Measurement and optional classifiers in Mandarin Chinese

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This paper presents a compositional analysis of the fact that Mandarin individuating classifiers are systematically optional in various degree constructions (see also Lin & Schaeffer 2018 for experimental evidence), by taking a mixed approach incorporating the insights from Chierchia (1998; 2010) that Mandarin nouns denote kind terms and individuating classifiers offer the level of individuation and those from Krifka (1995) that (bare) numerals do not encode the cardinality function. By considering (bare) numerals as degree terms (e.g., Hackl 2001; Nouwen 2010; Rett 2014; Kennedy 2015, among many others), the mixed approach advocated here embraces the hypothesis that the locus of variation between English and Mandarin lies in neither the semantics of nouns nor that of numerals, but in the measure operators: these linguistic elements (including sortal/individuating classifiers) are necessary to mediate between numerals and nouns to avoid the semantic type-mismatch. The proposed analysis of individuating classifiers not only explains the role of Mandarin individuating classifiers in degree constructions (i.e., their syntactic optionality, along with a semantic variation in the dimension of comparison), but also closely connects with Bale & Barner's (2009) idea about quantity judgments that comparative constructions can be used as a reliable diagnostic of the mass-count distinction in natural languages beyond English. Specifically, the fact that Mandarin unclassified nouns allow both cardinality and non-cardinality monotonic dimensions in a variety of degree constructions based on quantity judgments indicates that they are mass-count neutral; a tentative semantics of Mandarin nouns for their mass-count neutrality is thus suggested. Some factors leading to the individuation of nouns are also discussed.

Keywords: classifiers, comparatives, measurement, mass-count neutrality, degree semantics

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1. Introduction

It is well-known that in contrast to English, numerals cannot directly combine with nouns in a classifier language like Mandarin Chinese; instead, a classifier (henceforth CL) has to be used (see e.g., Hsieh 2008; Li 2011, 2013, among others). The contrast in (1) illustrates the point.[1]

(1) a. *san* **(ke) pingguo* (Mandarin Chinese)
three CL apple
b. three apples (English)

One influential view on why classifiers are required in a classifier language such as Mandarin has been proposed in Chierchia (1998; 2010). Following Krifka (1995), Chierchia (1998) assumes that Mandarin bare nouns denote kinds; then, the role of individuating/sortal classifiers is to take a kind term and return a set of atomic instances of the kind (Chierchia 2010: 142). Put differently, in Chierchia's view, all Mandarin bare nouns are mass and do not individuate (see e.g., Chierchia 1998: 400); thus, classifiers are semantically motivated and required for the individuation of Mandarin bare nouns.[2]

It has been observed by some researchers that individuating/sortal classifiers in Mandarin are apparently **optional** with the quantifier expression such as *henduo* 'a lot of' (Tang 2007: 984; Hsieh 2008: 61; Li 2011: 7; Cheng et al. 2012: 178), as illustrated in (2).[3]

(2) *Zhangsan mai-le* ***hen-duo*** *(kuai) rou*.[4]
Zhangsan buy-ASP very-much CL_{chunk} meat
With CL: 'Zhangsan bought many chunks of meat.'
Without CL: 'Zhangsan bought a lot of meat.'

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1. The empirical data of Mandarin Chinese in this paper is based on native speakers from Taiwan (including my own judgment). Specifically, two consultants are from the city Taipei, the northern part of Taiwan; two consultants are from the city Kaohsiung, the southern art of Taiwan; three consultants are from the city Taichung, the central part of Taiwan. For native speakers from Mainland China that I have also consulted: one consultant is from the Hunan Province, another is from the Hubei Province, and the other is from the Shandong Province.

2. We will come back to this point in § 2, after introducing the optionality of classifiers and its semantic impact.

3. Although previous studies have observed the optionality of sortal classifiers with expressions such as *henduo* 'a lot of', *xuduo* 'many' and *haoduo* 'many', they do not discuss whether there is a semantic difference hidden behind the optionality. As we shall see shortly, the optionality of sortal classifiers is NOT a free variation: the presence or absence of sortal classifiers in degree constructions crucially leads to an interpretative variation in the relevant dimension of measurement.

Most studies focus on the optionality of classifiers with the expression *henduo* 'a lot of'. Crucially, however, such optionality of sortal classifiers is NOT restricted to *henduo*. The same optionality repeats itself in a degree question (Zhang 2013: § 3.4), illustrated in (3), and queries the relevant number of pieces or the relevant amount of tofu.

(3) *Zhangsan mai-le* ***duoshao*** *(kuai) doufu?*
Zhangsan buy-ASP how.much/many CL_{chunk} tofu
With CLs: 'How many pieces of tofu did Zhangsan buy?
Without CLs: 'How much tofu did Zhangsan buy?'

The existence of facts like (3) indicates that the optionality of individuating classifiers witnessed by (2) does not result from the lexical idiosyncrasy of *henduo* 'a lot of' and the like.

Indeed, as we shall see shortly, examples like (2) and (3) only reveal the tip of the iceberg. The next section establishes that (a) Mandarin individuating/sortal classifiers are systematically optional in various degree constructions and (b) the optionality of CLs is NOT a free variation: without CLs, the dimension of comparison can be relative to cardinality or other monotonic dimensions such as weight or volume; in contrast, with CLs, the dimension of comparison must be cardinality.[5]

1.1 The optionality of Mandarin classifiers in degree constructions

Rothstein (2010; 2017) and much of her work suggest that *counting* and *measuring* are two different operations. Specifically, "Counting is putting entities in one-to-one correspondence with the natural numbers and requires a contextually determined choice to what counts as one entity." (Rothstein 2010: 362); by contrast, "measuring assigns an (plural) individual a value on a dimensional scale" (Rothstein 2010: 386). Building on Rothstein's insights about the nature of counting vs. measuring, we shall see shortly that quantity judgment based on the

4. Cheng et al. (2012) reported that a Mandarin sentence with the presence of sortal classifiers and *henduo*, such as the Example (2), is degraded. However, as shown in Hsieh (2008: 61), similar data are not only acceptable to native speakers, they can also be found in the corpus of Academia Sinica. Furthermore, according to my own survey, none of my consultants from Taiwan or Mainland China finds those sentences with the presence of sortal classifiers and *henduo* (e.g., (2)) degraded.

5. As will be reviewed in § 2, there has been an ongoing debate on why sortal classifiers are required in classifier languages, in contrast to number-marking languages such as English. For purposes of this paper, I shall confine my attention to individuating/sortal classifiers in Mandarin, given their unique status to classifier languages.

dimension of cardinality (i.e., putting entities in one-to-one correspondence with natural numbers) remain constant in various degree constructions, regardless of whether classifiers are present or absent.

First, the optionality of CLs under discussion is also observed in comparatives, as shown in (4). Without CLs, (4a) conveys that the amount of apples *Zhangsan* bought is more than that of apples *Lisi* did. The dimension of comparison can be in terms of cardinality (the number of apples bought by *Zhangsan* vs. those bought by *Lisi*) or other monotonic dimensions such as weight (the overall weight of apples bought by *Zhangsan* vs. those bought by *Lisi*). By contrast, crucially, such flexibility is unavailable for (4b): With CLs, the dimension of comparison has to be evaluated in terms of cardinality.

(4) **Comparative**

a. **√cardinality; √weight**
Zhangsan bi Lisi mai-le ***geng-duo*** *pingguo.*
Zhangsan than Lisi buy-ASP COMP-much apple
'Zhangsan bought even more apple(s) than Lisi.'

b. **√cardinality; #weight**
Zhangsan bi Lisi mai-le ***geng-duo*** ***ke*** *pingguo.*[6]
Zhangsan than Lisi buy-ASP COMP-much CL apple
'Zhangsan bought even more apples than Lisi.'

Such optionality of CLs and its semantic impact is not only puzzling but also mysterious under the view that without classifiers, Mandarin unclassified nouns cannot individuate without the help of classifiers. With or without classifiers, the cardinality dimension remains invariable in either case.

Second, the same optionality of CLs repeats itself in the excessive comparative, as shown in (5). Without CLs in (5a), what is excessive about the amount of apples bought by *Zhangsan* can be evaluated against cardinality or other monotonic dimensions such as weight. In contrast, crucially, with CLs in (5b), what is excessive about the amount of apples must be based on cardinality: the **number** of apples bought by *Zhangsan*.

(5) **Excessive comparative**

a. **√cardinality; √weight**
Zhangsan mai-le ***tai-duo*** *pingguo le!*
Zhangsan buy-ASP too-much apple SFP
'Zhangsan bought too much/too many apple(s).'

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6. Some of my consultants from Mainland China consider this sentence marginal; however, all of my consultants from Taiwan readily accept the presence of sortal classifiers in the comparative. I leave this dialectal variation for future research.

b. **√cardinality; #weight**
Zhangsan mai-le ***tai-duo*** ***ke*** *pingguo le!*
Zhangsan buy-ASP too-much CL apple SFP
'Zhangsan bought too many apples.'

Again, the observed optionality of CLs and its semantic impact is not only puzzling but also surprising; if Mandarin unclassified nouns cannot individuate for counting (on which the quantity judgment is based, in terms of cardinality), how come the cardinality dimension remains invariable in both cases (i.e., with or without classifiers)?

Third, the same optionality of CLs also shows up in the degree demonstrative construction, as shown in (6). In this degree construction, a demonstrative such as *zheme* 'this' or *name* 'that' functions like a measure phrase referring to a particular amount of apples in discourse. Crucially, with CLs in (6b), the demonstrative must refer to a particular **number** of apples based on cardinality. In contrast, without CLs in (6a), the amount of apples referred by the demonstrative can be based on either cardinality or other monotonic dimensions such as weight.

(6) **Degree demonstrative construction**
a. **√cardinality; √weight**
Zhangsan jingran yongyou ***zheme-duo/name-duo*** *pingguo!*
Zhangsan surprisingly have this-much/that-much apple
'Zhangsan, surprisingly, has this/that amount of apples.'
b. **√cardinality; #weight**
Zhangsan jingran yongyou ***zheme-duo/name-duo ke*** *pingguo!*
Zhangsan surprisingly have this-much/that-much CL apple
'Zhangsan, surprisingly, has this/that many apples.'

Fourth, the same optionality of CLs repeats itself in the quantity superlative and the equative.[7] Without individuating classifiers, the relevant dimension of measurement can be either cardinality or some monotonic dimensions such as weight. By contrast, the presence of individuating classifiers requires the relevant dimen-

7. There seems to be a systematic judgment variation between native speakers from Taiwan and those from Mainland China, with respect to the presence of sortal classifiers in the superlative and equative: all of my consultants from Taiwan readily accept the presence of classifiers in the superlative (e.g., (7)) and equative (e.g., (8)), while many of my consultants from Mainland China consider those sentences degraded. At this point, I have no explanation for such dialectal variation. But crucially, all of my consultants from Mainland China do accept the overall pattern: the optionality of sortal classifiers in degree constructions such as the positive, the excessive, the degree demonstrative construction, and the degree question. Therefore, minimally, the optionality of Mandarin sortal classifiers in degree constructions still requires explanation.

sion of measurement to be cardinality (i.e., other monotonic dimensions such as weight become unavailable).

(7) **Quantity superlative**
*Zhe-san-ge-ren zhizhong, Zhangsan mai-le **zui-duo** **(ke)** pingguo.*
This-three-CL-people among, Zhangsan buy-ASP SUP-much CL apple
'Of these three persons, Zhangsan bought more apple(s) than anyone else did.'

(8) **Equative**
*Zhangsan gen Lisi yongyou **yiyang-duo** **(ke)** (de) pingguo.*
Zhangsan with Lisi have equally-much CL DE apple
'Zhangsan has the same amount of apples as Lisi.'

Fifth, as we have seen, individuating classifiers can be optional in a degree question. Crucially, the presence vs. absence of CLs also leads to a variation on the relevant dimension of measurement. For example, in (9) without CLs, the question queries the **amount** of apples that *Zhangsan* bought and the answer can be based on cardinality or other monotonic dimensions such as weight. By contrast, in (10) with CLs, the question asks about the **number** of apples that *Zhangsan* bought; thus, crucially, the answer *zonggong shi gongjin* 'in total, ten kilos' based on weight is **infelicitous**, in contrast to the answer *zonggong shi ke* 'in total, ten' based on cardinality.

(9) **Degree question (without CLs)** **√cardinality; √weight**
Question: *Zhangsan mai-le **duoshao** pingguo?*
Zhangsan buy-ASP how.much apple
'How much/how many apple(s) did Zhangsan buy?'
Answer: *Zonggong shi ke* 'in total, ten'/
Zonggong shi gongjin 'in total, ten kilos'

(10) **Degree question (with CLs)** **√cardinality; #weight**
Question: *Zhangsan mai-le **duoshao** **ke** pingguo?*
Zhangsan buy-ASP how.much CL apple
'How many apples did Zhangsan buy?'
Answer: *Zonggong shi ke* 'in total, ten'/
#*Zonggong shi gongjin* 'in total, ten kilos'

Finally, for completeness, the case with positive constructions is repeated below. Again, with CLs, (11b) conveys that the **number** of apples *Zhangsan* bought has exceeded a contextual threshold; in contrast, without CLs, (11a) delivers that the **amount** of apples *Zhangsan* bought has exceeded a contextual threshold. Crucially, the contextual threshold in (11a) can be evaluated in terms of cardinality (say, ten apples) or other monotonic dimensions such as weight (say, ten kilos); but such flexibility is unavailable for (11b) when the classifier appears.

