

The Quantificational Domain of *dou*: An Experimental Study

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Abstract Which NP does *all* associate with in e.g. “The pandas, the children all saw”—the pandas, the children, or both? The intuition of adult Mandarin Chinese native speakers regarding the interpretation of the adverbial quantifier *dou* ‘all’ remains unclear and controversial, and various incommensurate theories of domain selection have been proposed. These studies may have failed to yield clear results because they used testing materials in which the interpretation of *dou* is confounded with other principles of NP interpretation (e.g. *zhexie xiaohai* ‘these children’ is truth-functionally synonymous with ‘all these children’). To address these concerns, we present the first set of experimental studies on adult knowledge and use of syntactic constraints on the quantifier domain of *dou*. The results support the hypothesis that *dou* can take one and only one *c*-commanding NP as its domain, but falsify interesting theoretical accounts that assume a strict locality constraint on *dou* quantification.

Keywords *Dou* · Universal quantification · Domain selection · Distributive operator · Mandarin Chinese

Introduction

There is an extensive body of literature investigating the syntax and semantics of *dou* in Mandarin Chinese (hereafter *Chinese*) (Cheng 1995, 2009; Chiu 1993; Feng 2014; Giannakidou and Cheng 2006; Huang 1982, 1996; Lee 1986; Li 1995, 1997; Lin 1996, 1998; Shyu 1995; Tsai 2014, 2015, 2009; Wu 1999; Xiang 2008; Xu 2014; Zhang 1997; Zhou and Crain 2011; among many others). The syntax and semantics of *dou* has prompted much debate, but most authors agree that *dou* is directly or indirectly associated with universal force/exhaustivity or distributivity (Cheng 2009; Giannakidou and Cheng 2006; Liu 2016a, b,

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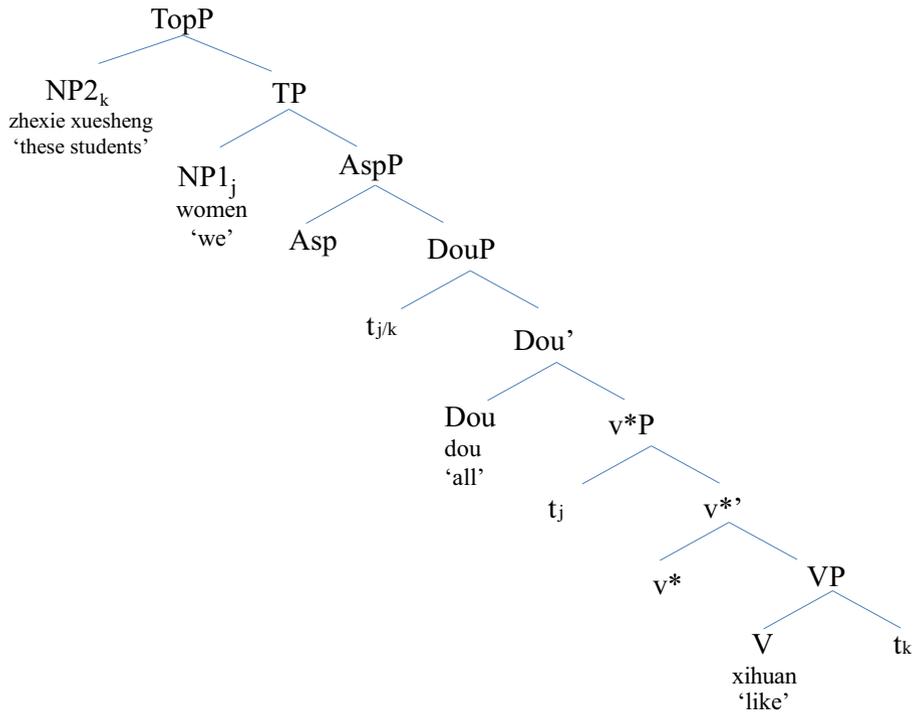
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Therefore, Zhang’s theory predicts a three-way ambiguity for sentence (1) (meanings (1a), (1b) and (1c)), although she observes that sometimes only the first two interpretations are available—an issue to which we return below.

According to Lin (1996, 1998), however, *dou* can quantify over one and only one NP in sentences such as (1), and either one of the two NPs can be the domain of *dou*. Lin treats *dou* as a generalized distributive operator. It distributes over a particular element by binding a trace left by the element that moves to/through the Spec of a Distributive Phrase (DistP) headed by *dou*, illustrated in (3).

(3) The syntactic structure of (1) according to Lin (1996; 1998):



As shown in (3), either the trace of the topic t_k (he assumes topicalization for topic structures in Chinese, not left dislocation), or the trace of the subject t_j (he adopts the VP-internal subject hypothesis), but not both simultaneously can be bound by *dou*, predicting either interpretation (1a) or (1b). Note that many other proposals including Li (1997), Wu (1999) and Tsai (2009) basically agree that *dou* heads a DistP and carries distributive force. Specifically, Li (1997, pp. 173–178) and Wu (1999) share the conclusion with Lin (1996; 1998) on the possible interpretations of sentence (1): *dou* can quantify over either one but only one NP.

Table 1 presents the predictions of the four theories briefly reviewed above. It shows that each theory makes distinct predictions about the domain of *dou* in sentences such as (1).

