Semantics of Quantifiers in Mandarin Chinese: *Mei* (每) 'Every' and *Dou* (都) 'All'

Yufeng Ruan

College of Foreign Languages, Nankai University, Tianjin, China

***Abstract*—From a syntactic-semantic perspective, based on the number feature of subjects and predicates, we propose that: 1. *Dou*, it is radically a maximal operator, while it is also a dependent distributor (or called "partial distributive operator"), which has to occur with plural individuality including *mei*; 2. Compared to *dou, mei* is a near-independent distributive operator, in that with a quantity predicate, it can be an independent distributive operator, whereas with a property one, it requires other linguistic elements like *dou* to create together the distributive effect; 3. The distributive effect can be achieved in diverse ways: by the sole entry *mei*, by "*mei* plus *dou*", and by the combination of *dou* with its scoped nominals that possess "plural individuality"; 4. From the various ways of yielding distributive effect, a generalized rule is obtained: the plural feature and the individual feature, they contribute together to yield distributive effect.**

***Index Terms*—semantics, quantifiers, Chinese, *mei*, *dou*, quantification**

I. INTRODUCTION

The quantifiers in Mandarin Chinese *mei* (每) 'every' and *dou* (都) 'all' have been extensively studied with significant accomplishments (e.g., Choe, 1987; Liu, 1990; Cheng, 1995; Lin, 1998; Huang & Shi, 2013; Niu & Pan, 2015; Shen, 2015; Ruan, 2018; Huang, 2022). However, two issues arise: 1. Irrespective of whether it is the study of *mei* or *dou*, contradictory viewpoints are drawn upon despite the same theoretical framework applied to the studies (e.g., formal semantics); 2. Surprisingly similar research findings have emerged concerning the semantic properties of *mei* and *dou*.

Previous research on the semantics of *mei* generally tends to three different viewpoints: universal quantifier (Huang, 1996, 2005), sum operator (Lin, 1998; Zhang & Pan, 2019), and distributive operator (Huang & Jiang, 2009; Luo, 2011).

A comparable threefold standpoint is also observed in the study of the semantics of *dou*: universal quantifier (Lee, 1986; Pan, 2006; Jiang & Pan, 2013; Feng & Pan, 2018), sum operator (Huang, 1996, 2005; Yuan, 2005b), and distributive operator (Lin, 1998; Pan, 2000, 2006; Cheng, 2009).

The aforementioned two problems existed in previous studies not only necessitate further investigation into *mei* and *dou*, but also demonstrate the inherent limitations of formal logic analysis in natural languages. Therefore, this paper will explore the semantic properties of *mei* and *dou* and their relationship by adopting an approach of natural languages.

This paper is organized as follows: we first explore semantic functions of *dou* in Section II, then we try to generalize the generative mechanism of distributive effect in Mandarin Chinese. In Section IV, we investigate semantics of *mei*. In the last section, we summarize all of the above discussions.

II. *DOU*, DISTRIBUTIVE OPERATOR VS. MAXIMAL OPERATOR

A. *Dou, a Dependent Distributor*

According to Cheng (2009), it functions as two operators: a distributive and a maximal one. See *dou* as a "distributive operator" in (1)[1] and (2).

(1)　a.　张三　　和　马丽　明天　　　结婚。
　　　　Zhangsan　he　Mali　mingtian　jiehun.
　　　　Zhangsan　and　Mali　tomorrow　marry
　　　　'Zhangsan and Mali will get married tomorrow.'
　　　　　　　　　　　　　　　　　　　　　Lee (1986, p. 58)
　　　b.　张三　　和　马丽　明天　　都　　结婚。
　　　　Zhangsan　he　Mali　mingtian　dou　jiehun.
　　　　Zhangsan　and　Mali　tomorrow　DOU　marry

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[1] Abbreviations used in the Chinese examples: 1: first person; 2: second person; 3: third person; BA: causative marker; CL: classifier; CL-General: General Classifier; CL$_{volume}$: the classifier *ben* 'volume'; CL$_{bottle}$: the classifier *ping* 'bottle'; CL$_{group}$: the classifier *zu* 'group'; DE: associative particle; DEM: demonstrative; PASS: passive; PL: plural; PRF: perfective aspect; SFP: sentence final particle; SG: singular.