(11) **Positive construction**

a. **√cardinality; √weight**
Zhangsan mai-le ***hen-duo*** *pingguo.*
Zhangsan buy-ASP very-much apple
'Zhangsan bought a lot of/many apples.'

b. **√cardinality; #weight**
Zhangsan mai-le ***hen-duo*** ***ke*** *pingguo.*
Zhangsan buy-ASP very-much CL apple
'Zhangsan bought a lot of/many apples.'

Summing up, we have seen that individuating classifiers in Mandarin can be systematically optional in various degree constructions. Furthermore, such optionality leads to a variation on the dimension of comparison: without individuating CLs, the relevant dimension of measurement for a given sentence can be based on either cardinality or some monotonic dimensions such as weight; in contrast, crucially, the presence of individuating CLs requires the relevant dimension of measurement to be cardinality (i.e., other monotonic dimensions such as weight become unavailable).

The linguistic facts (2–11) in Mandarin immediately raise several important questions, concerning the relation between measurement and sortal classifiers:[8] (a) what is the role of classifiers in the measurement constructions? (b) How is the measurement connected with classifiers? (c) How and why does the interpretative variation on the dimension of comparison arise? With these questions in mind, the next section shows that the optionality of CLs and the variation on the dimension of comparison, is NOT restricted to the noun *pingguo* 'apple' (which is used only for illustrative purposes here); instead, the observed pattern is quite general and applies to not only those notionally count nouns, but also to those notionally mass nouns and flexible nouns in Mandarin.[9]

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8. As correctly observed by one anonymous reviewer, there is a contrast between degree quantifiers formed with *duo* 'much' and those with *shao* 'little' with respect to the acceptability of sentences. In particular, the sentences become degraded when those degree expressions involving *shao* 'little' such as *geng-shao* and *tai-shao*. Honestly, I do not have a good explanation at this point and thus do not speculate further. I leave a detailed study of the linguistic contrast between these two sets of degree quantifiers in Mandarin for future research. I am very grateful to the reviewer for pointing out this important contrast between the two quantity-adjectives (i.e., *duo* and *shao*) with respect to their related degree expressions.

9. By "notionally count or notionally mass" these labels are intended to be only descriptive for the purposes of discussion and they may be intuitively associated with a pre-linguistic distinction between objects and substances (Li et al. 2008, 2009; Cheung et al. 2012; Lin & Schaeffer 2018). As correctly pointed out by one anonymous reviewer, a count noun in one language may have its counterpart mass in another. Before we can say whether a noun is count or mass in

1.2 Comparatives as a diagnostic for the mass-count distinction of nouns

Bale & Barner (2009) present an influential study showing that comparative constructions can be used as a reliable diagnostic of the mass-count distinction in English and potentially in languages beyond English. Specifically, Bale & Barner argue that in terms of **quantity judgement** induced by comparative construcitons (see also Barner & Snedeker 2005), English basically shows a two-way distinction: the quantity judment about English count nouns (e.g., *apple*) and object mass nouns (e.g., *furniture*) is based on cardinality, while that about English canonical mass nouns (e.g., *water*) is based on other monotonic dimensions (i.e, non-cardiniality). (12) illustrates the relevant facts in English, and (13) summarizes the picture of English suggested in Bale & Barner (2009).

(12) a. John has more stones than Bill. **√cardinality; #weight**
b. John has more stone than Bill. **#cardinality; √weight**
c. John has more furniture than Bill. **√cardinality**

(13) The pattern of quantity judgement with different types of nouns (Bale & Barner 2009)
a. Count nouns are evaluated in terms of **cardiniality**
b. Mass nouns are evaluated in terms of **non-cardiniality** (other monotonic dimensions)
c. Object-mass nouns (furniture-type mass nouns) are evaluated in terms of **cardinality**

Against this brief background, it seems that cardinality vs. non-cardinality monotonic dimensions is in complementary distribution with respect to English nouns.[10] Notice that English plural count nouns such as (12a) *cannot* be evaluated in terms of non-cardinality monotonic dimensions. In this respect, it is worth pointing out that with the absence of classifiers, Mandarin bare nouns are *unusual* in that they allow *both* cardinality and non-cardinality monotonic dimensions such as weight to be the dimension of comparison, but such flexibility is unavailable for English bare plurals in comparatives. More specifically, on the one hand, resembling plural count nouns in English, Mandarin unclassified nouns allow cardinality to be the dimension of comparison; on the other hand, resembling

a given language, those labels are used for descriptive purposes in the course of discussion. I thank the reviewer for this clarification question.

10. The situation of object-mass nouns (furniture-type nouns) is a bit complicated. As argued in Grimm & Levin (2012), under certain "functional" scenarios, English furniture-type nouns are also accessible to monotonic dimensions other than cardinality. I shall return to this issue and discuss the case of Mandarin object-mass nouns in § 4.2.

typical mass nouns in English, Mandarin unclassified nouns also allow non-cardinality monotonic dimensions such as weight to be the dimension of comparison. Importantly, such flexibility of Mandarin unclassified nouns suggests that at least some (if not all) Mandarin nouns are mass-count neutral (contra Chierchia 1998), reminiscent of the property of being number-neutral.

At this point, it is worth emphasizing that the variation in the dimension of comparison with respect to the presence vs. absence of CLs is not a peculiar property of the noun *pingguo* 'apple' (which is used only for illustrative purposes). (14) and (15) demonstrate that the same interpretative variation on the dimension of comparison also applies to flexible nouns such as *shitou* 'stone'.

(14) **√cardinality; √weight**
Zhangsan yijing jian-le ***name-duo*** *shitou la!*
Zhangsan already pick-ASP that-much stone SFP
'Zhangsan has already picked up that much stone/that many stones!'

(15) **√cardinality; #weight**
Zhangsan yijing jian-le ***nane-duo ke*** *shitou la!*
Zhangsan already pick-ASP that-much CL stone SFP
'Zhangsan has already picked up that many stones!'

With CLs, the dimension of comparison in (15) must be evaluated against cardinality. In contrast, crucially, without CLs, the dimension of comparison in (14) can be relative to cardinality or non-cardinality dimensions such as weight.

Other Mandarin nouns participating in the pattern include notionally count nouns, flexible nouns and notionally mass nouns, as listed below. Note that the list in (16) is not exhaustive.

(16) a. Notionally count nouns: *yingtao* 'cherry', *yu* 'fish' and *shu* 'book', inter alia.
b. Flexible nouns: *shitou* 'stone', *qiaokeli* 'chocolate' and *toufa* 'hair', inter alia.
c. Notionally mass nouns: *rou* 'meat', *mi* 'rice' and *shazi* 'sand', inter alia.

Recently, experimental studies concerning quantity judgments conducted in Cheung et al. (2012) and Lin & Schaeffer (2018) have similarly confirm that Mandarin unclassified nouns are both mass and count in that they allow both cardinality and non-cardinality monotonic dimensions. By giving different discourse conditions, the participants were asked to make quantity judgments with respect to the testing sentence in (17), parameterized with different types of nouns (i.e., notionally count nouns, notionally mass nouns, flexible nouns and object-mass nouns).

(17) a. *Shui you bijiao duo [noun]* ?
Who have relatively much [noun]
'Who has more [noun]?' (Cheung et al. 2012)
b. *Shui de X duo*?
Who DE *X much*
'Who has more X?' (Lin & Schaeffer 2018)

Statistic data systematically show that Mandarin native speakers are able to make quantity judgments about Mandarin unclassified nouns, based on both cardinality and non-cardinality monotonic dimensions. One apparent exception is the case of object-mass nouns such as *jiaju* 'furniture'. Interested readers are referred to Lin & Schaeffer (2018) and references therein for more details.

In short, not only the novel empirical data presented in this paper, but also the experimental evidence (Cheung et al. 2012; Lin & Schaeffer 2018) support the fact that at least some (if not all) Mandarin unclassified nouns may be mass-count neutral, according to the diagnostic of comparatives based on quantity judgments. Moreover, the well-known claim that all Mandarin nouns are mass across the board and do not individuate is challenged not only by the novel empirical data discovered in this paper, but also by the experimental evidence. Note that once we admit that Mandarin unclassified nouns do have the semantic ability to individuate (the cardinality dimension remains constant, regardless of whether sortal classifiers are present), it immediately becomes a puzzle why they *cannot* directly combine with numerals in Mandarin (in contrast to English); instead, classifiers must be used. I shall return to the issue of object mass nouns in Mandarin with which the optionality of CLs is apparently free variation in § 4.2, wherein I discuss some additional factors and suggest a tentative semantics of Mandarin unclassified nouns for their mass-count neutrality.

1.3 The goal of this paper

(18) summarizes three puzzles concerning the optionality of Mandarin individuating/sortal classifiers that any linguistic theory of Mandarin classifiers and bare nouns must explain.

(18) a. **The optionality of Mandarin individuating CLs**
Contrary to what has been observed in previous studies, Mandarin individuating CLs can be systematically optional in a variety of degree constructions.

b. **The availability of both cardinality and non-cardinality as the relevant dimension of measurement**
Without individuating CLs, Mandarin bare nouns demonstrate the flexibility of both cardinality and non-cardinality (such as weight/volume) as the dimension of comparison in degree constructions, in contrast to English nouns.

c. **The restriction to cardinality**
With individuating CLs, the relevant dimension of measurement has to be cardinality; other monotonic dimensions such as weight and volume become unavailable.

To my knowledge, these three puzzles have not been formally analyzed in the literature. This paper fills the gap by spelling out a formally compositional analysis of the optionality of Mandarin individuating classifiers in comparative constructions. The central proposal of this paper is two-fold: (a) Mandarin classifiers are semantically motivated and required for both numerals and nouns, to resolve the type-mismatch; (b) at least some (if not all) Mandarin unclassified nouns are mass-count neutral, contra Chierchia's (1998) view that all Mandarin bare nouns are mass.

From a wider perspective, the proposed analysis contributes to the study of Mandarin classifiers and bare nouns on two levels. Empirically, it offers a detailed documentation of the optionality of Mandarin individuating classifiers in various degree constructions along with a corresponding semantic variation on the relevant dimension of comparison, a linguistic area that has not been explored in the previous studies of Mandarin classifiers. Theoretically, it is suggested that the semantics of Mandarin individuating classifiers is to create a partition over the set of instances of the kind (denoted by the noun) relative to the cardinal value (i.e., the contribution of the numeral) and offers the level of individuation by requiring the instances in the cover to be atomic relative to the kind (i.e., the contribution of the noun). This semantic view of individuating classifiers is a mixed approach incorporating the core insights from Chierchia (1998; 2010) that sortal/individuating classifiers offer the level of individuation and those from Krifka (1995) that numerals do not encode the cardinality function, which is crucially provided by classifiers. This explains why the presence of classifiers immediately shifts the dimension of comparison to cardinality. Finally, given that some (if not all) Mandarin unclassified nouns may be mass-count neutral, they have the accessibility to both cardinality and non-cardinality dimensions in degree constructions based on quantity judgments.

The rest of this paper is structured as follows. § 2 reviews two influential views on why individuating classifiers are required in a classifier language such as Mandarin: Chierchia (1998; 2010) and Krifka (1995). § 3 first introduces some

theoretical assumptions endorsed in this paper and then presents a formally compositional analysis incorporating both insights from Chierchia (1998; 2010) and Krifka (1995). § 4 discusses some significant implications of the proposed analysis by addressing two issues: (a) individuating classifiers in Mandarin are semantically required for both numerals and nouns; (b) some (if not all) Mandarin unclassified nouns are not only number-neutral but also mass-count neutral. § 5 concludes.

2. Two views on why classifiers are required in Mandarin

Chierchia (1998; 2010) suggests that all Mandarin nouns (like English mass nouns) are lexically *registered* as kinds and CLs are required for Mandarin nouns to obtain their predicative meanings.[11] The following illustrations are borrowed from Bale & Coon (2014: 696–697): First, (19) shows that the Mandarin noun *gou* 'dog' is a kind term, just like English mass noun *furniture*, but in contrast to English count noun *dog*; second, (20) presents the semantics of CLs and numerals; finally, (21) illustrates the semantic equivalence between the denotation of English count nouns and that of the combination of Mandarin CLs and nouns.[12]

(19) a. $[\![$ gou $]\!]$ 'dog' $= {}^{\cap}$DOG (i.e., the dog-kind)
b. $[\![$ furniture $]\!] = {}^{\cap}$FURNITURE (i.e., the furniture-kind)
c. $[\![$ dog $]\!] = \{x\text{: atom}(x) \wedge \text{dog}(x)\}$ (i.e., a set of individual dogs)

(20) a. $[\![$ liang $]\!]$ 'two' $= \lambda P : \text{Atomic}(P).\{x\text{: } {}^{*}P(x) \wedge \mu_{\text{card}}(x) = 2\}$
b. $[\![$ zhi $]\!]$ "CL" $= {}^{\cup}$(i.e., the function from kinds to sets of atoms.)