There are other papers that address the question of which NP *dou* quantifies over, when multiple candidates are available, as based on the authors’ semantic intuitions. For example, Lü (1980/1999) suggests a stressed NP is preferred as the domain of *dou*, and Zhan (2004) hypothesizes that the NP that is structurally closer to *dou* is more likely to be the domain of

Table 1 Domain of *dou* for previous theories concerning the predicted interpretations of (1)

Theory	Predicted possible interpretations		
	Subject quantified	Topic quantified	Both quantified
Strict Unselective Binding	×	×	✓
Cheng's PED	✓	×	×
Zhang's Multiple Linking Hypothesis	✓	✓	✓
Lin's Distributive Operator Approach	✓	✓	×

Subject quantified, Topic quantified and Both quantified correspond to interpretations (1a), (1b) and (1c), respectively. Note that they are different from context types, i.e. Subject context and Topic context (see Fig. 2), which we will introduce in the methodology section

dou. Wen and Qiao (2002) on the other hand argue that *dou* can take multiple NPs simultaneously as its domain. In addition, Li (2013) proposes that the NP that is more salient, in terms of stress, (structural) position relative to *dou* and phrase length, will be taken as the domain.

Why Are the Judgments and Analyses so Disparate? A Confound in Previous Work

We suggest that these disparities in the semantic interpretations assumed by the different authors are due to the fact that most of the previous studies (including Cheng 1995; Lee 1986; Lin 1998; Lü 1980/1999; Zhang 1997) use plural nouns/phrases and demonstrative nouns/phrases, e.g. the topic and subject in (1), to examine the *dou*-induced ambiguity of the topicalized sentences. This is highly problematic because we usually interpret the plural or demonstrative phrases as exhaustive, no matter whether they are quantified by *dou* or not. Consequently, they are not clearly distinguishable from universal force in most cases (e.g. *those kids left* means *those kids all left*). In (1), *zhexie xuesheng* 'these students' is usually synonymous with "all of these students" even in the absence of the quantifier *dou*, thus masking the central question under experimental investigation, namely: whether or not a given NP is in fact quantified/quantifiable by *dou*.

An Experimental Paradigm to Avoid the Confound

To circumvent this problem, our experiments use bare nouns rather than plurals or demonstrative phrases, because bare nouns in Mandarin are ambiguous between a singular and a plural interpretation, that is, a plural interpretation of bare nouns is not required, and can be blocked depending on the linguistic context, unlike plural nouns/phrases and demonstrative nouns/phrases. Crucially, when a bare noun is quantified by *dou*, it loses this ambiguity and must be interpreted as exhaustive (hence plural). Therefore, the absence of a singular interpretation for a certain bare noun in the clause signals that the bare noun is quantified by *dou*.

Before we can use bare nouns as a diagnostic for *dou*-quantification, another question needs to be addressed. Will bare nouns (e.g. *xionghao* 'panda') lose their ambiguity and be obligatorily interpreted as exhaustive/plural when there are multiple participants/referents in the context (e.g. many pandas in the situation) that they can refer to? In our experiments, there are two participants in the story/event presented to the subjects, which each bare noun can refer to. In this situation, *must* the bare noun correspond to both referents? If the bare noun remains ambiguous and a singular interpretation is accepted, that is, it can apply to only one of

the two referents, then we can use the bare noun as a diagnostic for *dou*-quantification. For this reason, we did a pretest (lacking *dou*) to filter out participants that do not accept a singular interpretation but instead provide a plural interpretation to bare nouns in an experimental setting.

Experiment 1

We conducted an experiment to test adults' knowledge of *dou*-quantification when *dou* has two (c-commanding) NPs to quantify over. Which NP(s) will be taken as the domain of *dou*, the closest one to *dou*, either one of them, or both of them simultaneously?

Methodology

Task and Procedure

The experiment used the Truth Value Judgment Task (Crain and Thornton 1998) and involved two experimenters. One acted out stories using toys and pictures, and the other played the role of a puppet who watched the stories alongside the participant. After each story, the puppet produced a test sentence or a filler sentence telling the participant what he thought had happened in the story. The participant's task was to judge whether the puppet's statement was correct. The participant was then asked to provide a justification of her/his answer.

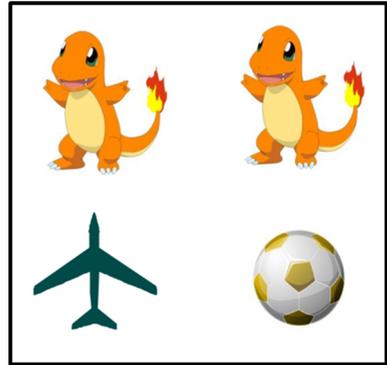
The test consisted of two parts, the pretest and the main test. The experiment was carried out in a quiet, empty office or lab at Beijing Language and Culture University. Participants were tested individually. Each experimental session typically lasted an hour.

Participants

50 native speakers of Chinese were recruited through flyers distributed at Beijing Language and Culture University in Beijing, China. The results of 40 native speakers of Chinese were included in the analysis, another set of 6 served as pilots and 4 did not pass the pretest (because they rejected 2 out of 3 pretest items). The results from the pilot study are not included in the analysis because the experimenter frequently paused to ask participants questions, in order to ascertain if any modifications needed to be made before the main study was carried out. Among the 40 subjects that were included in the analysis, 8 were males and 32 females, with a mean age of 22.95 years and an age range from 19 to 39 years.