'Zhangsan and Mali will both marry (someone else) tomorrow.'

(2)   a.   我们   合用   一   个   厨房。
Women heyong yi ge chufang.
1PL   share   one   CL-General   kitchen
'We share a kitchen.'

b.   我们   都   合用   一   个   厨房。
Women dou heyong yi ge chufang.
1PL   DOU   share   one   CL-General   kitchen
'We each share a kitchen (with someone else).'

Lee (1986, p. 177)

By means of symmetric predicates like *jiehun* 'marry (each other)', the distributive effect of *dou* is evidently demonstrated. In (1b), with *dou*, *Zhangsan* and *Mali* marry someone else, respectively. This contrasts with the husband-wife relationship between *Zhangsan* and *Mali* in (1a). The same is true of (2).

However, *dou* does not always play the role of distributor, as shown in (3), cited from Cheng (2009, p. 54).

(3)   a.   他们   都   一起   来。
Tamen dou yiqi lai.
3PL   DOU   together   come
'All of them came together.'

b.   这   座   桥   都   倒-下来-了。
Zheng zuo qiao dou dao-xialai-le.
whole   CL   bridge   DOU   fall-down-SFP
'The whole bridge collapsed.'

The co-occurrence of *dou* with *yiqi* 'together' implies that their meanings are not contrastive. This tells us that *dou* in (3a) cannot be a distributive operator, just as Cheng argued that the translation 'Each of them came together' is not grammatical.

On the other hand, in (3b), unlike Cheng's explanation, we would like to emphasize that *dou* is not a credible plural marker. In other words, *dou* does not license only plurals, since it can also receive singularity, such as *zheng zuo qiao* in (3b). We think that this phrase is referred to a singular entity rather than a plural one, which is however translated by Cheng (2009) as 'pieces of the bridge'.

To see *dou* is not a plural marker, we provide the following cases in (4).

(4)   a.   所有   的   爱   都   给   你。
Suoyou de ai dou gei ni.
all   DE   love   DOU   give   2SG
'All love is given to you.'

b.   一切   都   很   好。
Yiqie dou hen hao.
All   DOU   very   good
'All is good.' or 'All are good.'

In (4a), *ai* 'love' which is scoped by *dou* is massive, while the two possible translations of the sentence in (4b) tell that *dou* can occur with singular references as well.

B. Dou, a Radical Maximal Operator

Based on the fact that *dou* can scope nominal singulars, we can infer that *dou* in (3b) does not function as a distributor. More precisely, we think *dou* is a maximal operator that gives a total interpretation to the set '*zheng zuo qiao*' and involves all members of the set. But what happens to *dou* in this extreme case is that there is only one member in the set.

To see *dou* is maximal, we provide the following cases in (5).

(5)   a.   学生-们   去 学校 了。
Xuesheng-men qu xuexiao le.
student-PL   go school SFP
'The students have gone to school.'

b.   学生-们   都   去 学校 了。
Xuesheng-men dou qu xuexiao le.

student-PL   DOU   go school SFP
‘The students all have gone to school.’

In (5a), the number of the students do not have to be strictly maximal, most of them have gone to school is enough, whereas in (5b), with the presence of *dou*, the event involves every student of the set ‘*Xuesheng-men*’. This semantic contrast demonstrates that *dou* has maximal function.

To sum up, we partially concur with Cheng (2009) in claiming that *dou* functions not only as a maximal operator, but also as a distributive operator. Furthermore, we propose that *dou*’s maximality is primary (radical) and obligatory, whereas its distributivity is secondary and optional. This is supported by our findings that *dou* is neither a sufficient nor a necessary condition for generating distributive effect. This point is further confirmed by the fact that the distributive effect can be achieved in diverse ways: 1. By the combination of *dou* with its scoped nominals that possess “plural individuality”[2]; 2. By applying “*mei* plus *dou*”, as proposed by Cheng (2009)[3]; 3. By the standalone use of *mei*. The first two ways above demonstrate that *dou* needs other linguistic elements to generate the distributive effect. Therefore, *dou* is not an independent distributive operator, i.e. it is a dependent distributor (or called “partial distributive operator”).