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11. By "registered as kind terms", it is intended to mean that Mandarin bare nouns denote kinds rather than instances, unless they get type-shifted into instances. Specifically, on Chierchia's (1998) original proposal, Mandarin bare nouns essentially *cannot* obtain their predicative meaning (a set of instances) without the help of classifiers (which encodes the predicativization operator); this point is made more explicit in Chierhcia (2010: 142). Chierchia (1998) connects the property of bare nouns *registered* as kinds (i.e., all nouns are mass in classifier languages) with a bunch of seemingly-unrelated properties, such as the use of classifiers, the lack of overt definite article and the distribution of bare nouns in argumental positions.

12. In this section, I adopt the illustrations from Bale & Coon (2014) because it is relatively easier to see the key difference between Chierchia (1998; 2010) and Krfika (1995), regarding the locus of variation between English and Mandarin. Note that the capitals like DOG and FURNITURE in (19) represent the semantics of English nouns (i.e., a set of instances); thus the semantics of Mandarin bare nouns correspond to the nominalization of their English counterparts (i.e., kinds).

(21) Equivalence: ⟦ zhi gou ⟧ = {*x*: atom(*x*) ∧ dog(*x*)} = ⟦ dog ⟧ singular count noun

On this view, the locus of variation between English and Mandarin lies in the semantics of nouns. Because all Mandarin nouns are mass and lexically registered as kind terms, in order to combine with numerals, individuating classifiers are required for delivering the set of atomic instances of the kind denoted by the noun in Mandarin.

In contrast, Krifka (1995) proposes that the locus of variation does not lie in the semantics of nouns, but in the semantics of numerals. In particular, Mandarin CLs encode the cardinality function and Mandarin numerals do not (in contrast to English numerals). Thus, CLs are required because of numerals in Mandarin. The following illustrations are again taken from Bale & Coon (2014: 698): First, (22) presents the semantic equivalence between Mandarin noun *gou* 'dog' and English count noun *dog*. Second, (23) shows that Mandarin numerals (in contrast to English numerals) do not encode the cardinality function, which is crucially provided by CLs. Finally, (24) illustrates the semantic equivalence between English numerals and the combination of Mandarin CLs and numerals.[13]

(22) ⟦ gou ⟧ 'dog' = {*x*: atom(*x*) ∧ dog(*x*)} = ⟦ dog ⟧

(23) a. ⟦ two ⟧ = λ*P*: Atomic(*P*).{*x*: **P*(*x*) ∧ μ_{card}(*x*) = 2}
b. ⟦ liang ⟧ 'two' = λ*m*λ*P*: Atomic(*P*).{*x*: **P*(*x*) ∧ *m*(*x*) = 2}
c. ⟦ zhi ⟧ "CL" = μ_{card}

(24) Equivalence: ⟦ liang zhi ⟧ = λ*P*: Atomic(*P*).{*x*: **P*(*x*) ∧ μ_{card}(*x*) = 2} = ⟦ two ⟧

On this view, the locus of variation between English and Mandarin lies in the semantics of numerals. Because Mandarin numerals lack the cardinality function

13. Under Krifka's original proposal, numerals simply denote numbers and sortal classifiers encode a measure function OU (for object units). Moreover, the mechanism of *counting* is considered as a mechanism of *measuring*. Krifka's formalization is illustrated in (i), where RT is realization relation between a kind and its instances at the situation/world *i*.

(i) ⟦ san ⟧ 'three' = 3 (Krifka 1995: 401)
⟦ zhi ⟧ 'CL' = λnλyλiλx[$\mathbf{RT}_i$(x, y) ∧ $\mathbf{OU}_i$(y)(x) = n]
⟦san-zhi-xiong⟧ 'three bears' = λiλx[$\mathbf{RT}_i$(x, BEAR) ∧ $\mathbf{OU}_i$(BEAR)(x) = n]

As we shall see shortly in § 3, my analysis is similar to Krifka's original proposal regarding the semantics of classifiers, but it crucially differs in assuming that *counting* and *measuring* are two different operations (see also Rothstein 2017).

and this missing piece is crucially provided by the semantics of individuating classifiers; thus, Mandarin CLs are required because of numerals.[14]

Recall that Mandarin sortal classifiers can be systematically optional in various degree constructions while the cardinality dimension remains accessible in both cases (with or without CLs). On the surface, it seems that Krifka's proposal may fare better than Chierchia's because the former does not deny the inherent capacity of Mandarin bare nouns to individuate; by contrast, the novel empirical data presented in this paper seems difficult to accommodate under the view that all Mandarin nouns are mass nouns and the role of CLs is to deliver the relevant set of instances (shifting a kind term into the corresponding property). Furthermore, the availability of both cardinality and non-cardinality monotonic dimensions for Mandarin unclassified nouns also challenges the claim that all Mandarin nouns are mass across the board. However, despite these challenges, does it mean that Chierchia's (1998) proposal is completely wrong and should be abandoned altogether? The simple answer is no. This paper suggests a mixed approach where the locus of variation between English and Mandarin lies in neither the semantics of numerals nor that of nouns, but those elements (being overt or covert) mediating between them, while incorporating Chierhcia's (1998; 2010) insights that CLs provide the level of individuation for Mandarin nouns and Krifka's (1995) insights that numerals do not encode the cardinality function. More specifically, the job of individuating classifier is two-fold: (a) they impose a partition over the instances of the kind relative to a numerical value denoted by the numeral; (b) they encode a cardinality function and *count* the number of atomic instances of the kind denoted by the noun, based on the partition.

3. The proposal

This section spells out my compositional analysis of the optionality of Mandarin individuating classifiers and its semantic impact in degree constructions. § 3.1 introduces some theoretical assumptions endorsed in this paper and offers the proposed semantics of individuating classifiers. § 3.2 illustrates how the composi-

14. Krifka (1995: 406) observes the fact that while the numeral-classifier-sequence *san zhi xiong* 'three bears' in Mandarin can only apply to collections of three individual bears, while *three bears* in English can additionally refer to species. Thus, Krifka suggests that the measure function in English *numerals* or *count nouns* is underspecified: it can be OU vs. OKU. Furthermore, this under-specification of measure function can be built into the semantics of *numerals* or that of *count nouns*; thus, two possible analyses emerge. Krifka evaluates the two analytical possibilities and presents several arguments against the latter; finally, Krifka (1995: 408) opts for the first option to build the classifier-like semantics into English numerals.

tion with numerals is captured in the proposed analysis. § 3.3 demonstrates how the proposed analysis applies to the optionality of CLs along with the interpretative variation on the relevant dimension of measurement.

3.1 Theoretical foundations

First, I assume with Krifka (1995) and Chierchia (1998) that bare nouns in Mandarin Chinese denote kinds (see also Yang 2001). For concreteness, I shall adopt the version of the neo-Carlsonian approach proposed in Chierchia (1998). Kinds are like plural individuals in the sense that a kind can be identified as the sum of all individual instantiations of the kind. Take the dog kind for instance. It can be modeled as the largest member of the plural individual comprising all dogs. There is a correspondence between kinds and properties: the dog kind corresponds to the property of being a dog; conversely, dogs instantiate the dog kind. Chierchia (1998) exploits this correspondence and proposes systematic mappings (a) from kinds to their corresponding properties via a process of nominalization (the down operator $^{\cap}$, a nominalizer) as defined in (25), and (b) from properties to their corresponding kinds via a process of predicativization (the up operator $^{\cup}$, a predicativizer) as defined in (26).

(25) Nominalization (*nom*: $^{\cap}$)
For any property P and world/situation s,
$^{\cap}P = \lambda s\, \iota P_s$, if $\lambda s\, \iota P_s$ is in K (the set of kinds), undefined otherwise,
where P_s is the extension of P in s.

(26) Predicativization (*pred*: $^{\cup}$)
Let K be a kind, then for any world/situation s,
$^{\cup}K = \lambda s \lambda x.\ [x \leq K_s]$, undefined otherwise.
where K_s is the plural individual that comprises all of the atomic members of the kind.

However, unlike Chierhcia (1998), I assume that the application of the predicativization operator$^{\cup}$ in Mandarin comes as *last resort*, when composing Mandarin quantifiers with bare nouns.[15] Therefore, *ceteris paribus*, Mandarin bare nouns

15. Chierchia (1998) does not discuss how Mandarin quantifiers compose with bare nouns. But as indicated by the empirical facts in this paper, a bunch of quantifiers, such as *hen-duo* 'a lot', *tai-duo* 'too many/much', *name-duo* 'so many/much', *zheme-duo* 'this many/much', *geng-duo* 'even more', *zui-duo* 'the most amount of', etc., can either directly compose with the noun or with the classifier phrase containing the noun (i.e., the optionality of classifiers). If Mandarin bare nouns only denote kinds (i.e., never obtain their predicative meanings without classifiers), then we immediately need at least two lexical entries for each quantifier: one for them

denote kind terms by default and their shifted predicative meanings only come as the last resort, as shown in (27).

(27) a. Kind denotation:
$[\![\text{pingguo}]\!] = \text{APPLE}$ The default (kind terms)
b. Property denotation:
$[\![\text{pingguo}]\!] = \lambda x_e.{}^{\cup}\text{APPLE}$[16] The last resort (via $^{\cup}$)

Second, I assume with the abundant studies on modified numerals that bare numerals denote degree terms (e.g., Hackl 2001; Nouwen 2010; Kennedy 2015; Buccola & Spector 2016; Jackson & Penka 2017; Bylinina & Nouwen 2018, among others). Thus, the semantics of the numeral *san* 'three' denotes the numerical value *3* (of type *d*), as shown below.

(28) $[\![\text{san}]\!] = 3_d$

Third, to deal with various Mandarin degree constructions involving the quantity adjective *duo* 'much' (Q-adjective), I assume with Wellwood (2015; 2019) that the Q-adjective *duo* semantically encodes a measure function μ, whose dimension is contextually-valued by the assignment function *A*. Specifically, I assume a relational version of Wellwood's proposal, as shown in (29).[17]

(29) $[\![duo]\!]^A = \lambda d_d.\lambda\alpha_{\langle\eta\rangle}.A(\mu)(\alpha) \geq d$ $<d, <<\eta, t>>$

In (29), the measure function μ is of type $<\eta, d>$, where the input domain can be either individuals or degrees: the type η ranges over the domain of individuals (type *e*) and that of degrees (type *d*).[18]

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to directly compose with kinds, and the other compose with classifiers. However, if we allow the predicativization operator to be freely available in Mandarin, then we lose Chierchia's (1998) insights on the bunch of seemingly-unrelated properties of [+arg, -pred] languages like Mandarin, such as the lack of the definite article and the distribution of bare nouns in argumental position (among others). Given the tension between the burden on the lexical entries of Mandarin quantifiers and the typological properties of Mandarin, it is important to emphasize that the application of the predicativzation operator only comes as the last resort, rather than freely available.

16. For readability, I shall ignore the subscript *s* (for situation) in the intensional property (of type $<s, <e, t>>$) obtained via the predicativization operator. I thank one anonymous reviewer for pointing out this issue.

17. See Chen (Forthcoming: § 5.2) for discussion that the interval-based semantics of the Q-adjective *much* suggested in Solt (2015) & Rett (2008; 2014; 2018) can be considered a relational version of Wellwood's proposal for *much*.

18. Under Wellwood's (2015) original proposal, the input domain of μ can be various sorts of semantic objects such as individuals, events or states. For purposes of this paper, only individuals and degrees are relevant here.

Finally, let us shift our attention to the semantics of individuating classifiers. Given our semantics of bare numerals, crucially, without further ado, it naturally follows that (bare) numerals cannot directly combine with nouns due to a type-mismatch, unless *something* mediates in-between, as schematized in (30).

(30) a. Numeral + NP
d $\langle e, t \rangle$, or $\langle s, e \rangle$ **type-mismatch!**
b. Numeral + ?? + NP
d $\langle e, t \rangle$, or $\langle s, e \rangle$

The leading idea here is that individuating CLs are one natural candidate mediating between numerals and nouns to avoid the type-mismatch in natural language. Specifically, I propose that Mandarin individuating CLs encode the cardinality function (Krifka 1995). Moreover, individuating CLs impose a partition (relative to the numerical value denoted by the numeral) on the instances of the kind denoted by the noun and picks out those (plural) individuals for which there is a cover *C*, whose cardinal value is provided by the numeral. Finally, individuating CLs require the individuals in the cover to be *atomic* relative to the instances of the kind denoted by the noun.[19] For concreteness, (31) presents the semantics of the individuating/sortal classifier *ke*, and (32) provides the formal definition of *partition* and *cover* (e.g., Schwarzschild 1993; Ionin & Matushansky 2006).[20]

(31) $[\![\text{ke}]\!] = \lambda k_{\langle s, e \rangle} . \lambda d_{d} . \lambda x_{e} . \exists C [{}^{\cup} k(x) \wedge \prod(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(k)]$[21]

---

19. The notion of *atomicity* used here is only for illustrative purposes. As discussed in Grimm (2012), there are many empirical challenges to the definition of an atom. Extending the traditional mereology with topology, Grimm proposes to replace the notion of atomicity with the notion of maximally strongly self-connectedness (MSSC). One is welcome to adopt the notion of MSSC or MSC Maximally-self-connectedness; see Scontras (2014: 96) in replacement of atomicity.