Materials

Pretest The experiment includes the pretest and the main test. We have three items serving as the pretest. These three pretest items have two functions. First, they provide practice for subjects to understand and be familiarized with the Truth Value Judgment Task. Second, they are used to identify those participants who always accept the singular interpretation of bare nouns. If participants accept the singular interpretation of bare nouns in the pretest, but in the main test these same participants reject the singular interpretation of a bare noun with the presence of *dou*, we take this as evidence that they assume *dou*-quantification, rather than simply interpreting bare nouns as plural. Therefore only those participants who always accept the singular interpretation of bare nouns in the pretest were retained for the main test (as we describe below, about 9 in 10 were retained). These three pretest items were structured as in

Fig. 1 A picture used in a pretest item

the main experiment test items, in the sense that a story/context was presented first and then the experimenter who operated the puppet produced a statement. An example of the pretest follows.

The story was in accordance with the picture in Fig. 1 (see Appendix for a detailed example of the pretest). After the story, the puppet Mr. Tiger made a statement about what happened in the story:

- (4) Penghuolong zhaodao-le feiji.
 charizard find-ASP plane.
 ‘The charizard(s) found (a) plane(s).’

Note that bare nouns in Chinese are ambiguous between a singular and a plural interpretation. This is why in (4) the NPs *penghuolong* ‘charizard(s)’ and *feiji* ‘plane(s)’ can either be translated as singular or plural, although there are two charizards in the story. Our prediction is that if the participants accept (4) as a true description of the story, then participants can access the singular interpretation even when there are multiple referents that can satisfy the plural interpretation of the bare nouns. That is, when encountering singularity-plurality ambiguity of bare nouns, they will judge the sentence true given the bare nouns *can* be interpreted as singular. On the other hand, the rejection of sentence (4) could mean that the presence of two objects denoted by the bare noun leads to a plural interpretation of the bare noun.

Main test The main test has a 3 (sentence types) \times 2 (context types) factorial design, with 2 test items for each condition. Each subject saw all 12 combinations of test item and condition. Three simple statements concerning the stories served as fillers to check if subjects paid attention in the experiment. We focus here on materials from only one of the sentence types, a topicalized structure that allows for assessing the interpretation of *dou* in the presence of two potential NP domains. Sentence (5) below is one of the two test items used for this sentence type, each of which was presented in both context types as discussed below. The word length of the topic NP equals that of the subject NP.

- (5) [_{TopP} [_{NP2} tuzi]_k [[_{NP1} xiongmao] *dou* wei-le t_k]]
 rabbit panda all feed-ASP

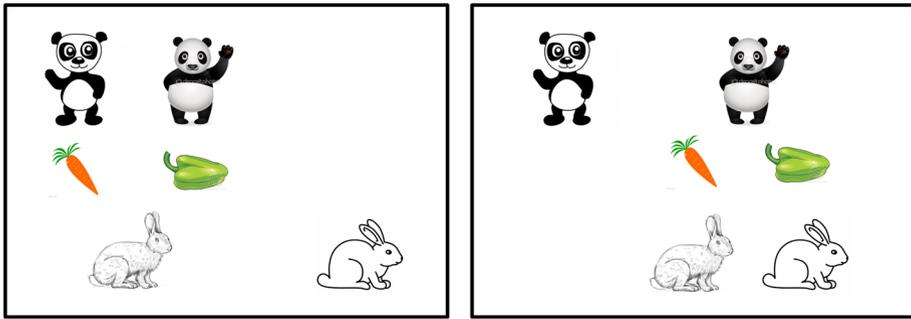


Fig. 2 Two context types: Subject context (left) and Topic context (right)

In the presentation of the test sentence, we put stress on *dou*, with the topic and the subject unstressed, to avoid, or at least weaken, a prosodic effect on domain selection (Lü 1980/1999). To help subjects recognize *tuzi* ‘rabbit’ as a topic,¹ we put a relatively long pause right after the topic (see the Materials section of the second experiment for an acoustic analysis of a test sentence). (5) is possibly 3 ways ambiguous as in (6a-c), depending on which NP(s) (either the subject NP₁ or the topic NP₂ or both) is quantified by *dou*.

- (6) a. One and only one of the two rabbits was fed by **both pandas**. (*True in Subject context*)
 b. One and only one of the two pandas fed **both rabbits**. (*True in Topic context*)
 c. **Both of the two pandas** fed **both rabbits**. (*False in both contexts*)

If (6a) is the correct interpretation, then sentence (5) would be judged as true under Subject context and as false under Topic context (Fig. 2). (For an example of the context type/story, see the Appendix.) Note that the contexts are stories that were acted out for the subjects using toys, and the pictures in Fig. 2 simply indicate those scenarios. Similarly, (5) would be true under Topic context and false under Subject context if (6b) is the correct interpretation. Finally, (5) would be judged false under interpretation (6c) in both context types, because there is always one NP that is not quantified by *dou* under these two context types.

¹ Without the relatively long pause, two alternative interpretations of (5) are available: (a) where *tuzi* ‘rabbit’ is the subject instead of the topic, and *xiongmao* ‘panda’ is the IP-internal topic moved from the object position (Kuo 2009; Paul 2002); (b) where *tuzi* and *xiongmao* form a coordinating structure, i.e. ‘rabbit and panda’. With the pause, these alternative interpretations are not readily available, and instead *tuzi* is interpreted as topic and *xiongmao* as subject. The explanations that participants provided indicate which interpretation they assigned. We found two cases of IP-internal topic interpretation and seven cases of coordinating interpretation, all of which occurred with the same test item under the Topic context (possibly because the verb phrase can be either transitive or intransitive). The experimenter asked the participants who gave these alternative interpretations to judge the sentence again, using an interpretation similar to the one they gave to (i).

