numeral appearing after *mei*). Fig. 2 shows a visualization of why *partition* and *exhaustive* domains are different in sensitivity to the indivisible domain.
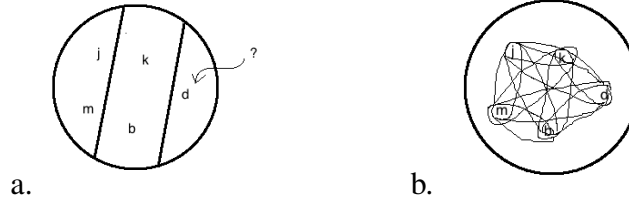
Figure 2: Visualization of *partition*(a.) and *exhaustive*(b.) quantificational domains

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

The motivation to take into account average sentence comes from the observation from English that the universal quantifiers like *every* seems not very compatible with average semantics (13).

(13) a. ??Every family has an average of 2.3 children.
      b. ??Every family has on average 2.3 children.

As in Kennedy & Stanley (2009), the more natural way to express the average meaning is to use indefinite subject as in (14).

(14) American families have on average/an average of 2.3 children.

What's interesting in Mandarin is that, to express the average meaning in Scenario 4 as in (15), *mei* can be quite naturally uttered together with the adverbial phrase (15a); while adding *dou* leads to ungrammatically (15b).

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

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

The contrast is clearer if we describe this same situation with an alternative 'the children built 0.5 raft on average' in Mandarin:

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

The contrast in (15, 16) indicates *mei*-sentences with or without *dou* are quite different constructions. It is not too surprising under the current proposal that Partition but not Exhaustive domain is compatible with average semantics, given the average meaning is basically calculated by 'the sum of rafts to be divided by the sum of children' (i.e. 2 rafts / 4 children = 0.5). As visualized in Fig. 3, the partition case captures the non-overlapping quantity of children in the context crucially by keeping track of different individuals, which should be compatible with average semantics. In contrast, the exhaustive domain allows overlapping covers and fails to capture the non-overlapping quantity of children, which might not be that compatible with average semantics.
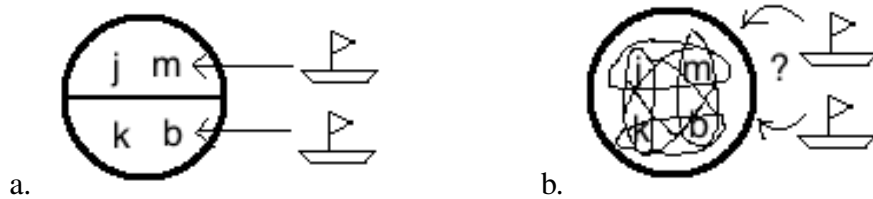

Figure 3: Visualization of *partition*(a.) and *exhaustive*(b.) quantificational domains under average semantics

Obviously more should be said on how the composition of universal quantifiers and the average operator fails exactly in semantics, but it is another question that I leave open for future research. What is important here is our proposal of Partition/Exhaustive difference of *mei* with/without *dou* seems to be on the right track.

3.2.4 Observation 4: *mei*-without-*dou* sentence emphasizes a meaning of ratio (a relation between two quantities)

The last observation is a pragmatic confirmation of the existence of ratio information in *mei*-without-*dou* constructions, which is absent in *mei*-with-*dou* ones. When under a scenario that two professors are discussing the policy of students' taking turns to host the afternoon tea for the department, it is perfect to continue (17a) with a complaint like (17c), which basically comments on the ratio of '2 students per Tea'. However, it is not possible to comment (17b), when *mei* and *dou* co-occur there, with (17c): the impression that (17b) leaves us is simply the students in the department all know each other very well (so that every two can form a pair to work together) and they really hosted a lot of teas last year! In other words, while (17a) emphasizes the information of a ratio, (17b) emphasizes the exhaustiveness of this situation!

(17) 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.'

      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.'

      c. 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.