20. Although it seems novel to apply the cover theory to the semantic interpretation of the numeral-classifier-noun sequence in Mandarin as suggested in this paper, it is certainly not new to see the application of the cover theory in the semantics of numeral expressions or the numeral-classifier-noun sequence in natural languages (see e.g., Ionin & Matushansky 2006 for complex numerals, and Dayal 2014 for Bangla plural classifiers).

21. For illustrative purposes, I assume a right-branching structure for Mandarin sortal classifiers. Nothing crucial in the analysis hinges on this choice. For simplicity, I ignore the semantic selection restriction between sortal classifiers and nouns combined with them. For example, the sortal classifier *ke* semantically requires the relevant objects to have a round shape. One way of capturing such semantic requirement is to encode them as a presuppositional condition on the use of the classifier, as shown in (i).

(32) a. C is a **partition** $\prod$ of an entity x if it is a cover of x and its cells do not overlap $\prod$ (C)(x) = 1 iff C is a cover of x, and $\forall$ z, y $\in$ C [z = y $\vee$ $\neg$ $\exists$a [a $\leq_i$ z $\wedge$ a $\leq_i$ y]]

b. A set of individuals C is a **cover** of a plural individual X iff X is the sum of all members of C: $\sqcup$C= X

Let us recall Krifka's (1995) insights that numerals do not encode the cardinality function, which is crucially provided by individuating CLs, and Chierchia's (2010) view that individuating CLs plays the role of individuation (i.e., returning a set of atomic instances of the kind denoted by the noun). The proposed semantics of individuating CLs in (31) incorporates those insights from both approaches: under the current analysis, individuating CLs not only encodes the cardinality function (Krifka 1995) but also provides the level of individuation (Chierchia 1998; 2010) by requiring the individuals in the cover to be *atomic* relative to the kind denoted by the noun (a relational sense of atoms).[22]

The following two subsections illustrate how the proposed semantics of individuating classifiers captures the compositions in the case of numerals and in that of degree constructions.

(i) $[\![\text{ke}]\!] = \lambda k_{\langle s, e \rangle} . \lambda d_d . \lambda x_e$: round($x$).$\exists C[^{\cup} k(x) \wedge \prod(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(k)]$

22. One anonymous reviewer wonders why the notion of partition is needed for counting. In this paper, I assume with Rothstein's insights that counting and measuring are two different semantic operations; in particular, the formalization here first utilizes the notion of partition (relative to numerical values, which is the contribution of numerals) and cardinality function, which are intended to obtain the effect of "**putting entities in one-to-one correspondence with the natural numbers**", and then makes the second part of the semantics of classifiers require the cells in the partition to be atomic relative to the kind, which is intended to obtain the effect of "**requiring a contextually determined choice to what counts as one entity**". Note that the notion of atomicity can be replaced with other relevant mereo-topological notions discussed in Grimm (2012) or Scontras (2014). However, it is worth emphasizing that the goal of this paper is NOT to argue for a particular theory of the mass-count distinction against all the others. Given the purpose of this paper, I do not see any reason why the semantics of Mandarin classifiers cannot be adapted in the system of Rothstein (2010), Landman (2016), or Sutton & Filip (2016), as long as the syntactic optionality of Mandarin classifiers and its semantic impact on quantity judgments in degree constructions can be properly explained. I thank the reviewer for helping me clarify the ideas behind the formalization.

3.2 The case of numerals

Let us consider the composition with numerals. (33) illustrates the semantic computation of the Mandarin phrase *liang-ke-pingguo* 'two apples' in the numeral-classifier-noun sequence.

(33) **Mandarin: *liang* 'two' + CL + *pingguo* 'apple'**

a. $[\![\text{liang}]\!] = 2_{\text{d}}$

b. $[\![\text{ke}]\!] = \lambda k_{\langle \text{s,e} \rangle} . \lambda d_{\text{d}} . \lambda x_{\text{e}} . \exists C[^{\cup} k(x) \wedge \Pi(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(k)]$

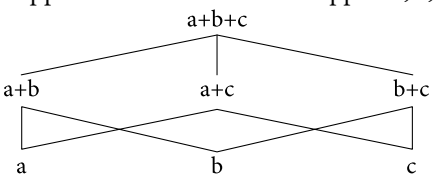
c. $[\![\text{pingguo}]\!] = \textsc{apple}$

d. $[\![\textit{ke-pingguo}]\!]$
$= \lambda d_{\text{d}} . \lambda x_{\text{e}} . \exists C[^{\cup} \textsc{apple}(x) \wedge \Pi(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(\text{apple})]$

e. $[\![\text{liang-ke-pingguo}]\!]$
$= \lambda x_{\text{e}} . \exists C[^{\cup} \textsc{apple}(x) \wedge \Pi(C)(x) \wedge |C| = 2 \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]$

According to (33), the Mandarin noun *pingguo* 'apple' is a kind term; the individuating classifier *ke* imposes a partition over the set of individuals relative to the cardinal value provided by the numeral *liang* 'two'; moreover, it requires that the individuals in the cover are atomic instances of the kind denoted by the noun *pingguo* 'apple'. Below, (34) illustrates the partition and covers in a toy context.

(34) a. Supposes that there are three apples *a, b, c* in the discourse:



b. [[liang-ke-pingguo]] = {a+b, b+c, a+c}

c. Covers: {a, b} {b, c} {a, c}

So far, we have seen how Mandarin individuating classifiers compose with numerals.[23] The next section presents a compositional analysis on the optionality of CLs in degree constructions.

3.3 The optionality of Mandarin individuating classifiers

Recall that Mandarin individuating CLs can be optional in various degree constructions. In this section, I use the positive construction as my illustration of the analysis. Similar analysis can be applied to other degree constructions. For expository purposes, I assume with Liu (2018) that Mandarin has a covert *pos*-morpheme *POS*, which (simplified a bit) requires the relevant degree(s) to exceed a contextual threshold for a gradable property (see von Stechow (1984) and Kennedy (1999) for the semantics of *pos*-morpheme).[24] Now, let us first con-

23. One anonymous reviewer wonders about what impact the current analysis would have on Chinese dialects that have [CL+N] for singular nominal reading. Would a single atomic structure within the set denoted by the noun be predicted under such a case? On the proposed analysis, *ceteris paribus*, classifiers semantically deliver a set of entities consisting of singular individuals and plural individuals (undergoing partition into subsets of entities relative to the numerical value). On this view, classifiers themselves do not determine the referential property of noun phrases or the plurality/singularity of noun phrases. To extend the current analysis to dialects that have [CL+N] for singular nominal meaning, at least two fundamental questions are worth considering: (a) Do those classifiers in the given dialect have exactly the same semantic representation as their counterparts in Mandarin? (b) Does the given dialect have any covert numerals in the language? These two questions are important because a negative answer to any of the two questions would lead us to the empirical facts dramatically different from what have been observed in Mandarin. If the answer to the first question is negative, then we may have a semantic representation of classifiers that encodes referentiality (and potentially also does something else); if the answer to the second question is negative, then we may have covert numeral one which provides the level of granularity for partition (into a set of atomic entities), and the classifier or some referential element (e.g., iota operator) determines the referential property. The two analytical options discussed here are not meant to be exhaustive, but it highlights the general connection between referentiality and the semantics of classifiers.

Another possibility is that the fact that sortal classifiers are required because of numerals (rather than nouns) may not be a universal property of classifier languages. More specifically, the reason why sortal classifiers are required in classifier languages may be subject to certain linguistic variation. Thus, it is possible that for some classifier languages, sortal classifiers have a closer syntactic relation with nouns than with numerals (thus the sequence [CL+N] with no numerals is not only well-formed but also has a different semantic interpretation than the sequence [Num+CL+N] does in a given language). I leave open whether and how the mixed approach advocated in this paper can be extended to these classifier languages.

24. In Chinese linguistics, there is an ongoing debate on whether the word *hen* 'very' is an overt *pos*-morpheme in Mandarin. In this paper, I remain neutral and agnostic about whether the word *hen* is the overt *pos*-morpheme. Interested readers are referred to Grano (2012); Liu

sider the case where sortal/individuating CLs are present in degree constructions. The relevant Mandarin example is repeated in (35). The LF and the semantic computation are illustrated in (36). Note that the assignment function *A* provides a contextually-valued dimension for the Q-adjective *duo* (Wellwood 2014; 2019), *c* gives the relevant contextual threshold d_c, and *g* values the indexes associated with the relevant syntactic traces.

(35) **The case with CLs: *henduo* 'a lot of' + CL + *pingguo* 'apple'**
Zhangsan mai-le ***hen-duo*** ***ke*** *pingguo.* **√cardinality; #weight**
Zhangsan buy-ASP very-much CL apple
'Zhangsan bought many apples.'

(36) a. LF: [**POS** [λ2 [d_2-**duo** [λ1 [Zhangsan bought [∃ [d_1-[**ke**- apple]]]]]]]]

b. $[\![duo_\mu]\!]^{A,c,g} = \lambda d_d.\lambda\alpha_{\langle d,t\rangle}.\, A(\mu)(\alpha) \geq d$ <d, <<d, t>, t>>

c. $[\![ke]\!]^{A,c,g} = \lambda k_{\langle s,e\rangle}.\lambda d_d.\lambda x_e.\, \exists C[^{\cup}k(x) \wedge \Pi(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(k)]$

d. $[\![pingguo]\!]^{A,c,g} = \textsc{apple}$

e. $[\![ke\text{-}pingguo]\!]^{A,c,g}$
$= \lambda d_d.\lambda x_e.\exists C[^{\cup}\textsc{apple}(x) \wedge \Pi(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]$

f. $[\![\,[d_1\text{-}[\textbf{ke}\text{-apple}]]\,]\!]^{A,c,g}$
$= \lambda x_e.\exists C[^{\cup}\textsc{apple}(x) \wedge \Pi(C)(x) \wedge |C| = g(1) \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]$

g. $[\![\,[\text{Zhangsan bought } [\exists\ [d_1\text{-}[\textbf{ke}\text{-apple}]]]]\,]\!]^{A,c,g}$
$= \exists z[\text{bought}(\text{Zhangsan}, z) \wedge \exists C[^{\cup}\textsc{apple}(z) \wedge \Pi(C)(z) \wedge |C| = g(1) \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]]$

h. $[\![\,[d_2\text{-}\textbf{duo } [\lambda 1\ [\text{Zhangsan bought } [\exists\ [d_1\text{-}[\textbf{ke}\text{-apple}]]]]]]\,]\!]^{A,c,g}$
$= A(\mu)(\lambda d.\ \exists z[\text{bought}(\text{Zhangsan}, z) \wedge \exists C[^{\cup}\textsc{apple}(z) \wedge \Pi(C)(z) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]]) \geq g(2)$

i. $[\![\,[\lambda 2\ [d_2\text{-}\textbf{duo } [\lambda 1\ [\text{Zhangsan bought } [\exists\ [d_1\text{-}[\textbf{ke}\text{-apple}]]]]]]]\,]\!]^{A,c,g}$
$= \lambda d''.\, A(\mu)(\lambda d.\ \exists z[\text{bought}(\text{Zhangsan}, z) \wedge \exists C[^{\cup}\textsc{apple}(z) \wedge \Pi(C)(z) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]]) \geq d''$

j. $[\![POS]\!]^{A,c,g} = \lambda D'_{\langle d,t\rangle}.\exists d'[D'(d') \wedge d' > d_c]$ <<d, t>, t>

k. $[\![\,(35)\,]\!]^{A,c,g} = 1$
iff $\exists d'[A(\mu)(\lambda d.\ \exists z[\text{bought}(\text{Zhangsan}, z) \wedge \exists C[^{\cup}\textsc{apple}(z) \wedge \Pi(C)(z) \wedge |C| = d \wedge \forall y \in C \rightarrow \text{Atom}(y)(\textsc{apple})]]) \geq d' \wedge d' > d_c]$

(2018) and references cited therein for detailed discussion. The current analysis of optional classifiers does not hinge on the status of the word *hen*. I thank an anonymous reviewer for raising this issue for clarification.

The bolded part in (36k) indicates the semantic contribution of the individuating classifier *ke*. (36b–d) are given by the lexical entries of *duo*, the noun *pingguo* and the classifier *ke*. (36e) is obtained by the composition of the individuating classifier and the noun via Functional Application. (36f) is derived by the quantifier-raising of *duo*, which leaves a degree trace saturating the numeral argument of the classifier. (36g) is derived by the composition of the verb with the syntactic subject and the syntactic object (with an existential closure over the individual variable in the semantics of the syntactic object). (36h) is derived by the composition of *duo* with the rest of the sentence via Functional Application (i.e., Predicate Abstraction over the degree trace). (36i) is obtained via Predicate Abstraction over the degree trace left by the quantifier-raising of *POS*. (36j) is given by the lexical semantics of *POS*. Finally, (36k) presents the truth-conditions of (35): according to (36k), (35) is judged true iff the number of apples that *Zhangsan* bought exceeds a certain contextual standard. Taken together, in (36), the individuating classifier *ke* imposes a partition over the set of apples relative to the cardinal value *d* and requires the apples in the partition to be atomic, and the Q-adjective *duo* induces a higher-order measurement on the degree interval (i.e., the number of apples that *Zhangsan* bought) where the number of apples exceeds a degree *d'*.[25] Finally, *POS* requires the degree *d'* to exceed a contextually-given standard d_c. Crucially, the dimension of comparison must be cardinality because the individuating classifier *ke* semantically encodes the cardinality function.