(i) *ji, wo dou chi-le.*

chicken, I all eat-ASP

‘Chicken, I had all eaten.’

(i) is not semantically ambiguous because our world knowledge excludes the unwanted interpretations where *ji* ‘chicken’ or both *ji* and *wo* ‘I’ are the agent of the eating event.

For the replication experiment, we put an even longer pause after the topic NP in order to make the wanted interpretation more readily available as the only possible interpretation, and we did not make any correction to participants’ responses.

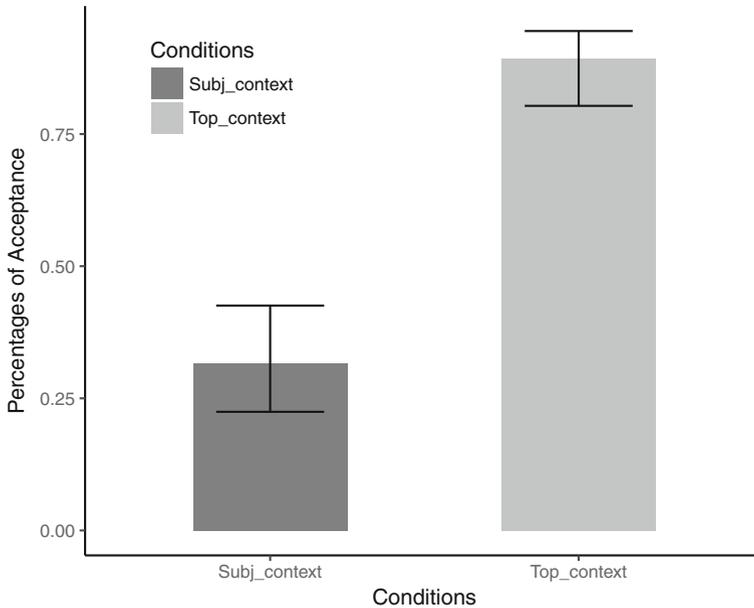


Fig. 3 The percentage of test sentences accepted by subjects, with 95% confidence intervals

Results

Pretests

Recall that pretests were used to identify participants who do not accept singular interpretation of a bare noun when there are two ‘referents’ this bare noun can refer to in the context. We found that 39 of 44 participants (after excluding the 6 pilot subjects) accepted at least two out of the three pretest items; the remaining 5 (11%) were not included for analysis of the main experimental items. The results from the pretests thus provide us with strong support for the acceptance of a singular interpretation of bare nouns when confronted with a context that is also compatible with a plural interpretation: there is more than one relevant referent of the bare nouns.

Main Test

The experimental results from the main test items reveal that either the topic or the subject NP can be the domain of *dou*. Fig. 3 presents the percentage of acceptance answers the participants gave for each condition. We report Wilson score intervals as the confidence intervals (following suggestions in Wallis (2013), Brown and Li (2005), and Newcombe (1998)), which are calculated using the R package *binom* (Dorai-Raj 2015).

Importantly, about 32% of the answers (25/79) are “yes” answers to the test sentence in (5) under Subject context, and 89% of the answers are “yes” answers to the test sentence under Topic context. This means that there are around 1/3 answers indicating that *dou* can quantify over the subject NP, whereas about 9/10 supported the hypothesis that *dou* can quantify over the topic NP.

Table 2 Number of subjects who accepted the test sentences

	<i>Subject context</i>		
	None	One	Two
<i>Topic context</i>			
None	0	2	0
One	3	1	0
Two	12	18	2

Interpretation of Results

This is the first experimental evidence regarding adult interpretation that either the subject NP or the topic NP is acceptable as the domain of *dou*, although it is the topic that is strongly preferred.

Our results suggest that *dou* can quantify over either NP in the topic sentences, thus not supporting Cheng's PED account of *dou*-quantification. A version of the locality restriction such as Cheng's (1995) PED predicts that in such sentences *dou* quantifies over only the closest NP, i.e. the subject.

Consider now Zhang's (1997) Linking Hypothesis, which allows a three-way ambiguity. It is consistent with either NP or both NPs being quantified simultaneously by *dou*. The simultaneous quantification reading over both NPs would be equivalent to the strict unselective quantifier approach to *dou*-quantification, in which *dou* would quantify over the two NPs simultaneously. Let us take a closer look at our experimental data to ascertain whether the prediction of Zhang's theory regarding *dou*-quantification is supported. Such a prediction would lead to a rejection of the test sentences over both the Topic context and Subject context, because each of these conditions are consistent with either the topic or the subject being the domain of *dou*, but not both simultaneously. Therefore, if we found that some subjects rejected the test sentences under both conditions, Zhang's Linking Hypothesis would be supported.

Table 2 presents detailed information about the subjects' individual responses. We count the number of subjects for all response patterns, which include accepting none of the items (*None* in Table 2), accepting only one of the items (*One* in Table 2) and accepting both test items in a condition (*Two* in Table 2).²

As shown in Table 2, 32(12 + 18 + 2) participants accepted both of the two items under Topic context, and only 2 participants accepted both of the items under Subject context. In addition, 21 subjects (1 + 18 + 2) accepted at least one of the items in the two conditions. This suggests that about half of the subjects considered either the topic (in Topic context) or the subject (in Subject context) as the domain of *dou* across their test items, although they preferred to take the topic as the domain. Moreover, 12 subjects accepted both items in Topic context, but rejected both items in Subject context. These participants accepted only the topic as the domain of *dou*.