Relevantly, only (17a) but not (17b) can be used to answer to a *how*-question like 'How was the afternoon teas hosted in your department last year?'. The reason might be, in order to provide information about the manner of hosting tea (for a *how*-question), it is suitable to include the ratio information since ratio is a generalization over the situation.

4 A compositional analysis

The four observations in Section 3 confirm the claimed *Partition/exhaustive* difference between *mei*-sentences with or without *dou*. In this section, I illustrate how such a difference can be captured in a compositional analysis.

Before going into technical details I present a conceptual picture in Fig. 4 to outline what must be achieved in the potential analysis: with four boys in the context, *mei* without *dou* sentence distributes over a partition; *mei* with *dou* sentence distributes over all the possible pairs.
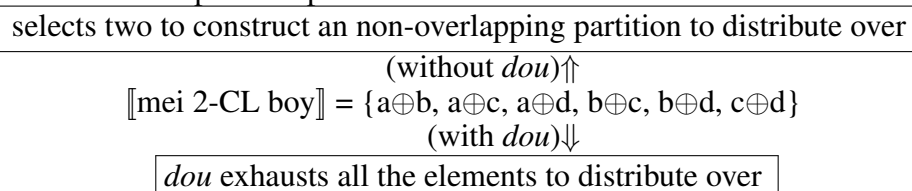
selects two to construct an non-overlapping partition to distribute over

(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

Figure 4: The conceptual picture of a potential analysis

To make '*mei* 2-CL boy' denote the set {a⊕b, a⊕c, a⊕d, b⊕c, b⊕d, c⊕d} in a context of four boys (a, b, c, d), I analyze cardinals as modifiers (Ionin & Matushansky 2006, Landman 2003) and ignore the contribution of classifiers for count nouns here. (18) means the cardinal '2(-CL)' takes a predicate and a contextually determined Cover to restrict the set denoted by the predicate, and yields a set of all pairs ('x' is a plural individual) of contextually relevant boys as output.

(18) ⟦2-CL⟧= λP. λC. λx.[$\forall$y$\leq$x. P(y) $\wedge$ C(y) $\wedge$ |x|=2]

Note it is also possible to apply the domain restriction to the plural individual, as in (19), rather than the singular atom of the plural individual. However with (19) it is a function that takes a predicate and a cover and yields a set of contextually relevant pairs of boys. This is not we want since in a context of four boys, '2-CL boy' under (19) might yield a set like {a⊕b, a⊕d, b⊕c}, which is too loose for our purpose.

(19) ⟦2-CL⟧= λP. λC. λx.[$\forall$y$\leq$x. P(y) $\wedge$ C(x) $\wedge$ |x|=2] (Too loose)

Some might wonder, if *2-CL boy* is already treated as a set of all possible pairs, then, what is *mei* contributing here? Does that mean it has no distributive/universal force at all, which would be a striking conclusion in terms of all the previous accounts. The answer is *no*! Within our system, any number expressions have two fates, either to go through an existential closure to become a referential expression (type *e*) or to maintain its property as a variable (20a, b). With *mei*'s existence, whose semantics is defined in (20b) , the number expression cannot go through existential closure any more. What's more, *mei* also adds the presupposition that there are at least two units of boys, the unit being defined by the number in the number

expression following *mei*. The intuition is that when people say '*mei* 2-CL boy...', it presupposes there are at least three boys in the context.

(20)   a.   ⟦(∃)2-CL boy⟧ = ∃x. ∀y≤x. BOY(y) ∧ C(y) ∧ |x|=2 → a⊕b

      b.   *mei*'s <u>distributive/universal strength</u> is shown by blocking this existential closure and presupposing the input set is plural:
⟦mei⟧ = λP: |P| ≥ 2. P
⟦mei 2-CL boy⟧ = λx.[∀y≤x. P(y) ∧ C(y) ∧ |x|=2] 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'!

