Do Mandarin count classifiers individuate: Experimental evidence from a quantity judgment task[*]

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1.   Introduction

Entities in the world can be distinguished by countability: Objects can be counted as discrete entities, while substances cannot (Quine 1960; Jackendoff 1993). Natural languages encode countability differently. For instance, languages such as English use count syntax. The examples in (1) illustrate a three-way distinction in English nominals: objects with count syntax in (1a), mass objects that resist count syntax in (1b), and flexible nouns that allow either in (1c).

(1)   a.   a car / a lot of car*(s) / {two, many} cars / *so much car
       b.   *a ketchup / a lot of ketchup(*s) / *{two, many} ketchups / so much ketchup
       c.   a stone / a lot of stone(s) / {two, many} stones / so much stone

Such morphosyntactic differences are absent in classifier languages such as Mandarin.

(2)   a.   yi   liang che / che / henduo che
             one CL   car / car / a.lot.of car
             'a car / car(s) / a lot of cars'

       b.   yi   tan fanqiejiang / fanqiejiang / henduo fanqiejiang
             one CL ketchup   / ketchup   / a.lot.of ketchup
             'one pile of ketchup / ketchup / a lot of ketchup'

       c.   yi   kuai shitou / shitou / henduo shitou
             one CL   stone / stone / a.lot.of stone
             'a piece of stone / stone(s) / a lot of stone(s)'

The above contrast has led to the claim that classifier languages such as Mandarin fail to make an ontological distinction between objects and substances at the level of noun (Lucy 1996). Mandarin bare nouns can be interpreted as singular or plural; consequently, the distinction between singular/plural collapses. Under a deterministic interpretation of this view, Mandarin speakers cannot access the object/substance distinction conceptually, because this distinction is not encoded linguistically (Sapir 1929). Opponents to this view, however, proposed two linguistic elements in Mandarin that do encode the ontological distinction: *nouns* (Cheng and Sybesma 1998, 1999; Zhang 2013; Chierchia 2021) and *classifiers* (Cheng and Sybesma 1998, 1999; Borer 2005; Pelletier 2012; Chierchia 2021).

The open question whether nouns or classifiers encode this distinction calls for experimental scrutiny. Mandarin nouns have been shown to semantically distinguish objects from substances (Cheung et al. 2012). However, previous studies on classifiers have introduced confounds to their experiment design, using familiar stimuli and known nouns (Chien et al. 2003), or using solidity as proxy of ontology (Li et al. 2008).

In this paper, we ask whether Mandarin morphosyntax encodes the object/substance ontological distinction through classifiers. We employed a quantity judgment paradigm (Barner and Snedeker 2005, 2006), manipulating classifiers and nouns while holding visual stimuli constant. Our findings reveal that count classifiers specify reference to objects, while mass classifiers specify reference to substances. Thus, the information encoded in classifiers influences the way in which Mandarin speakers quantify because Mandarin classifiers reflect a fundamental ontological distinction (Cheng and Sybesma 1998, 1999).

This paper is organized as follows: Section 2 outlines theoretical proposals concerning the conceptual and linguistic contribution of Mandarin nouns and classifiers. Section 3 presents our study. Section 4 discusses and concludes.

2. Background

2.1 Classifiers

Mandarin requires a classifier between a numeral modifier and the modified noun phrase. An example with the classifier *ge* 'individual-CL' is given in (3a). The direct combination of the numeral modifier *yi* 'one' and the modified noun phrase *pingguo* 'apple' in (3b) is ungrammatical.

(3) a. yi ge pingguo
      one individual-CL apple
      'one apple'

   b. #yi pingguo
      one apple
      '(intended) one apple'

(4) a. yi ge ren
      one individual-CCL person
      'one person'

   b. yi wan tang
      one bowl-MCL soup
      'one bowl of soup'

Classifiers can be count/individual (4a) or mass/individuating (4b, Cheng and Sybesma 1998, 1999; Borer 2005; Zhang 2013; Chierchia 2021). This syntactic division is evidenced by diagnostics including *de*-insertion and pre-classifier adjectival modification.