Most importantly, did any participants reject the test sentences under both conditions? The answer is "no", providing some evidence that strict unselective quantification was not consistently performed by any of the subjects, which would have led them to reject the test items in both conditions, since the discourse context in each condition was set up to favor

² The percentage of test sentences accepted by subjects, with 95% confidence intervals

dou-quantification over only one of the two c-commanding NPs (the topic or the subject NP), and not both.³

We thus conclude that no strong evidence was observed in Experiment 1 to support that *dou* quantifies over both the subject and the topic NPs simultaneously. We would not exclude this interpretation though, because it might be that a few participants rejected some items under both Topic context and Subject context, which would be compatible with this interpretation.

The small number of test items under each condition could restrict the generalizability of the experiment. Therefore, we present below results from a replication experiment (Experiment 2).

Experiment 2: A Replication Study

Experiment 2 was carried out for a different study. We present here only the results from the adult control group of that study, since the materials for the control group were designed along the same lines as those in Experiment 1.

Methodology

Task and Procedure

We used the same Truth Value Judgment Task as we did in Experiment 1, and the testing procedure was similar to that in Experiment 1, except that in Experiment 2, the stories and test sentences were recorded as videos and audios respectively and were presented on a computer screen to each participant, using a mouse tracking paradigm (Freeman and Ambady 2010). After the presentation of each test sentence, participants were asked to move the mouse to choose ‘True’ (“对” in Chinese character) or ‘False’ (“错” in Chinese character), which appeared either in the top-left or top-right of the screen, counter-balanced over all the trials. The experimental session lasted approximately one and a half hours.

Participants

Twenty-three new participants, 4 males and 19 females with a mean age of 23.4 and an age range from 18 to 31, were recruited for Experiment 2 at the same site as in Experiment 1.

Materials

This replication study (Experiment 2) included 16 test items in each of the test conditions (total $n = 32$), the Subject context and the Topic context condition. 16 Fillers were interpolated among the test trails, and the materials were presented in random order. The format of the test items was the same to those of Experiment 1, except for the use of the mouse track method and recorded videos for the presentation of the materials. The test sentences were produced by a female Chinese native speaker, who was a prosodically trained master’s student in Linguistics.

We present in Fig. 4 an acoustic analysis of a test sentence, showing the pitch contour and the pause between the topic and subject NP. The primary stress is on *dou*, as is indicated by

³ Notice that $6(0 + 2 + 3 + 1)$ participants rejected at least one item under both context types, which may be because these participants occasionally rejected the test sentence under both conditions. However, we will suggest that the theory we pursue can account for these data as well.

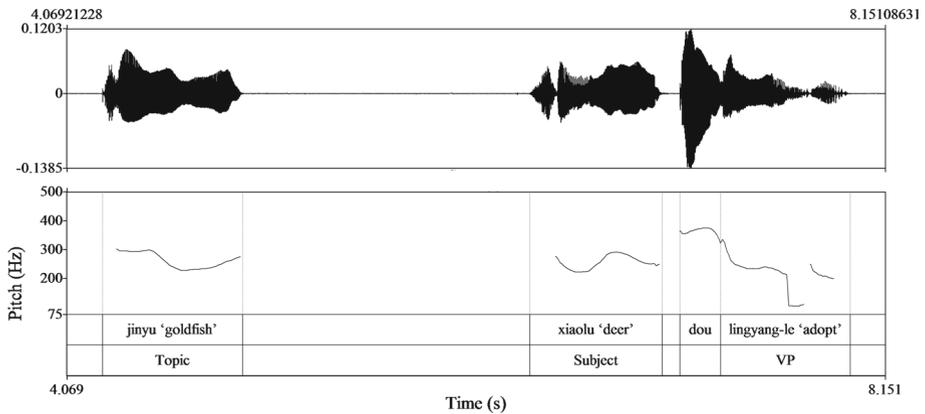


Fig. 4 The amplitude and pitch contour of a test sentence with tags

the higher pitch of *dou* compared to the topic and the subject. Across all 32 sentences, the mean duration of the pause between the topic and the subject is 1520 ms, with a standard deviation of 283 ms.

Results

The truth value judgment results from Experiment 2 are presented below.⁴ As illustrated in Fig. 5, the acceptance rate of the test sentences under the Subject context and Topic context in Experiment 2 were 36% and 71%, respectively, which is similar to the results we presented for Experiment 1. These results confirm our conclusions from Experiment 1. That is (i) either the subject NP or the topic NP can be the domain of *dou*, and (ii) the participants strongly preferred to take the topic over the subject NP as the domain of *dou*.

Discussion

The results from the pretests in Experiment 1 suggest that in the face of multiple referents in the context, participants can access the singular interpretation of a bare noun, which makes the test sentence acceptable. The results from the main test show that either the subject or the topic can be the domain of *dou*, therefore a locality constraint that predicts only the subject can be the domain is not supported empirically. In addition, there is no clear evidence supporting the idea that *dou* must quantify over both the subject and the topic NP simultaneously. Furthermore, the data in Fig. 3, Table 2 and Fig. 5 consistently suggest that the participants have a preference to take the topic NP, compared to the subject NP, as the domain of *dou*.

Using Bare Nouns as a Diagnosis for Dou-Quantification

We suggest that bare nouns, instead of plural and demonstrative NPs, should be used as a diagnosis for *dou*-quantification. But an important concern is that the rejections of the test sentences under context types Topic context and Subject context (Fig. 2) may be because of the plural interpretation of bare noun *tuzi* ‘rabbit’ or *xiongmiao* ‘panda’ in the test sentences,

⁴ The mouse tracking results are not directly relevant here, and will be presented in another paper.