III. GENERATIVE MECHANISM OF DISTRIBUTIVE EFFECT

In this section, we will analyze the three aforementioned ways to achieve distributive effect, with the intention of: 1. Demonstrating that the fundamental semantics of *dou* is not distributive; 2. Exploring the correlation between *mei* and *dou*. Initially, we investigate “plural and individual nominal+*dou*”, then *mei*, and in the end “*mei* plus *dou*”.

A. “Plural and Individual Nominal + Dou” & “Mei”

See the examples in (6) and (7) for “plural and individual nominal+*dou*” and *mei*, respectively.

(6) a. 他们   有   三   本   书。
         Tamen you   san   ben   shu.
         3PL   have three CL~volume~ book
         ‘They have three books.’

     b. 他们   都   有   三   本   书。
         Tamen dou   you   san   ben   shu.
         3PL   DOU   have three CL~volume~ book
         ‘Each of them has three books.’

     c. 这   三   个   人   喝   了   五   瓶   水。
         Zhe   san   ge   ren   he   le   wu   ping shui.
         DEM   three CL-General person drink PRF   five CL~bottle~ water
         ‘These three people have drunk five bottles of water.’

     d. 这   三   个   人   都   喝   了   五   瓶   水。
         Zhe san ge   ren dou he   le   wu   ping shui.
         DEM three CL-General person DOU drink PRF   five   CL~bottle~ water
         ‘Each of these three people has drunk five bottles of water.’

(7) a. 每   个   学生   有   三   本   书。
         Mei ge   xuesheng you   san   ben   shu.
         MEI CL-General   student have three CL~volume~ book
         ‘Every student has three books.’

     b. 每   个   学生   都   有   三   本   书。
         Mei ge   xuesheng dou   you   san   ben   shu.
         MEI CL-General   student DOU   have three CL~volume~ book
         ‘Every student has three books.’

In (6), the nominals *tamen* ‘they’ and *zhe san ge ren* ‘these three persons’ both refer to plural entities, i.e. objects with individuality and plurality. However, the minimal pair (6a) and (6b) offer different quantificational information. This is due to whether *dou* occurs. With the presence of *dou*, *tamen* ‘they’ is distributed, so every person among them has his own three books. The same account can cover the contrast between (6c) and (6d).

In brief, a nominal with plural individuality can produce distributive effect if it occurs with *dou*.

In (7) where *mei* occurs, there is no interpretative contrast, regardless of whether *dou* occurs. In both cases, the

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[2] With respect to “plural individuality”, it means referents that have not only the feature of semantic individuality but also that of semantic plurality. This rules out referents like: 1. *scissors* in English, having [-semantic plurality, +semantic individuality]; 2. *water* in English, having [-semantic plurality, -semantic individuality].
[3] Cheng (2009) proposed that the distributive effect does not attribute to a single-handed *dou*, instead, it is created by *mei* and *dou* together.

members of *xuesheng* 'student' set are distributed. This fact shows that *mei* can be a distributor without *dou*. In this sense, *mei* is an independent distributive operator. In addition, the contrast between (7a) and (7b), that is, *dou* is present or absent, demonstrates that *dou* is not a necessary element to produce distributivity.

Generally speaking, the sole entry *mei* can yield the distributive effect.

B. "Mei + Dou"

Now let's focus on "*mei* plus *dou*", as seen in (8).

(8)   a.   * 每　　个　　　　　学生　　笑　　了。
          * *Mei   ge   xuesheng   xiao   le.*
          MEI   CL-General   student   laugh   PRF
          Intended: 'Every student laughed.'
    b.   每　　个　　　　　学生　　都　　　笑　　　了。
          Mei   ge   xuesheng dou   xiao   le.
          MEI   CL-General   student   DOU   laugh   PRF
          'Every student laughed' or 'Every one of the students laughed.'

In (8), the illegal status of (8a) is caused by the absence of *dou*. It seems that *mei* must co-occur with *dou*, this appears to be contradictory to the fact shown in (7) where *mei* does not need to occur with *dou* together.

For this contradiction, we propose the following reason: it is correlated to the diverse nature of predicates. The predicate in (7) is quantificational, while the one in (8) is qualificational (it regards some property, not quantity).

This quantity-property contrast between predicates is clearly seen in cases like (9).