2.2   Hypothesis space

While there is a theoretical division between count and mass classifiers, it remains unclear whether Mandarin speakers make a conceptual distinction with the two types of classifiers. Researchers have two different perspectives on whether classifiers constitute an *individuating* expression, one that distinguishes between reference to objects and that to substances. If a classifier individuates, then it requires the denotation of the nominals that follow to be atoms or individuals (Cheng and Sybesma 1998, 1999; Chierchia 2021).

One view is that *count classifiers individuate, while mass classifiers do not* (Cheng and Sybesma 1998, 1999; Chierchia 2021). Classifiers directly reflect the object/substance distinction and guide speakers' interpretation of nouns that follow. Semantically, count classifiers pick out one instance of the denotation of the following count noun, and numerals specify the quantity of the instances (5a). By contrast, mass classifiers fail to select a member in the nominal denotation, but merely create a unit for the noun (5b). Hence, under this approach, a bare noun phrase denotes a set of entities, and a classified noun phrase with a count classifier singles out an object.

(5)   a.   count classifiers + count$_{sem}$ mass$_{syn}$ nouns
         b.   mass classifiers + mass$_{sem}$ mass$_{syn}$ nouns

Within this view of classifiers encoding count/mass distinction, there is divergence as to whether Mandarin *nouns* individuate. We can identify three distinct sub-hypotheses: Count nouns individuate in Mandarin (Cheng and Sybesma 1998, 1999; Chierchia 2021); Mandarin nouns do not individuate (Borer 2005); nouns are underspecified in their individuability before they combine with classifiers (Pelletier 2012).

In contrast to the above position that count classifiers do individuate, Zhang (2013) argues that *nouns alone encode the ontological distinction*. Classifiers then select nominals with matching syntactic features. This nominal-centric theory begins with a cross-linguistic categorization of nouns with two features [+/− NUMERABLITY] (whether nouns can be directly combined with numerals) and [+/− DELIMITABLITY] (whether nouns can be directly combined with delimitive adjectives).

(6)   *Zhang's (2013) feature analysis of nouns*

[NUM]	[DEL]	Syntactic countability	English examples	Mandarin
+	+	count	(one, big) unicorn	No
+	−	count	(one, *big) belief	No
−	+	non-count, non-mass	(*one, big) furniture	Yes: (7)
−	−	mass	(*one, *big) oil	Yes: (8)

(7)   a.   *yi jiaju   b.   da jiaju
              one furniture   big furniture
              '(intended) a piece of furniture'   'big furniture'

(8) a. *yi you   b. *da you
        one oil   big oil
        '(intended) a unit of oil'   '(intended) big volume of oil'

The table in (6) shows that while English has all four categories, Mandarin only has non-count, non-mass nouns [−NUM, +DEL] and mass nouns [−NUM, −DEL]. These two classes of nouns differ in their syntax and lexical semantics. Non-count, non-mass nouns provide intrinsic units for count/individual classifiers, while mass nouns do not. Classifiers then select nouns with matching features in syntax: mass/individuating classifiers select mass nouns (9a), while count/individual classifiers select non-count, non-mass nouns (9b).

(9) a. mass classifiers + mass$_{sem}$ mass$_{syn}$ nouns
     b. count classifiers + count$_{sem}$ non-count, non-mass$_{syn}$ nouns

These different theoretical approaches about linguistic and ontological specification of classifiers and nouns are summarized in (10).

(10) *Hypothesis space*

Hypotheses	Count nouns do not individuate	Count nouns individuate
Null hypothesis: Count classifiers do not individuate	N/A	Zhang 2013
Alternative hypothesis Count classifiers individuate	Borer 2005	Cheng and Sybesma 1998, 1999 Chierchia 2021
	Pelletier 2012	

We set aside the debate on Mandarin nouns and ask whether Mandarin count classifiers individuate. To answer this question, our experiment directly targets the ontological information encoded in classifiers through the quantity judgment paradigm.

3. Experiment

3.1 Methodology

To examine the individuability of classifiers in Mandarin, we adopted the quantity judgment paradigm, which was developed by Barner and Snedeker (2005, 2006) to examine the mapping between ontology and English morphosyntax and count/mass noun status. The paradigm assumes that objects are quantified in number, and substances in mass/volume. It tests for the object/substance distinction by introducing participants to two characters, each with a set of items, and asking participants 'who has more.' The contrast is captured in (11). Suzie (left) has six small items, which are each low in mass/volume. Billy (right) has two larger volume items.