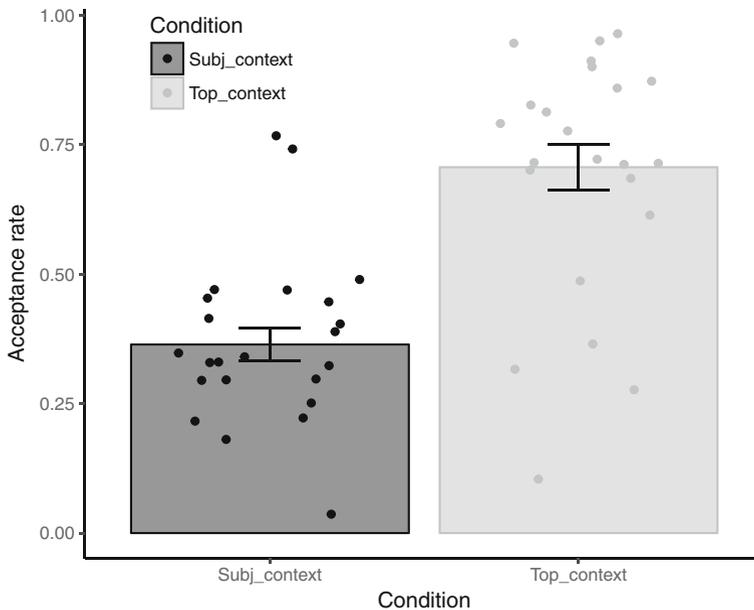


Fig. 5 Results of the replication study (Experiment 2) by condition (the dots represent the average acceptance rates of each participant)

since bare nouns are ambiguous in their singular or plural interpretation, rather than because of *dou*-quantification over the bare nouns. However, it is very unlikely that subjects ignored *dou* completely, because *dou* is important to the semantics of the sentence and *dou* was stressed in the presentation of the test sentences, and as shown by the feedback after Experiment 1, subjects were aware that *dou* was presented in most sentences.

Furthermore, there are at least four other independent reasons to expect that participants would accept the singular interpretation of bare nouns.

First, Crain and Thornton (1998, Chapter 6) point out that participants prefer choosing the interpretation of a sentence that makes the sentence true under a given context: “[T]he sentence processing system attempts to access a linguistic analysis that makes the sentence true in the discourse context. ... [t]his ‘tendency’ is manifested in resolving ambiguities. This results in a bias to say ‘Yes’ to either reading of an ambiguous sentence in contexts that are compatible with both interpretations. The perceiver assumes that the speaker intends to say something that is true in the domain of discourse; accordingly, the perceiver attempts to analyze an ambiguous sentence in a way that makes it express a true proposition” (pp. 52–53). Since in our experiments, the singular interpretation of the bare noun in the test sentences renders the test sentence true, subjects will in principle have a preference for accessing and adopting the singular interpretation.

Second, the pretest results indicated that the subjects did accept the sentence under the contexts similar to our testing contexts, in accordance with Crain and Thornton’s (1998) predictions. Only 4 out of 44 subjects gave a plural interpretation on two of the three pretest items, and these four subjects were excluded from the final analysis. Among the remaining 40 subjects, only one subject gave one case of plural interpretation (1%) in the pretest. Therefore, the plural interpretation of bare nouns may have led to some rejection of the test sentences; however, the percentage should not be high enough to affect the patterns in the results.

Third, Subjects' explanations for their judgment in Experiment 1 confirm that they rejected the test sentences primarily because of *dou*-quantification. We observed that almost all subjects realized the test sentences were ambiguous between a singular interpretation and plural interpretation (the first author talked to the subjects after the experiments), and they were struggling and even appeared stressed when they judged the ambiguous sentence to be false, under contexts where one of the interpretations makes the test sentence true and the other makes it false. When they rejected the test sentence because of their preference for plural interpretation over singular interpretation, they would give reasons such as "well, the puppet was not clear on whether the other participant did the event or not." (So they rejected the test sentence because the sentence was ambiguous.) This response is rare though: there are only two rejections that were clearly due to the test sentences being ambiguous between a singular and a plural interpretation.

Fourth, results from fillers (7a, b) in Experiment 1 provide evidence that the participants accepted a singular interpretation of bare nouns. In the case of sentence (7a), given a discourse context in which only one of the two pandas ate a carrot, 34 out of 39 (87%) participants judged the sentence as true.

- (7) a. Xiongmao chi-le huluobo.
 panda eat-ASP carrot
 'The panda(s) ate carrot.'
- b. Xiaoniao *dou* qin-le xiaoji.
 bird all kiss-ASP chicken
 'Both of the birds kissed (a) chicken.'

In addition, the test items from another condition not presented in this paper, e.g. (7b), was judged as true 95% of the time under the context that both of the birds kissed only one of the two chickens. The other 5% rejection might be due to the plural interpretation of the object. Therefore, it seems that the plural interpretation of bare noun has contributed to about 5–15% of rejections to the relevant sentences, which will not change the overall pattern in our results.