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25. One anonymous reviewer wonders how the measurement of degrees is done. First of all, it is worth pointing out that the idea and the operation of measuring degrees are not unique to this paper. Rett (2008) has explicitly argued that quantity adjectives in Balkan (like Romanian *mult*) semantically encode a measurement operator over degrees (i.e., overt realization of M-OP$_d$ in Rett 2014; see also Rett 2014: § 5). Rett (2014: § 4) provides a detailed discussion on the idea of measuring degrees. In particular, Rett (2014: 59) suggests a sample entry of M-OP$_d$: *λD.λd''. μ(D)= d''*. According to Rett (2014: 256), the degree-measuring operator M-OP$_d$ measures the *size* of a set of degrees. Furthermore, Rett (2014: 61) suggests *equality of measure*, as demonstrated below:

(i) a. $\mu_{\text{quantity}}(a \oplus b \oplus c) = \{1, 2, 3\}$
b. $\mu_{\text{d}}(\{1, 2, 3\}) = 3$

As Rett (2014: 256) puts it; "Although the maximum plurality in (61) numbers 3, there is also a member of the plurality (e.g. a⊕b) that numbers 2, and another member (e.g. a) that numbers 1. So the set of quantity measures of the plurality a⊕b⊕c is {1,2,3}." To my understanding, the set of degrees is akin to the notion of intervals and the operator M-OP$_d$ is like a function from an interval to its highest point. Interested readers are referred to Rett (2008; 2014) for more detailed discussion on the measurement of degrees and the overt lexical realization of the degree-measuring operator M-OP$_d$ in natural language.

Now, let us consider the case where sortal/individuating CLs are absent in degree constructions. The relevant Mandarin example is repeated in (37). The LF and the semantic computation are illustrated in (38).

(37) **The case without CLs: *henduo* 'a lot of' + *pingguo* 'apple'**
Zhangsan mai-le ***hen-duo*** *pingguo.* **√cardinality; √weight**
Zhangsan buy-ASP vey-much apple
'Zhangsan bought a lot of apples.'

(38) a. LF: [**POS** [λ2 [Zhangsan bought [∃ [d_2-**duo** [apple]]]]]]
b. $[\![duo_{\mu}]\!]^{A,c,g} = \lambda d_{d}.\lambda \alpha_{e}.\ A(\mu)(\alpha) \geq d$ <d, <e, t>>
c. $[\![pingguo]\!]^{A,c,g} = \lambda x_{e}.{}^{\cup}\text{APPLE}\ (x)$
d. $[\![\ [d_2\text{-}\mathbf{duo}\ \text{apple}]\ ]\!]^{A,c,g}$
$= \lambda x_{e}.{}^{\cup}\text{APPLE}\ (x) \wedge A(\mu)(x) \geq g(2)$
e. $[\![\ [\text{Zhangsan bought}\ [\exists\ [d_2\text{-}\mathbf{duo}\ \text{apple}]]]\ ]\!]^{A,c,g}$
$= \exists z[\text{bought(Zhangsan, } z) \wedge {}^{\cup}\text{apple}(z) \wedge A(\mu)(z) \geq g(2)]$
f. $[\![POS]\!]^{A,c,g} = \lambda D'_{\langle d,t\rangle}.\exists d'[D'(d') \wedge d' > d_c]$ <<d, t>, t>
g. $[\![\ (37)\ ]\!]^{A,c,g} = 1$ iff $\exists d'\ \exists z[\text{bought(Zhangsan, } z) \wedge {}^{\cup}\text{apple}(z) \wedge A(\mu)(z) \geq d' \wedge d' > d_c]$

(38b–c) are given by the lexical semantics of *duo* and the predicativization of the noun *pingguo*. (38d) is obtained by the composition of *duo* with the noun *pingguo* via Predicate Modification (the degree argument of *duo* is saturated by the trace left the quantifier-raising of *POS*). (38e) derived by the composition of the verb with the syntactic subject and the syntactic object (with an existential closure over the individual variable in the semantics of the syntactic object). (38f) is given by the lexical semantics of *POS*. Finally, (38g) presents the truth-conditions of (37), according to (38g), (37) is judged true if and only if the number of apples that *Zhangsan* bought exceeds a certain contextual standard (i.e., cardinality) or the amount of apples that *Zhangsan* bought has a measure value which exceeds the contextual standard along a contextually-given dimension (e.g., weight). Specifically, in (37), the amount of apples that *Zhangsan* bought can be evaluated in terms of cardinality or other monotonic dimensions such as weight, as long as the relevant value exceeds a certain contextual threshold. Crucially, given that no individuating classifier (encoding the cardinality function) is present in the degree construction, the availability of both cardinality and non-cardinality monotonic dimensions such as weight arise from the semantics of *duo*

(i.e., the dimension of comparison is left open), together with the semantics of the Mandarin unclassified noun *pingguo*.[26]

Before leaving this section, I would like to further demonstrate how the current analysis applies to other degree constructions, taking the degree demonstrative construction for illustration. This is done to further strengthen the fact that the proposed analysis is not limited to the positive construction, but generalized to a variety of degree constructions interacting with optional classifiers (see § 1). Now, let us first consider the case where sortal/individuating CLs are present. The relevant Mandarin example is repeated in (39). The LF and the semantic computation are illustrated in (40).

(39) **The case with CLs: *nameduo* 'that amount' + CL + *pingguo* 'apples'**
Zhangsan (jingran) *mai-le* ***name-duo ke*** *pingguo!*
Zhangsan surprisingly buy-ASP that-much CL apple
'(Surprisingly,) Zhangsan bought that many apples.'

(40) a. LF: [**name-duo** [λ1 [Zhangsan bought [∃ [d_1-[**ke**-apple]]]]]]
b. $[\![duo_{\mu}]\!]^{A,c,g} = \lambda d_{d}.\lambda\alpha_{\langle d,t\rangle}.\ A(\mu)(\alpha) \geq d$ <d, <<d, t>, t>>
c. $[\![ke]\!]^{A,c,g} = \lambda k_{\langle s,e\rangle}.\lambda d_{d}.\lambda x_{e}.\ \exists C[^{\cup}k(x) \wedge \prod(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \mathrm{Atom}(y)(k)]$
d. $[\![pingguo]\!]^{A,c,g} = \textsc{apple}$
e. $[\![ke\text{-}pingguo]\!]^{A,c,g}$
$= \lambda d_{d}.\lambda x_{e}.\ \exists C[^{\cup}\textsc{apple}(x) \wedge \prod(C)(x) \wedge |C| = d \wedge \forall y \in C \rightarrow \mathrm{Atom}(y)(\textsc{apple})]$
f. $[\![name]\!]^{A,c,g} = \iota d\ [d = d_c]$
g. $[\![name\text{-}\mathbf{duo}]\!]^{A,c,g} = \lambda\alpha_{\langle d,t\rangle}.\ A(\mu)(\alpha) \geq \iota d$, where $d = d_c$
h. $[\![\ [d_1\text{-}[\mathbf{ke}\text{-apple}]]\ ]\!]^{A,c,g}$
$= \lambda x_{e}.\ \exists C[^{\cup}\textsc{apple}(x) \wedge \prod(C)(x) \wedge |C| = g(1) \wedge \forall y \in C \rightarrow \mathrm{Atom}(y)(\textsc{apple})]$
i. i. $[\![\ [\lambda 1\ [\text{Zhangsan bought } [\exists\ [d_1\text{-}[\mathbf{ke}\text{-apple}]]]]]]\ ]\!]^{A,c,g}$
$= \lambda d'.\exists z[\text{bought}(\text{Zhangsan}, z) \wedge \exists\ C[^{\cup}\textsc{apple}(z) \wedge \prod(C)(z) \wedge |C| = d\ ' \wedge \forall y \in C \rightarrow \mathrm{Atom}(y)(\textsc{apple})]]$
j. $[\![\ (39)\ ]\!]^{A,c,g} = 1$
iff $A(\mu)(\lambda d.\ \exists z[\text{bought}(\text{Zhangsan}, z) \wedge \exists\ \mathbf{C}[^{\cup}\mathbf{APPLE}(z) \wedge \prod(C)(z) \wedge |\mathbf{C}| = \boldsymbol{d} \wedge \forall y \in \boldsymbol{C} \rightarrow \mathbf{Atom}(y)(\textsc{apple})]]) \geq \iota d$, where $d = d_c$

As before, the bolded part in (40j) indicates the semantic contribution of the individuating classifier *ke*. (40b–d) are given by the lexical entries of *duo*, the noun

26. See § 4.2, where a tentative semantics for the mass-count neutrality of Mandarin unclassified nouns is suggested.

pingguo and the classifier *ke*. (40e) is obtained by the composition of the individuating classifier and the noun via Functional Application. (40f) provides the semantics of the degree demonstrative *name*, assuming that it is anaphoric and refers to a degree that is previously established in the discourse (i.e., d_c). (40g) composes the degree demonstrative *name* with the Q-adjective *duo* via Functional Application. (40h) is derived by the quantifier-raising of *name-duo*, which leaves a degree trace saturating the numeral argument of the classifier. (40i) is derived by the composition of the verb with the syntactic subject and the syntactic object (with an existential closure over the individual variable in the semantics of the syntactic object) and by Predicate Abstraction over the degree trace. Finally, (40j) presents the truth-conditions of (39): according to (40j), (39) is judged true iff the number of apples that *Zhangsan* bought exceeds the contextual degree which is established in the previous discourse and the degree demonstrative *name* is referring to. Again, given that classifiers semantically encode the cardinality function, this explains why the presence of classifiers unequivocally restricts the dimension of comparison to be only cardinality (other non-cardinality monotonic dimensions become unavailable).

Next, let us turn to the case where sortal/individuating CLs are absent. The relevant Mandarin example is repeated in (41). The LF and the semantic computation are illustrated in (42).

(41) **The case without CLs: *nameduo* 'that amount' + *pingguo* 'apples'**
Zhangsan (jingran) *mai-le* ***name-duo*** *pingguo!*
Zhangsan surprisingly buy-ASP that-much apple
'(Surprisingly,) Zhangsan bought that amount of apples.'

(42) a. LF: [Zhangsan bought [∃ [**name-duo** [apple]]]]
b. $[\![duo_{\mu}]\!]^{A,c,g} = \lambda d_{d}.\lambda\alpha_{e}.\ A(\mu)(\alpha) \geq d$ <d, <e, t>>
c. $[\![pingguo]\!]^{A,c,g} = \lambda x_{e}.{}^{\cup}\textsc{apple}(x)$
d. $[\![name]\!]^{A,c,g} = \iota d\ [d = d_c]$
e. $[\![\ [name\text{-}\mathbf{duo}]\ ]\!]^{A,c,g} = \lambda\alpha_{e}.\ A(\mu)(\alpha) \geq d$, where $d = d_c$
f. $[\![\ [name\text{-}\mathbf{duo}\ \text{apple}]\ ]\!]^{A,c,g}$
$= \lambda x_{e}.{}^{\cup}\textsc{apple}(x) \wedge A(\mu)(z) \geq \iota d$, where $d = d_c$
g. $[\![\ (41\rangle\ )\ ]\!]^{A,c,g} = 1$ iff $\exists z$[bought(Zhangsan, z) $\wedge$ ${}^{\cup}\textsc{apple}(z) \wedge A(\mu)(z) \geq \iota d$], where $d = d_c$

(42b–d) are given by the lexical semantics of *duo*, the predicativization of the noun *pingguo*, and the lexical semantics of *name*. (42e) composes the degree demonstrative *name* with the Q-adjective *duo* via Functional Application. (42f) is obtained by the composition of *name-duo* with the noun *pingguo* via Predicate Modification. Finally, (42g) presents the truth-conditions of (41), according to

(42g), (41) is judged true if and only if the number of apples that *Zhangsan* bought exceeds the contextual degree which is previously mentioned in the discourse and the degree demonstrative is anaphoric to (i.e., cardinality) or the amount of apples that *Zhangsan* bought has the contextual degree which is previously mentioned in the discourse and the degree demonstrative is anaphoric to, along a contextually-given dimension (e.g., weight). Crucially, given that no individuating classifier (encoding the cardinality function) is present in the degree demonstrative construction, the accessibility to both cardinality and non-cardinality monotonic dimensions such as weight arise from the semantics of *duo* (i.e., the dimension of comparison is left open), together with that of the Mandarin unclassified noun *pingguo*.[27, 28]

4. Implications

This section discusses some important implications of the current analysis of SMs by addressing two issues: (a) classifiers are required for both numerals and nouns; (b) some (if not all) Mandarin nouns are mass-count neutral, reminiscent of their property of being number-neutral.