(11)   *Example stimuli in quantity judgment tasks (Bale and Barner 2018)*

Instruction: 'Who has more?'

The visual stimuli can be accompanied by specific linguistic prompts as in (12). In this example, it is important to note that The English noun *stone* can be count or mass flexibly. The prompt (12a) uses *stone* in count syntax, with the plural marker $-s$. The prompt (12b) uses the noun in mass syntax, with no number marking. Thus, the syntax should influence the means by which participants quantify stones: either by object number (12a) or by total mass (12b), and the way they respond, by the character they choose, demonstrates this.

(12)   a.   Suzie has some stones. Billy has some stones. Who has more stones?
         b.   Suzie has some stone. Billy has some stone. Who has more stone?

To answer the binary-choice question, a participant who selects Suzie (left) quantifies in number and provides an 'object' response, while a participant who selects Billy (right) quantifies in mass/volume and provides a 'substance' response. The dependent measure is the percentage of responses indicating an object/count interpretation. This paradigm has been translated into a Mandarin version with count and mass nouns (Cheung et al. 2012; Lin and Schaeffer 2018).

However, previous studies focusing on classifiers rely on other methodologies such as lexical selection: Chien et al. (2003) used familiar stimuli and known nouns to test for noun-classifier association; Li et al. (2008) interpreted physical distinction between solidity and non-solidity as proxy of ontological distinction between objects and substances. There is a research gap of using count and mass classifiers in the linguistic prompts in a quantity judgment task, which directly targets the quantificational standard inherent to the ontological object/substance distinction. Given our hypotheses and paradigm, one can make the predictions in (13).

(13)   a. H_0: If count classifiers *do* not individuate (Zhang 2013), then both count and mass classifiers will induce similar chance-level response patterns.
         b. H_1: If count classifiers *do* individuate (Cheng and Sybesma 1998, 1999; Chierchia 2021), then count classifiers will induce more object/count responses, and mass classifiers will induce more substance responses.

3.2   Stimuli

8 sets of novel stimuli, whose neutrality for count/mass status was ensured via a norming study, were used in the testing session, each with a novel nominal label. In the norming study, we asked the participants to select and rank the classifiers they would use for 28

novel stimuli. Each stimulus is paired with 2 count and 2 mass classifiers based on the syntactic diagnostics of *de*-insertion and pre-classifier adjectival modification. Novel stimuli that showed an imbalance in the selection of count or mass classifiers were discarded. For example, the novel stimuli in (14) are equally likely to be described with the count classifier *ge* 'individual-CCL' in (16a) and the mass classifier *kuai* 'lump, block-MCL' (16b).
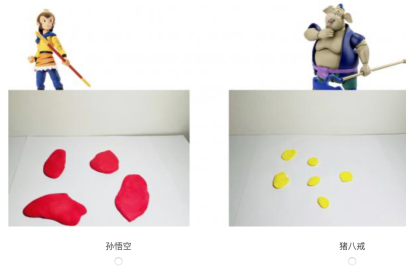
(14)   *Test stimuli*   (15)   *Control: mixed familiar items*

(16)   a.   Sun.Wukong you ji-ge   wenhun, Zhu.Bajie ye you ji-ge
            Sun.Wukong have some-CCL WENHUN, Zhu.Bajie also have some-CCL
            wenhun. Zongtilaishuo,   shei de   duo?
            WENHUN. Overall.speaking, who GEN more?
            'Sun Wukong has some CCL WENHUN. Zhu Bajie also has some CCL WEN-
            HUN. Overall, whose is more?'

       b.   Sun.Wukong you ji-kuai   wenhun, Zhu.Bajie ye you ji-kuai
            Sun.Wukong have some-MCL WENHUN, Zhu.Bajie also have some-MCL
            wenhun. Zongtilaishuo,   shei de   duo?
            WENHUN. Overall.speaking, who GEN more?
            'Sun Wukong has some MCL WENHUN. Zhu Bajie also has some MCL WEN-
            HUN. Overall, whose is more?'

Given the linguistic stimuli in (16), choosing Sun Wukong (left) would reflect a substance response, since it would indicate that participants quantify the novel stimuli by mass/volume instead of number. By contrast, choosing Zhu Bajie (right) would reflect an object response, indicating that participants quantify the stimuli by number instead.