Possible Mental States Regarding Dou-Quantification

Which theory do the results support then? Recall that we found that participants preferred to take the topic NP as the domain of *dou*-quantification, and that the acceptance rate of the test sentence under the Subject context was relatively low. The second finding is not predicted if either the subject or the topic NP can be the domain of *dou*: the acceptance rates under both conditions should have been close to 100%. In order to account for these findings, in Table 3 we extend Table 1 systematically to include other logically possible patterns of interpretation—corresponding to assertions about the implications of distinct mental states. The predictions of the possible mental states concerning the truth value judgment of the test sentences under two context types are given, in order to identify participants' mental state(s) that make(s) predictions most consistent with the results. T and F entries in the table mean:

For Subject context: T(rue) if the mental state licenses *dou*-binding of the subject; F(alse) otherwise.

For Topic context: T(rue) if the mental state licenses *dou*-binding of the topic; F(alse) otherwise.

Table 3 Predictions of participants' possible mental states concerning domain selection in *dou*-quantification

	Possible mental state	Subject context	Topic context	Theory
1	Require <i>dou</i> to bind only subject (not topic).	T	F	Economy principle (Cheng 1995)
2	Require <i>dou</i> to bind only topic (not subject).	F	T	
3	Require <i>dou</i> to bind both.	F	F	Strict unselective binding
4	Require <i>dou</i> to bind subject; topic-binding is optional.	T	F	
5	Require <i>dou</i> to bind topic; subject-binding is optional.	F	T	
6	Require <i>dou</i> to bind one of topic or subject or both	T	T	Linking hypothesis (Zhang 1997)
7	Require <i>dou</i> to bind <i>only one</i> of topic or subject (No preference)	T	T	Distributive approach (Lin 1998)
8	Require <i>dou</i> to bind <i>only one</i> of topic or subject; either is fine but prefer topic.	T	T	<i>This paper's proposal</i>
9	Require <i>dou</i> to bind <i>only one</i> of topic or subject; either is fine but prefer subject.	T	T	

Mental State 1–5 can be excluded because our results show that participants do accept either the subject or the topic as the domain of *dou*. Mental State 6–9 are not distinguishable by the predictions. As we have mentioned, however, no positive evidence in our experiments supports the possibility that *dou* quantifies over both the topic and the subject simultaneously. Therefore, Mental State 6 (corresponding to Zhang's Linking hypothesis), despite standing as a possible mental state, is not supported.

We are more interested in Mental States 7–9. Then the question is, do participants have a preference for the topic NP?

We use the word “preference” to refer to probabilistic preference. The results show that participants took the topic NP as the domain more often than the subject NP (89 vs. 32%), which could be due to two possible reasons.

First, it could be because all individuals have deterministic preference (they always take either the topic or the subject as the domain) but there are more topic-preferers in the population than subject-preferers. A second possibility is that all individuals have a probabilistic preference. Under the second possibility, each individual has some probability p_i , and the distribution of this probability p_i is shifted in favor of topic-preferers. It seems to us that the data from Experiment 1 in Table 2 favors the second possibility, because most participants (55%) chose the topic NP more frequently than the subject NP (consistent with the second possibility), none chose the subject NP only, and some (32%) chose the topic only (inconsistent with the first possibility).

If individuals largely prefer to take the topic NP as *dou*'s domain, will their preference be adjusted according to the context? If yes, then we expect the subject NP should have been accepted overwhelmingly as the domain of *dou* under Subject context, which is not the case.

Therefore, we assume the following principles (8) to account for participants' performance in the experiments.

(8) a. **Grammar:** adult grammar licenses *dou* binding either the subject or the topic.

b. **Probabilistic processing:** processor commits to one binding probabilistically with

some probability p that varies across individuals.

c. **Resistance to revising commitment:** once the commitment is made, it tends not to be revised based on context.

The third principle suggests that at least in this true/false task, people are not compelled to revise their initial interpretations, even if doing so would render the sentence True. This is somewhat surprising given the Crain and Thornton (1998) observation above that people favor the interpretation that makes the sentence true. But we found that the acceptance of the test items in Subject context actually drops from the first to the second presentation, suggesting that participants might be learning that “False” responses are just as acceptable as “True” in the Truth Value Judgment Task.

As the results support the argument that participants can take either the subject NP or the topic NP as the domain, an additional question then is why they preferred the topic NP to the subject NP as the domain. We have reason to expect that the subject NP could be the preferred domain, because it is closer to *dou* both in surface structure and at LF under Cheng’s (1995) assumption. For example, English seems to observe a locality constraint: in an English counterpart, the English native speakers we informally consulted confirmed that they preferred to have the subject, rather than the topic, as the domain of *all*.

One way that Chinese is different from English though is that the topic is more prominent or salient than the subject in Chinese. Chinese is said to be a topic prominent language where topic plays an important role (Huang et al. 2009; Li and Thompson 1981). As Li and Thompson (1981) point out, a topic is always in the initial position of a sentence, and it is what the whole sentence and possibly even the whole context of that sentence is “about”. A sentence always has a topic, but does not always have a subject. If this is on the right track, then the preference for a topic NP over a subject NP as the domain of *dou* in Mandarin can be attributed to a parsing strategy/mechanism rather than a purely syntactic principle. Indeed, if the locality constraint is not operative in *dou*-quantification, then some prosodic properties that are associated with the topic might have directed subjects to take the topic as the domain. For instance, the topic naturally receives stress (although we tried to shift the stress to *dou* when producing the test sentences) and the pause after it may increase its salience. This is predicted if *dou*-quantification can be affected by contextual information, as assumed in Cheng (2009), where *dou* functions as a domain restrictor that can be associated with a contextually provided variable. Tsai (2015) as well as Y. Jiang, J. Jiang and Pan (Jiang and Pan 2013; Jiang 1998; Pan 2006) all recognized that *dou* can take as domain an element that is implicit (at the subject or topic positions) but recoverable from the context.