(9)   a.   他们　　笑　　了。
          Tamen xiao   le.
          3PL   laugh   PRF
          'They laughed.'
    b.   他们　　都　　　笑　　　了。
          Tamen dou   xiao   le.
          3PL   DOU   laugh   PRF
          'They all laughed.'
    c.   他们　　有　　三　　本　　　　书。
          Tamen you   san   ben   shu.
          3PL   have   three CL_{volume} book
          'They have three books.'
    d.   他们　　都　　有　　三　　本　　　　书。
          Tamen dou   you   san   ben   shu.
          3PL   DOU   have   three CL_{volume} book
          'Each of them has three books.'

In (9), the predicates of (9a) and (9b) are both a property *xiao* 'laugh', while those of (9c) and (9d) both regard a quantity *you san ben shu* 'have three books'. With the quantity predicate there is a different interpretation between (9c) and (9d), whereas with the property predicate (9a) and (9b) almost have the same meaning.

More precisely, for (9d), *tamen* 'they' and *dou* product together the distributive effect. The nominal *tamen* 'they' is distributed, each member that belongs to the set *tamen* has three books. If the set has two members, they have six books in total. The accumulation is visible due to the quantificational predicate. However, for (9b), following the same way, the accumulation is not directly sensed, since the relevant predicate is qualificational: *xiao* 'laugh' plus *xiao* 'laugh' is still *xiao* 'laugh'.

Returning to the previous "*mei* plus *dou*" question, i.e. why there is a contrast of grammaticality between (7a) and (8a), our explanation is that the distributive function of *mei* is weakened by a property predicate. For cases like (8) where there is a property predicate, *mei*'s distributive function is weakened, and it needs the help of *dou,* which can contribute to add distributive effect.

As for cases like (7), the optional presence of *dou* attributes to the nature of its predicate: a quantity one, which makes the distributive effect visible. In this situation, a sole *mei* is enough to finish the distributive operation. To justify our proposal above, we present a selection of examples in (10) drawn from Cheng (2009, pp. 60-62).

(10)   a.   每　（一）　个　　学生　　*（都）　来　　了。
          Mei (yi)   ge   xuesheng *(dou) lai   le.
          MEI   one   CL   student   DOU   come   PRF

'Every student came.'

b.　每　（一）　个　学生　*（都）　看　了　那　本　书。
　　*Mei (yi) ge xuesheng *(dou) kan le nei ben shu.*
　　MEI　one　CL　student　　DOU　read　PRF　that CL book
　　'Every student read that book.'

c.　每　（一）　个　厨师　（都）　做　一　道　菜。
　　Mei (yi) ge chushi (dou) zuo yi dao cai.
　　MEI　one　CL　chef　　DOU　make　one　CL　dish
　　'Every chef makes a dish.'

d.　每　（一）　个　厨师　*（都）　做　那　道　菜。
　　*Mei (yi) ge chushi *(dou) zuo nei dao cai.*
　　MEI　one　CL　chef　　DOU　make　one　CL　dish
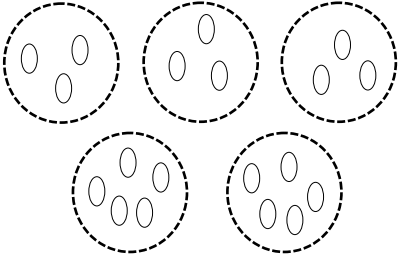　　'Every chef makes that dish.'

As shown in (10), *lai* 'come' in (10a) is a standard property predicate, while *kan nei ben shu* 'read that book' in (10b) and *zuo nei dao cai* 'make that dish' in (10d), seem, at first glance, a quantity one. But if we think carefully, we will discover that they both regard a definite referent. Therefore, this type of predicate indicates a property as well, just like predicates such as *kan shu* 'read books' does. On the other hand, *zuo yi dao cai* 'make a dish' in (10c) belongs to quantity predicates.

To sum up, we argue that there are three ways to yield distributive effect. One is using only a word *mei* (*dou* is optional), if the predicate of a clause is a quantity one. Another is combining *mei* and *dou*, if the predicate of a clause is a property one. The last one is through the pattern "plural and individual nominal+*dou*".

IV. *MEI*, A NEAR-INDEPENDENT DISTRIBUTOR

As we mentioned before, *mei* can be an autonomous distributor if the predicate of a clause is a quantity one. Now let's explain why it is so.