Control items included 8 familiar objects and 8 familiar substances adapted from Cheung et al. (2012): for example, cars, desks (objects) and ketchup, cream (substances). We also included 9 stimuli with pluralities of familiar items intermingled in the set to detect count bias (15). With these items, participants with a strong count bias would always choose 6 items over 4 items, since 6 is numerically bigger than 4. We balanced the noun types (objects vs. substances) and the sides (choosing 4 vs. choosing 6; Sun Wukong vs. Zhu Bajie) for the mixed control items.

3.3   Participants & Procedure

A total of 120 adult native speakers of Mandarin Chinese (aged 18–64; gender balanced) participated in the study, who indicated they use Mandarin on a daily basis. Each participant was compensated $2–3 for their time.

Participants accessed a Qualtrics questionnaire via Prolific or WeChat. They provided their demographic and language background, answered five training questions to familiarize themselves with the binary-choice question type, and were informed when the testing session began. The testing session included 33 quantity judgment questions and 2 attention checkers. In the attention checkers, participants were prompted to ignore the visual stimuli and choose the character indicated by the instruction. We included the attention checkers as exclusion criterion to ensure that participants read linguistic instructions.

To focus attention on the contribution of the classifier, we manipulated nominals to include either no noun or a novel noun. Thus, participants could not be influenced by the contribution of nominal semantics. In this way, we held the nominals constant and tested whether and how different kinds of classifiers influence participants' selection by manipulating the presence/absence of count/mass classifiers [+/−CC, +/−MC].

These linguistic variables were hence systematically manipulated across 6 between-subject conditions: 2 baseline conditions without classifiers, and 4 conditions manipulating presence/absence of novel noun and count/mass classifier. In (17), each condition is characterized by whether nouns [N] and classifiers [C] were used in the linguistic stimuli. [−N] means no nouns were used. [−C] means no classifiers were used. [+CC] and [+MC] mean that count and mass classifiers were used, respectively.

(17)   *Linguistic stimuli across conditions*

−N	−C	Look what Sun has, and look what Zhu has.
+N	−C	Sun has some WENHUN. Zhu also has some WENHUN.
+N	+CC	Sun has some CC WENHUN. Zhu also has some CC WENHUN.
+N	+MC	Sun has some MC WENHUN. Zhu also has some MC WENHUN.
−N	+CC	Sun has some CC. Zhu also has some CC.
−N	+MC	Sun has some MC. Zhu also has some MC.

The first two conditions ([−N, −C] and [+N, −C]) were the baseline conditions. In Condition [−N, −C], participants were prompted to pay attention to what Sun Wukong has and what Zhu Bajie has and determine who has more. Condition [+N, −C] added novel nouns into the linguistic stimuli. As novel nouns have no semantic content, participants would not have lexically-encoded information to guide their selection, and would pattern at chance. The next two conditions ([+N, +CC] and [+N, +MC]) retained novel nouns and added either count or mass classifiers into the linguistic stimuli. The last two conditions ([−N, +CC] and [−N, +MC]) removed novel nouns and examined whether classifiers alone could encode ontological specifications when nouns were absent.

Across all conditions, we asked the quantity judgment question in (18), and calculated the percentage of responses indicating an object (count) interpretation.

(18) Zongtilaishuo, shei de duo?
      Overall.speaking, who GEN more?
      'Overall, whose is more?'

We generated the following predictions. In the baseline conditions without classifiers or familiar nouns, participants would pattern at chance. If count classifiers do not individuate (Zhang 2013), participants will pattern at chance with both count and mass classifiers. If count classifiers do individuate (Cheng and Sybesma 1998, 1999), participants will show more object responses with count classifiers and substance responses with mass classifiers.

3.4   Results

We fit a multinomial log-linear model via neural networks (nnet) and calculated the estimated marginal means (emmeans) in R to compare the percentages in each condition against the chance level (50%), in (19). The modeling results suggested that in the 90% confidence interval, the percentages of object selection in baseline conditions ([−N−C], [+N−C]) were at chance. By contrast, percentages in conditions with count classifiers ([−N+CC], [+N+CC]) were significantly above 50%, while percentages in conditions with mass classifiers ([−N+MC], [+N+MC]) were significantly below 50%.