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27. One anonymous reviewer suggests that the current analysis may be extended to verbal classifiers and the domain of event, and wonders about the relevant Mandarin data. As shown in (i), the verbal classifier *ci* 'times' similarly combines with a bunch of different (degree) quantifiers, parallel with the facts about sortal classifiers discussed in this paper.

(i) *Zhangsan qu-guo Taipei {hen-duo-/ tai-duo-/ name-duo geng-duo-/ zui-duo} *(ci).*
Zhangsan go-ASP Taipei very-much too-much that-much more-much SUP-much CL
'Zhangsan has been to Taipei many times/too many times/so many times/more times/the most times.'

One notable difference is the fact that the verbal classifier *ci* 'times' cannot be omitted in the counting of events. For reasons of space, I leave research on the degree semantics of verbal classifiers to the future. I thank the reviewer for drawing my attention to the case of verbal classifiers and suggesting this line of research.

28. The editor raises a question about whether a decompositional analysis of these degree quantifiers is required in this paper. Although the proposal in this paper does not hinge on the choice of a decompositional analysis, I believe that decomposing these degree quantifiers are necessary based on morpho-semantic grounds. Of course, we can assign some independent lexical entries to each of these degree quantifiers (e.g., *hen-duo* 'a lot', *tai-duo* 'too many/much', *name-duo* 'so many/much', *zheme-duo* 'this many/much', *geng-duo* 'even more', *zui-duo* 'the most amount of', etc.), but such a move (to me) appears to miss the generalization that these degree quantifiers all involve the Q-adjective *duo* 'much' and a degree morpheme in one way or another, and miss the link between the morphology of these degree quantifiers and their semantics.

4.1 Classifiers are required for both numerals and nouns

A key contrast between a typical number-marking language such as English and a typical classifier language such as Mandarin is whether (bare) numerals can directly combine with nouns in a given language. Chierchia (1998; 2010) suggests that the locus of variation between English and Mandarin lies in the semantics of nouns, while Krifka (1995) proposes that it lies in the semantics of numerals. In this paper, based on the optionality of individuating classifiers in a variety of degree constructions, I have suggested a third approach, where the locus of variation between English and Mandarin lies in those elements mediating between numerals and nouns (assuming numerals are degree terms).

(43) a. Numeral + NP
d $\langle$e, t$\rangle$ or $\langle$s, e$\rangle$
type-mismatch!

b. Numeral + ?? + NP
d $\langle$e, t$\rangle$ or $\langle$s, e$\rangle$

In Mandarin, classifiers are the natural candidate mediating between numerals and nouns. A natural question immediately arises as to why English allows the apparently direct combination of nouns with numerals. In the literature on comparatives, it is not uncommon to assume that a covert measurement operator exists in English, though it has many different names by different authors (see e.g., *many* in Hackl 2001; M-OP in Rett 2014, 2018; *Meas* in Solt 2015; Kennedy 2015; Buccola & Spector 2016, among others). Furthermore, as pointed out by an anonymous reviewer, such covert operators mediating between numerals and nouns are also not uncommon to find in the literature on countability either (see e.g., Scontras 2014; Filip & Sutton 2017; Sag 2019).[29] Below, (45) illustrates the composition of the English phrase *three apples*, with the semantics of the covert operator M-OP (cf. Rett 2014; 2018) in (44).[30]

(44) $[\![\text{M-OP}]\!] = \lambda P_{\langle e, t\rangle}.\lambda d_d.\lambda z_e.[P(z) \wedge \mu_{card}(z) = d]$ (Rett 2014: 255)

29. I thank the reviewer for suggesting this point and bringing my attention to the existence of these covert operators in the literature on countability.

30. In Rett's (2014) original formulation, the dimension of M-OP is left open; while it is cardinality that is assumed here. This difference is related to Rett's analysis of the Q-adjective *much* and does not concern us here. See § 4.2 for more detailed discussion on the correlation between the relevant dimension of comparison and the denotations of nouns.

(45) **English: *three apples***

a. LF: [three [M-OP [apples]]]

b. $[\![\text{three}]\!] = 3_{\text{d}}$

c. $[\![\text{apples}]\!] = \lambda x_{\text{e}} .\text{apple}(x)$

d. $[\![\text{M-OP}]\!] = \lambda P_{\langle \text{e, t} \rangle} .\lambda d_{\text{d}}.\lambda z_{\text{e}}.[P(z) \wedge \mu_{\text{card}}(z) = d]$

e. $[\![\text{M-OP apples}]\!] = \lambda d_{\text{d}}.\lambda z_{\text{e}}.[\text{apple}(z) \wedge \mu_{\text{card}}(z) = d]$

f. $[\![\text{three M-OP apples}]\!] = \lambda z_{\text{e}}.[\text{apple}(z) \wedge \mu_{\text{card}}(z) = 3]$

In other words, bare numerals do not directly combine with nouns, even in English. Specifically, the apparent direct combination of numerals and nouns results from the existence of a covert measurement operator M-OP. Semantically, the numerical value names the number of atoms on the dimension cardinality. It is worth emphasizing that the current analysis does NOT claim that there is no mass-count distinction in English concerning the (in)compatibility between numerals and different types of nouns. Instead, the third approach advocated here offers a new perspective on the traditional observation that numerals cannot directly combine with mass nouns in English; under the current terms, numerals cannot combine with mass nouns even with the presence of M-OP. What is at stake underlying the nature of incompatibility is the fact that the dimension of cardinality cannot apply to mass nouns. Depending on one's particular view on the semantics of mass nouns, the reason could be that mass nouns lack atoms (Link 1983) or that mass nouns do not have stable atoms (Chierchia 1998; 2010), the number of (stable) atoms thus cannot be counted grammatically on the dimension of cardinality.[31]

At this point, it is worth pointing out that although Mandarin requires the obligatory presence of classifiers between nouns and numerals, not every classi-

31. There are many different views on how and where the mass-count distinction is encoded in the grammar (e.g., see Rothstein 2017: Chapter 4 for an overview and discussion). It is not our intention to claim that Link (1983) or Chierchia (1998; 2010) is the correct approach to the mass-count distinction, nor is it the purpose of this paper to evaluate different views on the mass-count distinction. The point here is simply to point out that under the current analysis, the core issue underlying the traditional observation on the (in)compatibility between numerals and the type of nouns is the fact that the dimension of cardinality does not (intuitively) apply to mass nouns, rather than the surface (in)compatibility with numerals. Any theory of mass-count distinction in natural language should be able to explain why the dimension of cardinality does not apply to mass nouns (while it readily applies to count nouns). Crucially, with this shift of perspective, the surface (in)compatibility with numerals will no longer be a reliable diagnostic for the type of nouns; it would then depend on (a) whether a language has a covert M-OP; (b) what the specific semantics of M-OP is. Specifically, these two parameters will together determine whether numerals can *directly* combine with mass nouns on the surface in a given language and what interpretations arise with those combinations.

fier language does so (e.g., Magahi, Turkish, Hungarian, inter alia).[32] Crucially, note that languages like Magahi, Turkish, and Hungarian seem to involve a hybrid system with both number-marking and classifiers; classifiers in these languages can be optional even with numerals. This forms a sharp contrast with the pattern observed in Mandarin, where classifiers cannot be omitted and are obligatory with the presence of numerals; see (49) below. Thus, there is a further distinction within classifier languages regarding whether classifiers are obligatory (or optional) in the composition of nouns with numerals. Crucially, this additional distinction between classifier languages is compatible with the approach advocated here: Mandarin-type classifier languages have only overt individuating classifiers (but no covert measure operators), while other classifier languages may have both.[33]

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32. Interested readers are referred to Sag (2019) and references cited therein for discussion of optional classifiers in Turkish, and to Erbach et al. (2019) for discussion of Hungarian, which also demonstrates the pattern of optional classifiers.

33. One anonymous reviewer wonders what are the crucial factors leading to such a distinction (where some classifier languages have covert M-OP while others have only overt classifiers), despite the fact that they are all classifier languages. One possible line of thought is to consider such point of variation as is along the distinction between classifier languages vs. number-marking languages: more specifically, languages that are typical classifier languages such as Mandarin (among others) vs. languages that encode a hybrid system (have both classifiers and number-marking morphology) such as Turkish, inter alia. More generally, this paper provides a more nuanced perspective on the cross-linguistic facts concerning the apparent direct combination of nouns with numerals: the possibility of the presence of some covert operators (M-OP is simply a cover term; it may well be the cardinality head in number-marking languages, discussed in Scontras 2014; Sag 2019 and references therein). Note that Chierchia (2021) makes a similar suggestion for his Type III languages such as Nez Percé and Yudja and identifies the use of covert classifiers as a potential parameter of cross-linguistic variation. The main difference between the current analysis and Chierchia (2021) lies in the semantics of numerals: in this paper, it is assumed to be simply numerical values; in contrast, in Chierchia (2021), numerals sometimes can be simply numerical values and sometimes can be a predicative modifier imposing some semantic restrictions on the denotation of nouns. Crucially, the semantic content of what have been assigned to bare numerals as predicative modifiers in Chierchia (2021) is akin to that of M-OP envisioned in the current analysis (thus allowing numerals unequivocally and uniformly denote numerical values).

The same reviewer also wonders about what would be the semantic content of those covert operators M-OP. Given that M-OP is simply a cover term, the semantics of such covert operators/classifiers/cardinality heads may impose certain presuppositions on the denotation of nouns or have their own semantic contributions, depending on the linguistic facts of a given language. For example, such covert elements may impose restrictions that only nouns with an atomic structure can combine with M-OP and then in turn with numerals; assuming some version of semantic theories modeling the mass-count distinction in terms of the issue of atomicity, such semantic restriction of M-OP would lead us to the fact that numerals only combine with

Now, if we take a step back and focus on the distribution of classifiers in Mandarin, we immediately see that Mandarin classifiers are required due to the syntactic presence of numerals.[34] Zhang (2019) discusses some cases where Mandarin numerals are apparently missing, leaving the classifier-noun sequence stranded,

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count nouns, but not with mass nouns. Thus, on the approach advocated in this paper, the ultimate semantic content of M-OP in a given language is also closely connected with the semantic theory of the mass-count distinction.

34. One anonymous reviewer wonders how the claim that sortal classifiers are required due to the syntactic presence of numerals fares with the case of reduplicated classifiers in Mandarin, which essentially cannot combine with numerals: **san-ben-ben-shu*. The reviewer is correct in pointing out that Mandarin reduplicated classifiers cannot combine with numerals (i.e., any numeral higher than one). Crucially, however, this is only half of the story. In particular, *reduplicated classifiers in Mandarin require neither numerals nor nouns*; this property forms a sharp contrast to their non-reduplicated form (which is typically sandwiched between numerals and nouns) and thus challenges most (if not all) existing linguistic theories of classifiers (including the mixed approach advocated here, of course). Consider the following examples of reduplicated classifiers in Mandarin (adapted from the online source: https://www.jipai.cc/a/202105/580874.html):

(i) *Zhexie Wukelan junren, (yi)* ***ge-ge*** *dou shi yingxiong.*
These Ukrainian soldiers one CL-CL all be hero
'For these Ukrainian soldiers, each of them is a hero.'

(ii) *Zhexie zhaopian, (yi)* ***zhang-zhang*** *dou hen jingcai*
These pictures one CL-CL all very brilliant
'For these pictures, each of them is very brilliant.'

(iii) *Kan naxie hua, *(yi)* ***duo-duo*** *duo piaoliang a!*
Look.at those flower one CL-CL how beautiful SFP
'Look at those flowers! Each one is so beautiful!'

(iv) *Nimen pai-hao dui, *(yi)* ***ge-ge*** *jinqu.*
You stay line one **CL-CL** enter
'You guys line up! Go inside one by one.'

Three remarks are in order. First, all the examples of reduplicated classifiers above cannot combine with any numeral higher than one (e.g., *san* 'three'). Second, reduplicated classifiers convey some semantic flavor of distributivity, which is crucially absent in their non-reduplicated forms. Third, there is a further contrast between examples in (i) and (ii) versus those in (iii) and (iv), where the numeral *yi* 'one' can be apparently optional in the former case, while it seems obligatory in the latter. By considering reduplication as a morphological process of word-formation (e.g., as affixation), it is highly possible that those classifier words in the form of reduplication have different semantic representations and syntactic behaviors than their non-reduplicated forms; therefore, a different linguistic explanation is called for. Seen from this perspective, a detailed study of the syntax and semantics of reduplicated classifiers in Mandarin (especially the issue of whether the linguistic behaviors of reduplicated classifiers can be derived from those of their non-reduplicated forms) is left to future research. I thank the reviewer very much for drawing my attention to the case of Mandarin reduplicated classifiers.

as illustrated in (46). Crucially, the numeral information in (46) must be *one* (i.e., the *number* of novels cannot be understood to be any numeral above *one*); as argued in Zhang (2019), a covert numeral *yi* 'one' is hidden in these cases. The contrast in (47) further illustrates that numerals above *yi* 'one' cannot be absent under the intended meanings.

(46) *Zhangsan zuotian mai-le ben-xiaoshuo.*
Zhangsan yesterday buy-ASP CL-novel
'Zhangsan bought a novel yesterday.'