First, we argue that *mei* is an individualizing operator. This proposal is different from the standpoint in Cheng (2009) where *mei* is thought of as universal force. The individualizing function of *mei* is due to facts illustrated in (11).

(11)　a.　每　　　三　　　本　　　书
　　　　mei　*san*　*ben*　*shu*
　　　　MEI　three　CL~volume~　book
　　　　'every three books'

b.　每　五　瓶　水
　　mei　*wu*　*ping*　*shui*
　　MEI　five　CL~bottle~　water
　　'every five bottles of water'

From (11a), we can see that, *mei* scopes over the whole numeral expression *san ben shu* 'three books'. In this expression, the Cl *ben* 'volume' modifies only the noun *shu* 'book', and it individualizes this noun. In addition, the whole phrase *mei san ben shu* 'every three books' has an individualizing meaning.

These two points imply that it is not the Cl *ben* 'volume' that contributes to the individuality of the whole phrase *mei san ben shu* 'every three books', but the sole *mei* does, as shown by the dotted circles in (11). As a consequence, we can say that *mei* is an individual operator. The same is true of (11b).

Second, we claim that *mei* is a pluralizing operator. This is supported by Lin's (1998) viewpoint that nouns phrases with *mei* is a plurality, as shown in (12) and (13).

(12)　a.　我们　　　每　　　个　　　人
　　　　women　*mei*　*ge*　*ren*
　　　　1PL　　　MEI　CL-General　person
　　　　'all of us'

b.　*　我　　　每　　　个　　　人
　　　*　*wo*　*mei*　*ge*　*ren*
　　　　1SG　　　MEI　CL-General　person

(12b) is illegal in that the first and singular personal pronoun *wo* 'I' cannot be co-indexed with *mei ge ren* 'everyone', whereas (12a) is acceptable due to the plural referent of *women* 'we', which regards two persons at least.

(13) a. 我   有   三   本   书，   每   本   都   很   好。
Wo   you   san ben   shu,   mei   ben   dou   hen   hao.
1SG   have   three CL_{volume} book   MEI   CL_{volume} DOU   very   good
'I have three books, each of them is good.'

   b. * 我   有   一   本   书，   每   本   都   很   好。
* *Wo   you   yi ben   shu,   mei   ben   dou   hen   hao.*
1SG   have   one CL_{volume} book   MEI   CL_{volume} DOU   very   good
'I have one book, each of them is good.'

   c. * 我   吃-了   冰淇淋，   每   个   人   都   很   开心。
* *Wo   chi-le   bingqilin,   mei   ge   ren   dou   hen   kaixin.*
1SG eat-PRF ice-cream   MEI   CL-General person DOU very   good
'I have eaten ice-cream, everyone is happy.'

   d. 我们   吃-了   冰淇淋，   每   个   人   都   很   开心。
Women chi-le   bingqilin,   mei   ge   ren   dou   hen   kaixin.
1PL   eat-PRF ice-cream   MEI CL-General person dou   very   good
'We have eaten ice-cream, everyone is happy.'

The contrast between (13a) and (13b) is caused by the opposite number of the quantifying expressions: in (13a) *san* 'three' explicitly indicates the plural state of *shu* 'book', so *mei* is legal; whereas in (13b) *yi* 'one' expresses the nominal singularity, thereby, *mei* is illegal.

Furthermore, the contrast between (13c) and (13d) is provoked by the contrary number of pronoun: in these two examples, we presume that pronouns *wo* 'I' and *women* 'we' in the first clause are co-indexed with *mei ge ren* in the second clause, respectively. Under this premise, the ungrammatical status of (13c), i.e. *wo* 'I' and *mei ge ren* 'every person' fail to have an anaphoric relationship, tells us that *mei* has to be a plural marker.

In brief, we propose that *mei* has pluralizing function. This is further supported by the following minimal pair, offered by Lin (1998, p. 236).

(14) a. 每   一   组   小孩   都   画   了   一   张   画。
Mei   yi   zu   xiaohai dou   hua   le   yi   zhang hua.
MEI   one   CL   child   DOU   draw   PRF   one   CL   picture
'Every group of children drew one picture.'

   b. 那   一   组   小孩   都   画   了   一   张   画。
Nei   yi   zu   xiaohai dou   hua   le   yi   zhang hua.
that   one   CL   child   DOU   draw   PRF   one   CL   picture
'That group of children all drew a picture'

In (14a) *zu* 'group' is distributed, whereas in (14b) *xiaohai* 'child(ren)' is distributed. This contrast results from the absence of *mei* in (14b). As mentioned before, *mei* gives plural feature to its local (nearest) elements. In (14a), it gives this feature to the Cl *zu* 'group', instead of the nominal *xiaohai* 'child(ren)'.