(19) *Comparisons to chance (90% CI)*   (20) *Pairwise comparison (90% CI)*
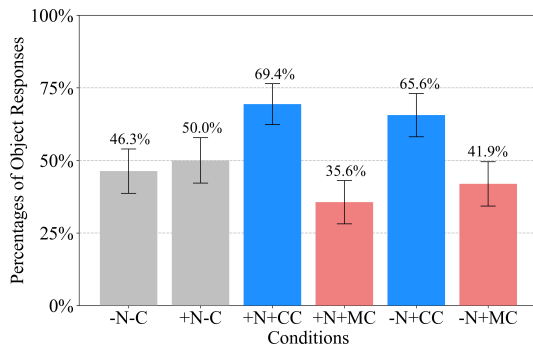
Contrast	[−N+CC] [−N+MC]	[+N+CC] [+N+MC]
Estimate	0.24	0.34
SE	0.05	0.05
T-ratio	4.39	6.42
P-value	0.07	0.01

Contrast	[−N+CC] [+N+CC]	[−N+MC] [+N+MC]
Estimate	-0.04	0.06
SE	0.05	0.05
T-ratio	-0.72	1.15
P-value	1.00	0.98

Pairwise comparisons in (20) show significant differences between conditions with different types of classifiers, but not between conditions with/without novel nouns. Percentages in [+CC] conditions were significantly higher than [+MC], regardless of the presence/absence of novel nouns ($p < 0.1$). Percentages in [−N] conditions are not significantly different from [+N], regardless of classifier types ($p > 0.1$).

Thus our results show that (i) in baseline conditions without classifiers, participants' response patterns are chance; (ii) in conditions with count classifiers, participants provide *more object/count responses*; and (iii) in conditions with mass classifiers, participants provide *fewer object responses*.

We suspect that the non-at-ceiling performance in our results is a result of the challenges posed by novel nouns and visual stimuli in the task. In the [+N] conditions, participants either attempt to assign a meaning to novel nouns based on the Chinese characters, or

simply leave empty the meaning until they encountered more information with a familiar classifier. Then, they use such information to answer the quantity judgment question. In the [−N] conditions, participants has no noun to rely on, although they might have expected a noun following the classifier. The classifier alone guided their selection. Both challenges complicate the cognitive process and suppress participants' response rates. Despite this noise, however, the results still showed significant differences from chance level and between the conditions, thereby illustrating the contribution of classifiers.

4.   Discussion and Conclusions

We collected experimental evidence from a quantity judgment task to answer the question whether count/mass classifiers in Mandarin distinguish between objects and substances. Our results demonstrate that count classifiers induce more object responses, while mass classifiers induce fewer object responses, indicating that Mandarin count classifiers do individuate. A count classifier leads participants to interpret the novel stimuli as objects, while a mass classifier leads them to interpret the novel stimuli as substances. Hence, the ontological information encoded in classifiers influences participants' assessment of quantities. The results therefore support Cheng and Sybesma (1998, 1999) and Chierchia (2021), who claim that that classifiers encode the distinction between count and mass. Our conclusion is also compatible with Borer (2005) and Pelletier (2012), as we did not investigate whether Mandarin nouns individuate, since we used novel nouns or no nouns at all.

The patterns we observe indicate that classifier languages like Mandarin do not lack the distinction between count and mass, contra Lucy (1996). However, we cannot definitively say whether this count/mass distinction in classifiers is encoded in the syntax and/or the semantics. Our experiments suggest that it could be both: On one hand, the distinction between count and mass classifiers is supported by syntactic diagnostics, which we employed to design our linguistic stimuli. On the other, the nature of quantity judgment task draws upon the semantics of classifiers. Future theoretical work should aim to make a clearer distinction between the semantic and syntactic count/mass distinction.

Our results have clear implications for language acquisition and learning, demonstrating the viability of a syntactic boostrapping approach (Landau and Gleitman 1985) even for languages such as Mandarin. If children are aware of the different ontological specifications of classifiers, they might utilize the information to learn the nouns they encounter for the first time. The syntactic knowledge of nouns and classifiers might then feed into the acquisition of lexical semantics. Further experimental work should test whether children replicate the patterns we observe in Mandarin speaking adults, and at which developmental stage they acquire the knowledge of count and mass classifiers.

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