(47) a. *Zhangsan zuotian mai-le **(yi-)**ben-xiaoshuo.*
Zhangsan yesterday buy-ASP one-CL-novel
'Zhangsan bought a novel yesterday.'
b. *Zhangsan zuotian mai-le **#(san-)**ben-xiaoshuo.*
Zhangsan yesterday buy-ASP three-CL-novel
'Zhangsan bought three novels yesterday.'

The same point applies to the case with demonstratives, where numerals other than *yi* 'one' cannot be absent under the intended meanings, as evidenced by the contrast below. In other words, the classifier-noun sequence can only be interpreted as a covert numeral one hidden there.

(48) a. *zhe/na (yi-)ben-shu*
this/that one- CL-book
'this/that book'
b. *zhe/na #(san-)ben-shu*
this/that three-CL-book
'these/those three books'

By adding the current study, the emerging picture regarding the distribution of Mandarin classifiers is that classifiers are required due to the syntactic presence of numerals (i.e., the numeral can be an overt one like *san* 'three', or the covert numeral *yi* 'one' suggested in Zhang 2019).[35] See (49).

(49) **Classifiers are required for numerals**

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35. One anonymous reviewer wonders why the covert numeral can only be *yi* 'one', but not other numerals. To be honest, I do not have an answer to this question; however, it has been suggested that the numeral one is somehow special in the number system in natural language, given its presence still indicates the singularity of nouns. It is possible that given the special semantic connection between the numeral one and singularity, it may become the unmarked; in contrast, any numeral higher than one is connected to plurality and thus cannot be omitted or covert in order to specify the relevant information of cardinality. This conceptual/semantic reason suggests a broader picture than depicted here: the fact that only numeral one (in contrast to other numerals) can be covert or omitted may not be exclusively restricted to Mandarin,

a. With the syntactic presence of numerals, Mandarin sortal classifiers are *obligatory*
b. In degree constructions (with no numerals), Mandarin sortal classifiers can be *optional*.

Crucially, by considering numerals as degree terms, (49a) and (49b) are thus not independent of each other; a better understanding about the role of classifiers in natural language is thus obtained.

4.2 Mandarin bare nouns are mass-count neutral

This section addresses another implicational aspect of the current study: the connection between the relevant dimension of comparison and the denotations of nouns. Recall that we have seen in § 1 that a variety of Mandarin unclassified nouns in degree constructions demonstrate an intriguing flexibility in allowing both cardinality and non-cardinality monotonic dimensions as the relevant dimension of comparison.[36] By contrast, however, neither canonical count nouns nor canonical mass nouns in English demonstrate such flexibility in the diagnostic (i.e., comparatives).[37]

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it is expected that other languages may also show the same restriction. However, more studies are required in the future to ascertain whether this line of thought is on the right track.

36. The flexibility of allowing both cardinality and non-cardinality monotonic dimensions is not unique to Mandarin unclassified nouns; it is also observed with Japanese unclassified nouns (see Barner et al. 2009; Inagaki & Barner 2009 for discussion and experimental evidence).

37. An anonymous reviewer suggests that getting a non-cardinality dimension does not make a noun mass, because such readings are straightforwardly possible for count nouns in measure phrases like *sixty kilos of apples*. I agree with the reviewer on this empirical point on pseudo-partitives; I think this empirical point is exactly why it is comparatives, but not pseudo-partitives, that serve as a diagnostic of the mass-count distinction: pseudo-partitives such as *sixty kilos of apples/water* are not sensitive to the mass-count distinction, in contrast to comparative constructions; more generally, degree constructions based on quantity judgment (e.g., Barner & Snedeker 2005; Bale & Barner 2009 and many other subsequent cross-linguistic studies). One central insight of Barner & Snedeker (2005) and Bale & Barner (2009) is to suggest that comparatives can be used as a (new) diagnostic for the mass-count distinction in cross-linguistic studies (i.e., beyond English), based on quantity judgments (i.e., whether certain dimensions are available for a given noun). This suggestion has led to many cross-linguistic theoretical and experimental studies in the last decade. Seen in this light, the goal of this paper is modest: we apply the diagnostic to Mandarin and discover the new empirical data where classifiers can be systematically optional in degree constructions; furthermore, the presence of classifiers restricts the dimension of comparison to be only cardinality, while Mandarin bare nouns (i.e., without classifiers) in general allow both cardinality dimension and non-cardinality monotonic dimensions (in contrast to English canonical plural count nouns in comparatives);

One class of nouns that has not been discussed so far is object-mass nouns (furniture-type nouns). Contrary to Bale & Barner's (2009) view on object-mass nouns, Grimm & Levin (2012) argues that object-mass nouns such as *furniture* do allow non-cardinality dimensions in certain contexts, in their terminology: **the fulfillment of function**, as shown in (50) and (51). See also Rothstein (2017) for discussion of supporting evidence from cross-linguistic data.

(50) Context: You are visiting different friends.
   a. Imagine upon entering Friend A's room, you see a sofa, an easy chair, a coffee table, and a small bookcase. (4 items)
   b. Imagine upon entering Friend B's room, you see one table and four chairs. (5 items)
   Question: Whose room has more furniture?

(51) Context: Different dealers bought furniture at an antiques auction.
   a. Dealer A bought a sofa, an easy chair, a coffee table and a small bookcase. (4 items)
   b. Dealer B bought one table and four chairs. (5 items)
   Question: Which dealer bought more furniture at the auction?

According to Grimm & Levin (2012), in the context of (50), native speakers make quantity judgments based on the fulfillment of function, rather than based on the cardinality. By contrast, in the context of (51), native speakers make quantity judgments based on the number of items. To capture the reference and countability of furniture-type nouns, Grimm & Levin (2016) propose that the meaning of an artifact noun (such as *furniture*) includes an 'associated event', often representing the artifact's intended function. Interested readers are referred to their paper for details. In short, English object-mass nouns such as *furniture* have the flexibility of allowing both cardinality and non-cardinality monotonic dimensions.

Adding the situation of object-mass nouns into the picture, there are two possible responses to the observed flexibility of Mandarin unclassified nouns in this paper: (a) one is to claim that Mandarin unclassified nouns are object-mass nouns; (b) the other is to say that Mandarin unclassified nouns have both mass and count denotations (e.g., atomic vs. non-atomic meanings). The former option has been suggested in Rothstein (2017) for Brazilian Portuguese and the latter option is argued by Lin & Schaeffer (2018) for Mandarin Chinese. So, how do furniture-type nouns fare with degree constructions in Mandarin? At first blush,

these linguistic facts together suggest that at least some Mandarin unclassified nouns are mass-count neutral, crucially contra the standard view that Mandarin bare nouns are all mass across the board (Chierchia 1998), which is assumed in most of the previous studies on Chinese nouns or classifiers.

they align with the pattern of English object-mass nouns, as suggested in Bale & Barner (2009) where only cardinality is available: thus, the optionality of individuating classifiers becomes an apparent free variation, as illustrated in (52).[38]

(52) a. **√cardinality; #weight**
Zhangsan mai-le ***hen-duo*** *jiaju.*
Zhangsan buy-ASP very-much furniture
'Zhangsan bought a lot of furniture.'

b. **√cardinality; #weight**
Zhangsan mai-le ***hen-duo*** ***jian*** *jiaju.*
Zhangsan buy-ASP very-much CL furniture
'Zhangsan bought many pieces of furniture.'

Given examples like (52), it is not surprising that Lin & Schaeffer (2018) reach the conclusion that Mandarin object-mass nouns are marked for the individuation in the lexicon (based on their experimental results).

However, after taking a closer look, Mandarin object-mass nouns such as *jiaju* 'furniture' do have the accessibility to non-cardinality monotonic dimensions such as weight. Consider the two contexts in (53): In (53a), only cardinality is relevant; by contrast, in (53b), only weight (a non-cardinality monotonic dimension) is relevant.

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38. One anonymous reviewer wonders about what is an OBJECT MASS NOUN or a FURNITURE-TYPE NOUN in Mandarin. Just like other labels "notionally count or notionally mass", the term OBJECT MASS NOUNS or FURNITURE-TYPE NOUNS are descriptive and used only for purposes of discussion; it refers to those Mandarin counterparts of English object mass nouns such as *furniture, jewelry*, and *kitchenware*, etc. Whether a classifier language such as Mandarin has bona fide object mass nouns is a controversial issue. According to Chierhcia (2021), classifiers languages such as Mandarin are not expected to find bona fide object mass nouns. By *bona fide object mass nouns*, I mean that there is a grammatical distinction between count syntax and mass syntax, and those object mass nouns are semantically like count nouns in their denotation while pattern with mass noun with respect to the morpho-syntactic diagnostics. Seen in this light, I do not see any substantial morpho-syntactic diagnostics distinguishing OBJECT MASS NOUNS from the others in Mandarin, even though the former are intuitively superordinate terms, having a set of heterogeneous entities at the atomic elements. In this paper, at least for Mandarin, I shall assume with Chierhcia (2021) that Mandarin does not have bona fide object mass nouns, leaving open the question of whether there are genuine object mass nouns that can be identified by certain morpho-syntactic diagnostics in Mandarin. Readers are referred to Erbach (2020; 2021) for a nice overview on different approaches to object mass nouns and a proposal for the semantics of object mass nouns; see also Erbach et al. (2017) for an analysis of object mass nouns in Japanese.

(53) a. Context 1: *Zhangsan* is a worker for moving furniture. The regulation requires that any worker who has moved five pieces of furniture can take a rest for thirty minutes. Now, *Zhangsan* has moved seven pieces of furniture.
b. Context 2: *Zhangsan* is a worker for moving furniture. The regulation requires that regardless of how many pieces of furniture have been moved, only those workers who have moved the furniture that weighs more than fifty kilos in total can take a rest for thirty minutes. Now, although *Zhangsan* has moved only two pieces of furniture, they weigh one hundred kilos in total.

Given the flexibility of Mandarin unclassified nouns witnessed above, we expect that the optionality of individuating classifiers with Mandarin object-mass nouns is NOT a free variation: specifically, the sentence without a classifier would be judged felicitous under both contexts (53a) and (53b); by contrast, however, the sentence with a classifier would be judged **infelicitous** under the context (53b), where cardinality is NOT relevant. The prediction is indeed borne out by (54) and (55).

(54) **√cardinality; √weight**
*Zhangsan yijing ban-le **name-duo** jiaju, keyi xiuxi le.*
Zhangsan already move-ASP that-much furniture can rest SFP
'Zhangsan has moved that much (weight)/that many pieces of furniture; he can take a rest.'

(55) **√cardinality; #weight**
*Zhangsan yijing ban-le **name-duo jian** jiaju, keyi xiuxi le*
Zhangsan already move-ASP that-much CL furniture can rest SFP
'Zhangsan have moved that many pieces of furniture; he can take a rest.'

Against the two contexts in (53), where cardinality/weight is relevant in one but not the other, (54) is judged felicitous under both contexts, indicating that Mandarin unclassified object-mass nouns can be evaluated against both cardinality and non-cardinality monotonic dimensions. By contrast, (55) is judged infelicitous under (53b) where cardinality is irrelevant, indicating that the individuating classifier *jian* does play a semantic role here (thus it is NOT semantically vacuous). Similar examples can be reproduced with other Mandarin object-mass nouns like *xingli* 'luggage'.

In short, there is a linguistic difference in the degree of accessibility to non-cardinality monotonic dimensions between object-mass nouns such as *jiaju* 'furniture' and those nouns witnessed in this paper (e.g., notionally count nouns such as *pingguo* 'apples', notionally mass nouns such as *doufu* 'tofu', and *rou* 'meat', and flexible nouns such as *shitou* 'stone'): Mandarin object-mass nouns such as *jiaju* 'furniture' (in contrast to other nouns) require more contextual effort to

get the access to non-cardinality monotonic dimensions; but crucially, it is not completely impossible. This discrepancy clearly speaks against the first option which claims that Mandarin unclassified nouns are object-mass nouns across the board. Therefore, we are led to the second option that Mandarin unclassified nouns are mass-count neutral. Importantly, this view of Mandarin unclassified nouns takes us one step forward beyond their number-neutrality (suggested in Chierchia 1998):

(56) **The Mass-Count Neutrality Hypothesis**
Some (if not all) unclassified nouns in Mandarin are not only being *number-neutral* but also being *mass-count neutral*.

Note that the hypothesis may come in two versions: a strong one and a weak one. The strong version claims that *all* Mandarin unclassified nouns are mass-count neutral and additional factors (e.g., contexts) privilege one reading over the other; in contrast, the weak version claims that *at least some* (if not all) Mandarin unclassified nouns are mass-count neutral, leaving open the situation of the others. This paper leaves open here which version should be the correct one for future research. Just like the typical assumption about the number-neutrality of bare nouns in classifier languages, where their denotations include both singular individuals and plural individuals, one way to model the mass-count neutrality of Mandarin unclassified nouns is to have both the count-denotation and mass-denotation inside their semantic representations. The proper semantic representation of the mass vs. count denotations of nouns has been an ongoing debate in the current literature (e.g., Link 1983; Chierchia 1998; Rothstein 2010, 2016; among many others). It is beyond the scope of this paper to settle the debate here. However, below, I suggest a tentative semantic implementation of the idea that Mandarin unclassified nouns are mass-count neutral, couched in Chierchia's (2015; 2021) idea that Mandarin has the mass-count distinction located at the level of kinds.