The competition between *mei* and existential closure is not an *ad hoc* assumption since it can be supported by the following facts. It is well-known that Chinese does not allow an indefinite subject but requires an existential quantifier *you* 'have' to make it acceptable (21). Li (2014) raises an explanation that the existential closure in Chinese is as low as VP (Tsai 1994) so that it has the object within its scope but not the subject. Our analysis that '*mei*' blocks the existential closure correctly predicts (22).

(21)   a.   *(you) liang-ge nanhai lai-le.
          have   2-CL   boy   come-PERF

          'Two boys came.'

      b.   wo yudao-le   liang-ge nanhai.
          I   meet-PERF 2-CL   boy

          'I met two boys.'

(22)   a.   *mei liang-ge nanhai lai-le.
          MEI 2-CL   boy   come-PERF

      b.   *you mei liang-ge nanhai lai-le.
          have MEI 2-CL   boy   come-PERF

      c.   *wo yudao-le   mei liang-ge nanhai.
          I   meet-PERF MEI 2-CL   boy

Secondly, I treat *dou* as a universal quantifier in a canonical GQT (Generalized Quantifier Theory, Barwise & Cooper 1981) way (23). Since it is an adverb that combines with VP first, it is the set denoted by the first argument it takes that entails the set denoted by the second argument.

(23)   ⟦dou⟧ = λP.λQ. Q ⊆ P
⟦dou built 1-CL raft⟧
= ⟦dou⟧ (⟦built 1-CL raft⟧)
= λQ. Q ⊆ λz. [∃x. BUILD(z, x) ∧ ∀y≤x. RAFT(y) ∧ C(y) ∧ |x|=1]

The full composition of a *mei*-with-*dou* sentence (24) is given in (25). It means for every possible pair of boys, that pair built a raft, which is what we intend.

(24)   mei liang-ge nanhai dou   zao-le   yi-zhi   fazi.
      MEI two-CL boy   DOU build-PERF one-CL raft

      'Every two boys built a raft.'

(25) ⟦mei liang-ge nanhai dou zao-le yi-zhi fazi⟧
= ⟦dou⟧ (⟦zao-le yi-zhi raft⟧) (⟦mei liang-ge nanhai⟧)
= ⟦dou⟧ (⟦built 1-CL raft⟧) (⟦mei 2-CL boy⟧)
= $[\lambda x.\ [\forall y \leq x.\ BOY(y) \wedge C(y) \wedge |x|=2]] \subseteq [\lambda z.\ [\exists k.\ BUILD(z, k) \wedge \forall s \leq k.\ RAFT(s) \wedge C(s) \wedge |k|=1]]$

Now I turn to the trickier *mei*-without-*dou* sentence (26). As mentioned above (22), the phrase 'mei Num-CL NP' is ungrammatical as a subject since 'mei' blocks the existential closure (27). Now I argue the grammaticality of (26) is due to a covert ratio operator '∅' (in a place similar to the adverb 'dou' in (24)) that is available only when there is some number expression in VP. The semantics of such a ratio operator is given in (28).

(26) mei liang-ge nanhai zao-le   yi-zhi   fazi.
     MEI two-CL boy   build-PERF one-CL raft

     'Every two boys built a raft.'

(27) *mei liang-ge nanhai zao-le   fazi.
     MEI two-CL boy   build-PERF raft

     'Every two boys built rafts.'

(28) $\llbracket \emptyset_R \rrbracket = \lambda P.\lambda Q.\exists Y \in \wp_{NO}(Q).\forall i \in Y: P(i)$ where $\wp_{NO}(Q)$ is a powerset of all the maximal non-overlapping subsets of Q.
     i.e. 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!)

Different from *dou*, what the null operator does is to distribute VP property over *a special set* constructed from the input set Q: namely a random/contextually-dependent partition of Q. The way I achieve that is to define a partition as the 'maximal non-overlapping subset of Q': crucially that kinds of subset should try to pick more members from Q but at the same time the members cannot have overlapping with each other. As (28) shows, $\wp_{NO}(Q)$ is a powerset which collects all the possible maximal non-overlapping subsets that could be formed based on Q. Then the null operator picks one of the partition from that powerset and distributes the VP property over the members in that partition, which is also what we intend.