In contrast, in (14b), *mei* is not present, so *zu* 'group' does not get the opportunity to demonstrate plural feature. In addition, *nei yi zu* 'that group' denotes a singular referent. As a consequence, *dou* is forced to turn to other possible plural individuality, that is, *xiaohai* 'child(ren)', a bare noun with RB (referential boundary)[4] that can offer the feature required by *dou*, i.e. plurality.

In order to explore *mei* in a deeper way, it needs to generalize the conditions of distributive operation.

If we change the number of the expression that *dou* scopes in (14b), *dou* will help to distribute *zu* 'group' again, instead of *xiao hai* 'child(ren)', as illustrated in (15). The contrast between (14b) and (15) implies that to finish the distributive operation, the object to be distributed must have plurality feature.

(15) 那   三   组   小孩   都   画   了   一   张   画。
Nei   san   zu   xiaohai dou   hua   le   yi   zhang hua.
that   three CL_{group} child   DOU   draw   PRF   one   CL   picture
'These three groups of children all drew a picture'

Based on the above conclusion that plural feature is indispensable to realize distributive operation, we wonder

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[4] The RB notion has been proposed by Ruan (2018, p. 79).

whether individuality feature is also indispensable. To seek the answer, we would like to analyze examples in (16).

(16)   a.   桌子-上   全部   的   水   都   被   擦干-了。
            Zhuozi-shang   quanbu   de   shui   dou   bei   cagan-le.
            table-on   all   DE   water   DOU   PASS   wipe-up-PRF
            'All the water on the table was wiped up.'
       b.   我   买-了   三   瓶   水,   我   把   全部   的   水   都   喝-了。
            Wo   mai-le   san   ping   shui,   wo   ba   quanbu   de   shui   dou   he-le.
            1SG   buy-PRF three CL$_{bottle}$ water   1SG   BA   all   DE   water   DOU   drink-PRF

            'I bought three bottles of water, all of them were drunk by me.'

From the contrast between (16a) and (16b) in terms of translations, we can say that *quanbu de shui* 'all the water' in (16a) is not distributed, whereas that in (16b) is. This is because this expression in (16b) refers to three bottles of water, which are three individual entities; while that in (16a) does not refer to individualized objects.

Hence, we argue that like plural feature, individual feature is also necessary to realize distributive operation. In addition, we argue that these two features contribute together to yield distributive effect.

To sum up, we propose that occurred with a quantity predicate, *mei* can be an independent distributive operator, whereas with a property one, it requires other linguistic elements like *dou* to create together the distributive effect. In this sense, *mei* can be seen as a near-independent distributive operator, in comparison to *dou.*

V. CONCLUSION

Starting from natural language facts, we explored semantic properties of *mei* and *dou* from a syntactic-semantic perspective. We found that: 1. *Dou*, it is radically a maximal operator, while it is also a dependent distributor (or called "partial distributive operator"), which has to occur with plural individuality including *mei*; 2. Compared to *dou, mei* is a near-independent distributive operator, in that with a quantity predicate, *mei* can be an independent distributive operator, whereas with a property one, it requires other linguistic elements like *dou* to create together the distributive effect; 3. The distributive effect can be achieved in diverse ways: by the sole entry *mei*, by "*mei* plus *dou*", and by the combination of *dou* with its scoped nominals that possess "plural individuality". These diverse ways of yielding distributive effect can be reduced to a generalized rule: the plural feature and the individual feature, they contribute together to yield distributive effect.

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Yufeng Ruan was born in Anhui, China in 1987. She received her Ph.D. degree in Linguistics from University of Florence, Italy in 2018.

She is currently an assistant professor in the College of Foreign Languages, Nankai University, Tianjin, China. Her research interests include syntax and semantics with special attention to the analysis of Chinese and Italian. She also concerns herself with issues relating to second language acquisition. Email: yufeng.ruan@nankai.edu.cn