Contra Chierchia's (1998) view that all Mandarin nouns are mass across the board, Chierchia (2015; 2021) suggests that there is a mass-count distinction in the semantics of Mandarin bare nouns, though it is located at the level of kinds. Moreover, the semantic correspondence between kinds and properties, modeled in Chierchia (1998), hold for both count kinds and mass kinds: count kinds have their corresponding count properties and mass kinds have their corresponding mass properties (see Chierchia 2021: Figure 1). Assuming with Chierchia (2021) that Mandarin is a kind-oriented language, Mandarin unclassified nouns denote kinds by default. In this view, the mass-count neutrality of Mandarin unclassified nouns can be considered as denoting both count kinds and mass kinds, as in (57); alternatively, one may assume some version of lexical ambiguity, as in (58).

(57) a. The default (kind terms)
Kind denotation: $[\![pingguo]\!] = \text{APPLE}_C \cup \text{APPLE}_M$
b. The last resort (via$^{\cup}$)[39]
Property denotation: $[\![\text{ pingguo }]\!] = \lambda x_e.\, x \in {}^{\cup}\text{APPLE}_C \cup {}^{\cup}\text{APPLE}_M$

(58) a. $[\![pingguo]\!] = \text{APPLE}_C$ Count Kinds
(alternatively, the last resort: $\lambda x_e.{}^{\cup}\text{APPLE}_C(x)$)
b. $[\![pingguo]\!] = \text{APPLE}_M$ Mass Kinds
(alternatively, the last resort: $\lambda x_e.{}^{\cup}\text{APPLE}_M(x)$)

The implementation here is only suggestive in nature. For reasons of space, a detailed semantic formalization of the mass-count neutrality of Mandarin unclassified nouns must be left for another occasion. However, it is worth emphasizing that while the semantic details of the formal implementation may vary with one's particular choice semantic theories of mass-count distinction (see e.g., Rothstein 2010; Landman 2016; Sutton & Filip 2016), the notion of the mass-count neutrality of Mandarin unclassified nouns (the central proposal of this paper) remains.[40]

So far, the discussion of the mass-count neutrality of Mandarin unclassified nouns is completed.[41] The question now is how to match a given denotation of

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39. For readability, I ignore the subscript *s* (representing the situation) in the property denotation here.

40. Deal (2017) divides countability distinctions into those related to sums (cumulativity) and those related to parts (divisiveness, atomicity, and related notions). Furthermore, she suggests that at least one countability distinction may be universal and that languages without any countability distinctions may be unlearnable. On the current view that some (if not all) Mandarin unclassified nouns are mass-count neutral, it is left open whether Mandarin would fit with Deal's proposal.

41. One anonymous reviewer wonders about how the current analysis is connected with Cheng & Sybesma's (1999) view that there is a mass-count distinction in Chinese nominal phrases, which is reflected at the level of classifiers and not of nouns, versus Li's (2011; 2013) proposal that there is a division of classifiers at the phrasal level into count classifier and measure classifier phrases (thus against Cheng & Sybesma's (1999) view that a grammatical distinction between count classifiers and mass classifiers holds at the word level). The main debate between Cheng & Sybesma's (1999) view and Li's (2011; 2013) concerns whether there is a grammatical distinction between count classifiers and mass classifiers at the word level vs. at the phrasal level. Both analyses seem to have a consensus on the semantics of Mandarin bare nouns (i.e., all nouns are mass across the board), following Chierchia (1998). In contrast, one key contribution of this current paper is to provide novel empirical evidence showing that at least some (if not all) Mandarin unclassified bare nouns may have both count denotation and mass denotation (in our terms, being mass-count neutral), according to the diagnostic of comparatives based on quantity judgments. The focus of this paper concerns only the distinction between unclassified nouns vs. nouns with classifiers, with respect to the diagnostic of compar-

nouns with the relevant dimension of comparison. In particular, given the variable dimensionality of the Q-adjective *much*, how come only cardinality is available for a sentence with plural count nouns *Adam ate more apples than Bill*? As pointed out by Wellwood (2018; 2019), crucially, the monotonicity constraint (Schwarzschild 2006) alone cannot explain such restriction to cardinality. To capture this intrinsic connection between the denotation of nouns and the dimension of comparison, Wellwood (2018; 2019) proposes that the selection of variable dimensionality induced by the Q-adjective *much* is not only constrained by the monotonicity constraint, but also a much stronger condition: the A-invariance constraint in (59).

(59) **A-invariance**
$\forall\ x \in D_P, \forall\ h \in Aut\ (<D_P, \precsim_P>), \mu(x) = \mu(h(x))$[42]

Abstracting away from formal details, the key idea behind Wellwood's proposal is that only the cardinality function satisfies the A-invariance constraint, while other monotonic measure functions (e.g., weight) crucially do not: this is so because **weight** $(h(b)) \neq$ **weight** (b), assuming that D_P={b, c, bc}, h is an automorphism on D_P such that $h(b) = c$, and ; weight: {b ↦60 kilos, c ↦80 kilos,...}; by contrast, $\boldsymbol{\mu}_{card}\ (h(b)) = \boldsymbol{\mu}_{card}\ (b)$, assuming that D_P={b, c, bc}, h is an automorphism on D_P such that $h(b) = c$, and $\boldsymbol{\mu}_{card}$: {b ↦1, c ↦1,...}. In short, Wellwood's account

atives; it is left open whether there is a grammatical distinction of classifiers at the word level (Cheng & Sybesma's 1999 view) or at the phrasal level (Li's 2011; 2013 view).

42. As Wellwood (2018: 88) elaborates: "More formally, I assume that an automorphism h is any bijective function that maps a set, here D_P, to itself, in accord with (i): any ordering relations holding between x and y in D_P must hold between $h(x)$ and $h(y)$. Since any automorphism h on D_P is invertible (bijectivity), and its domain is (exactly) the same as its range (endomorphy), (i) cannot be satisfied by a function that preserves only trivial ordering relations between elements of D_P (order preservation)...".

(i) $\forall x, y \in D_P, x \precsim_P y$ iff $h(x) \precsim_P h(y)$)
Wellwood (2018: 89) illustrates an example of an automorphism on D_P, where D_P={a, b, c, ab, bc, ac, abc} (the inclusive set of pluralities whose minimal parts are the individuals a, b, c) and the ordering $\precsim_P$ on this set has all the properties we think the domains of plural nouns like *apples* or superordinate mass nouns like *furniture* have (i.e., they are atomic join semi-lattices). See Wellwood (2018; 2019) for more details.

(ii) Automorphisim h in $Aut\ (<D_P, \precsim_P>)$
a. h=[a↦b, b↦c, c↦a, ab↦bc, bc↦ac, ac↦ab, bc↦abc]
b. **range** (h) = **domain** (h) [endomorphy]
c. there is a function g such that domain (g) = range (h) [bijectivity]
d. $\neg\exists x, y\ [x \precsim_P y \wedge h(x) \not\precsim_P h(y))]$ [order preservation]

roughly goes as follows: resolving the variable dimensionality of the Q-adjective *much* involves an orderly selection from a list of measure functions; cardinality holds a privileged position in this list; if the comparison targets entities in an atomic semi-lattice, there is a requirement that the selection goes to cardinality.[43]

Before closing this section, let me briefly mention some factors that make cardinality more salient than other non-cardinality monotonic dimensions for some Mandarin unclassified nouns. During the discussion of Mandarin furniture-type nouns, we have seen that despite the general flexibility of Mandarin unclassified nouns with respect to the dimension of comparison, more contextual effort is required to elicit those non-cardinality monotonic dimensions for those object-mass nouns. Two important lessons are learned. First, factors such as discourse conditions also play a key role in making one dimension more salient than the others, reminiscent of the fact that a potentially ambiguous sentence can be disambiguated in a given context. Second, although both cardinality and non-cardinality monotonic dimensions are in principle available for Mandarin unclassified nouns in degree constructions, they do not have the same degree of accessibility. In particular, the default to cardinality (as witnessed by object-mass nouns) may be influenced by the conceptual distinction between objects and substances. It has been well-recognized that the mass-count distinction in natural language does NOT fully correspond to the conceptual distinction between objects and substance (see Bale & Barner 2018 and references therein), but this should not be taken to mean that the conceptual distinction plays *no* role at all. Beyond the traditional binary distinction, one important insight of Grimm (2012) is that countability is a scalar phenomenon (with a scale of individuation). By establishing an ordering on entity types from the parings between entity types and morphological coding, the scale of individuation in (60) is yielded on

43. One anonymous reviewer wonders why only monotonic dimensions are available as the dimension of comparison. Where does this monotonic restriction come from? The monotonicity condition on the measurement has been well-observed since at least Schwarzschild's (2006) work pseudo-partitives (see also Krifka 1989 for discussion on extensive measure functions). For Schwarzschild, the monotonicity requirement of pseudo-partitives is encoded in the syntactic head Mon. If we shift our attention to the case of comparatives (or more generally, degree constructions involving the Q-adjective), Wellwood (2014; 2019) suggests that the monotonicity requirement observed in comparatives results from the semantics of English *much*. Specifically, the measured domain of *much* cannot be flat/unstructured; that is, the measured domain of *much* must be structured by the part-of relation and the measure function in *much* tracks this part-whole structure (see Wellwood 2019: 54). In the current study, I assume with Wellwood's (2014; 2019) insights that the monotonicity requirement comes from the semantics of the quantity adjective *duo*, where the measurement tracks the part-whole structure in the domain of individuals. See also Luo et al. (2017) for discussion on the role of monotonicity on the presence of pre-classifier adjectives in Mandarin.

the basis of the coding preferences across four different languages (i.e., Welsh, Turkana, Maltese, and Dagaare).

(60) The scale of individuation (Grimm 2012: 55)
Liquids < foodstuffs < granular aggregates < vegetation/cereals/fruits ≤ insects < small animals 〈pair/grouped body parts ≤ middle-sized animals < types of people < individuals

Against this brief background, although Mandarin does not have the corresponding morphological marking, those Mandarin unclassified nouns referring to types of people (such as *xuesheng* 'student' and *jingcha* 'police') do show a strong preference for cardinality. From the perspective of the current study, the scale of individuation potentially reflects the different degrees of accessibility to cardinality or those non-cardinality monotonic dimensions in degree constructions, with respect to different types of Mandarin unclassified nouns (correspondingly situated somewhere on the scale).[44]

5. Concluding remarks

This paper has presented a compositional analysis of the fact that Mandarin individuating classifiers are optional in various degree constructions, by taking a mixed approach incorporating the insights from Chierchia (1998; 2010) that Mandarin nouns are kind terms and individuating classifiers offer the level of individuation and those from Krifka (1995) that (bare) numerals do not encode the cardinality function. By considering numerals as degree terms (e.g., Hackl 2001; Nouwen 2010; Rett 2014; Kennedy 2015, among others), the mixed

44. One anonymous reviewer wonders why object mass nouns need heavy context to get the non-cardinal reading while other mass nouns do not. At this point, I do not have a definite answer. But I think, the ultimate answer lies in the denotation of these "object mass nouns". In particular, these object mass nouns typically refer to superordinate terms, containing a set of heterogeneous entities as the atomic elements (e.g., furniture: {chairs, tables, desks, etc.}). It is possible that the status of superordinate terms (consisting of heterogeneous atomic entities) makes it easier to get access to the cardinality dimension for these nouns. This may in turn reflect Rothstein's insights that counting and measuring are two different operations: "Counting is putting entities in one-to-one correspondence with the natural numbers and requires a contextually determined choice to what counts as one entity, while measuring assigns an (plural) individual a value on a dimensional scale". It is the special semantic property connected with the denotation of these nouns that gives the cardinality dimension (i.e., counting) a privilege over other monotonic dimensions such as weight (i.e., measuring). Therefore, more contextual effort may be needed for these "object mass nouns" to get the accessibility to those non-cardinality monotonic dimensions.

approach advocated here embraced the hypothesis that the locus of variation between English and Mandarin lies in neither the semantics of nouns nor that of numerals, but in the measure operators: these linguistic elements (including sortal/individuating classifiers) are necessary to mediate between numerals and nouns to avoid the semantic type-mismatch. The proposed analysis of individuating classifiers has not only explained the role of Mandarin individuating classifiers in degree constructions (i.e., their syntactic optionality, along with a semantic variation in the relevant dimension of measurement), but also closely connected with Bale & Barner's (2009) insights about quantity judgments that comparative constructions can be used as a reliable diagnostic of the mass-count distinction in languages beyond English; in particular, the fact that Mandarin unclassified nouns allow both cardinality and non-cardinality monotonic dimensions in a variety of degree constructions based on quantity judgments indicated their mass-count neutrality; a tentative semantics of Mandarin nouns for their mass-count neutrality was thus suggested. Finally, some factors leading to the individuation of nouns (e.g., contextual support and the scale of individuation) have also been discussed.

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Abbreviations

ASP	aspect
CL	classifiers
COMP	comparative morpheme
DE	a modification marker
MSSC	maximally strongly self-connectedness
POS	pos-morpheme
SFP	sentence final particle
SUP	superlative morpheme

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