With this definition we can further explain why the *mei* without *dou* sentence is sensitive to the indivisible domain case: it is reflected compositionally by the inner conflict of picking the maximal subset possible yet not allowing overlapping, i.e. when there are 3 boys a, b, c in the domain and the partition unit is *2-CL boy*, as in (29). That's why the speaker wonders 'what happens to the last person?' when hearing (26) in the context of three boys.

(29) a. ⟦2-CL boy⟧ = {a⊕b, a⊕c, b⊕c}
      b. $\wp_{NO}$(⟦2-CL boy⟧) = {{a⊕b}, {a⊕c}, {b⊕c}}

    c. Y is an element chosen (arbitrarily or context-dependently) from the power set above.

The full composition of (26) is given as follows:

(30) ⟦mei liang-ge nanhai $\emptyset_R$ zao-le yi-zhi fazi⟧
     = ⟦$\emptyset_R$⟧ (⟦zao-le yi-zhi raft⟧) (⟦mei liang-ge nanhai⟧)
     = $\lambda Q.\exists Y \in \wp_{NO}(Q).\forall i \in Y: \exists k.$ BUILD(i, k) $\wedge \forall s \leq k.$ RAFT(s) $\wedge$ C(s) $\wedge$ |k|=1] (⟦mei liang-ge nanhai⟧)
     = $\exists Y \in \wp_{NO}([\lambda x.\ [\forall y \leq x.$ BOY(y) $\wedge$ C(y) $\wedge$ |x|=2]]).$\forall i \in Y: \exists k.$ BUILD(i, k) $\wedge \forall s \leq k.$ RAFT(s) $\wedge$ C(s) $\wedge$ |k|=1]

To summarize, the current analysis claims a number phrase *2-CL boy* denotes a set of all possible pairs of boys itself, though it is able to undergo existential closure when *mei* is absent. As a result, *mei* itself is not a quantifier only in terms of its disability to establish a subset relation between two sets (a type mismatch in compositionality), though it does have crucial contribution to the distributive or universal force of the number phrase. On the other hand, *dou* is a quantifier in the sense that it can establish a subset relation between two sets. Since *dou* has many other usages like NPI licensor or scalar marker (see a most recent paper, Xiang 2016), summarizing different usages of *dou*), it might not simply be a distributive quantifier but my analysis of *dou* should be compatible with these usages. I will not go further here since it is out of the scope of this paper.

5 Some potential advantages

This section discusses some relevant phenomenon which can be automatically explained by the analysis above.

Firstly, the current analysis explains why *mei* sometimes can be freely omitted, i.e. when there is no episodic marker like perfective *le* in the sentence. As in (31), the sentence has almost the same meaning with or without *mei*, which is not surprising if we assume without the episodic marker NO existential closure is required on the subject and the existence of two numbers in the sentence guarantees that a null ratio operator is available. As a result, *mei* is optional in this case.

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

Secondly, 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>. Unlike English which needs to add *time* to form *every time* in order to modify a VP, Mandarin *mei* can take VP directly as in (32). Again, since there is no episodic marker in (32), *mei* can be freely omitted without changing the meaning of the sentence.

(32)   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.'

6 Conclusions

This paper aims to establish a difference, with four empirical observations, between two constructions: (1) the construction where *mei* occurs without *dou*, and (2) the construction where *mei* and *dou* co-occur. Then I propose a potential compositional analysis for such a difference, which yields some implications for *mei* and *dou* in Mandarin: *mei* is not a quantifier in terms of its disability to establish a subset relation between two sets, but it does contribute to the distributive or universal force of the number phrase that it combines with (by blocking the existential closure of the number phrase); *dou* is a quantifier in terms of its ability to combine with a predicate and distribute the property denoted by the predicate over the elements of a plurality. The further implication is that only the co-occurrence of *mei* and *dou* licenses a standard universal quantification while the sentences with *mei* alone do not. This analysis also has some advantages when explaining other phenomena involving *mei*, for instance, its free omission in some cases or its adverbial usage.

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Appendix: Results from a pilot study

This appendix reports data from a series of experiments for the first two observations in section 3. The experiments are all carried out in the form of questionnaires.

Experiment 1 was conducted to investigate whether there is a truth-conditional difference between *mei*-with-*dou* sentence and *mei*-without-*dou* sentence. In each trial, participants saw a paragraph describing a scenario that either matched the one-time dividing interpretation (P) or the exhaustive cover-building (E) interpretation. Then they were asked to judge the truth-value of a sentence (either with or without *dou*, notated as W and O) in that scenario. According to the experimental hypothesis, we make the following predictions:

	Scenario P	Scenario E
Sentence O	True	True(but pragmatically bad)
Sentence W	False	True

Table 1: Predictions for Exp1

Methods

Participants. The data is collected online by thirty native speakers of Mandarin. *Materials.* This is a 2×2 design, with 4 conditions that are P.W (one-time dividing scenario followed by a sentence with *dou*), P.O (one-time dividing scenario followed by a sentence without *dou*), E.W (exhaustive cover-building scenario followed by a sentence with *dou*) and E.O (exhaustive cover-building scenario followed by a sentence without *dou*). We select four kinds of events (building sand castles, doing dances, making wooden tables, moving suitcases) as items in the experiment. These events are particularly chosen to ensure both one-time dividing and exhaustive cover-building scenarios are pragmatically reasonable and easily imaginable. All materials are in Chinese. A sample stimulus is given here:

Scenario P(partition): There are 4 boys a, b,c, d building castles on the beach. a and b built a castle, c and d built a castle.

Scenario E(exhaustive): There are 4 boys a, b,c, d building castles on the beach. 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-ge nanhai zao-le 1-ge chengbao*

Sentence W(with *dou*): *mei 2-ge nanhai dou zao-le 1-ge chengbao*

→ Question: Whether the sentence is true under this scenario?

Results

A logistic regression model of the ratio of 'True' response is run on the data: by coding P.O as the intercept, there is no significant effect of Scenario and a marginal effect of the interaction between Scenario and Sentence ($p < 0.1$), which means sentence O is judged as true under both scenarios. By coding P.W as the intercept, there is a significant effect of Scenario ($p < 0.01$) and also a marginal one of the interaction between Scenario and Sentence ($p < 0.1$).

Experiment 2 was conducted to investigate whether textitmei without *dou* sentence is sensitive to Divisible/Indivisible domain while *mei* with *dou* sentence is not. In each trial, participants saw a paragraph describing a scenario in which a leader is giving a command that is either "mei 2-CL people do something"(O) or "mei 2-CL people dou do something"(W) to a group of people, then they were asked to answer a yes-and-no question about whether the command given can be carried out by that group of people exactly in the way required by the command. Crucially the scenarios differ in the number of people in that group and that number is either an even number like 4 (D) and an odd one like 5 (I). According to the experimental hypothesis, we make the following predictions:

	Scenario D	Scenario I
Command O	Yes	No
Command W	Yes	Yes

Table 2: Predictions for Exp2:

Methods

Similar to Exp 2. A sample stimulus is given here:

Scenario D (divisible): 7 carpenters are doing work together. Their master makes a command.
Scenario I (indivisible): 6 carpenters are doing work together. Their master makes a command.
Command O (without *dou*): *mei 2-ge mujiang zuo 1-ge zhuozi*
Command W (with *dou*): *mei 2-ge mujiang dou zuo 1-ge zhuozi*
→ Question: Whether the Command can be carried out exactly under this Scenario?

Results

A logistic regression model of the ratio of 'True' response is run on the data: by coding D.O as the intercept, there is a significant effect of Scenario ($p < 0.01$) and also of the interaction between Scenario and Sentence ($p < 0.1$); by coding D.W as the intercept, there is no significant effect of Scenario.