In sum, by employing bare nouns as a tool to identify *dou*-quantification, we find that when there are multiple NPs available for *dou*, either one of them can be *dou*’s domain, compatible with Lin’s (1996, 1998) theory and other theories that allow this kind of two-way ambiguity (e.g. Cheng 2009; Li 1997; Wu 1999; Zhang 1997). In addition, the preference for the topic NP may be relevant to the prominence of topics in Chinese. Note, however, that although the results address a puzzling problem concerning which interpretations arise from *dou*-quantification in topicalized sentences, they do not enable us to distinguish whether *dou* is a distributive operator or any of its alternatives/variants. The experiments offer a new experimental basis for future theoretical as well as acquisition studies concerning the syntax of *dou*, especially when domain selection is concerned.

Conclusions

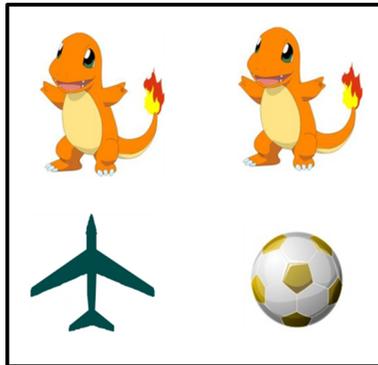
We hypothesize that if there are two NPs available for *dou*-quantification, then either one, but not both simultaneously, can be the domain of *dou*. We also argue that a locality constraint that restricts the domain of *dou* to the closest c-commanding NP is not operative in *dou*-quantification.

There are limitations in this study, of course, which may be addressed in future studies. We need evidence to ascertain if the salient status of topics, compared to subjects, is indeed the primary factor that contributed to the topic-preference reported in the results from Subject context and Topic context conditions. Will the results be different, if we increase the salience of the subject, or manipulate the prosodic stress positions (either on the subject or the topic or *dou*), or add another universal quantifier ‘every’ to the subject so that the NP in the subject position is obligatorily quantified by *dou*?

Another limitation of the present design is that in principle Zhang’s (1997) Linking Hypothesis cannot be ruled out—*dou* might still quantify over both NPs simultaneously some of the time, leading to some of the “False” responses. Nevertheless, the data can be accounted for without assuming multiple linking, and the Linking Hypothesis cannot explain why the acceptance rate of the test sentences under Subject context is relatively lower than that under Topic context across most participants. Future study will need to use testing stimuli that satisfy the following two conditions: (1) the test sentence is true if *dou* quantifies over both NPs simultaneously; (2) it is false if *dou* quantifies over either NP.

Appendix

An Example of Pretests



Story/context (in Chinese): (指向两只小动物) 你知道他们是什么吗？他们是喷火龙。他们来北京旅游，想找些好玩儿的宝贝带回家。这只喷火龙（指向图片左边那只喷火龙）找到了一架飞机。开飞机很好玩儿吧？另一只喷火龙找到了足球。他们高高兴兴地把这些宝贝带回家里了。好，故事讲到，小老虎，你说说这个故事讲了什么？

English translation of the story (Point to the two animals) Do you know what they are? They are charizards. They came to Beijing for a trip and wanted to find some interesting treasures and take them home. This charizard (point to the charizard on the left of the picture) found

a plane. Flying a plane is interesting, isn't it? The other charizard found a football. They happily took these treasures home. OK. The story is finished. Mr. Tiger, can you tell me what happened in this story?

Puppet: Zhe shi (yi)-ge he zhaobaobei youguan de gushi. En, zuihou, Penghuolong

This is one-cl with find treasure relevant de story. Er, finally, charizard
zhaodao-le feiji.

find-ASP plane

'This story is about looking for treasures. Finally, the charizard(s) found a plane.'

Examples of the Main Test

Item 1 in Subject Context Condition (Experiment 1)

Story/context (in Chinese): 两条小鱼生活在鱼缸里，老听到有两只动物（鸭子）嘎嘎的叫声，所以很想看到这两只动物。有一天，两只鸭子突然对鱼缸感兴趣，在鱼缸外面走来走去。两条小鱼跳起来（每条小鱼都表演一次），均见到了一只鸭子，但另外一只鸭子太矮小，两只小鱼均没有见到。

小老虎：嗯，让我看看。嗯，鸭子，小鱼都见了。

English translation of the story Two fish lived in a fish tank and the fish tank was not transparent. They heard two animals (ducks) quacking, but did not know what the two animals looked like. They wanted to see the two animals. One day, the two ducks became interested in the fish tank and walked around the tank. The two fish jumped up (perform once for each fish) and saw the tall duck, but they were not able to see the short duck.

Puppet: Er, let me see. Er,

duck, fish *dou* jian-asp.

Interpretations under consideration:

- (i) 'One and only one duck was seen by both fish.' (T under Subject context, F under Topic context)
- (ii) 'One and only one fish saw both ducks.' (F under Subject context, T under Topic context)
- (iii) 'Both fish saw both ducks' (F under Subject context, F under Topic context)

Item 2 in Subject Context Condition (Experiment 1)

Story/context (in Chinese): 为了进城里抢东西，两个海盗攻击两个老虎侍卫。海盗 1 的第一次进攻被一个老虎挡住了，这个海盗的第二次进攻又被另一个老虎挡回去了。海盗 2 乘机走后门溜进了城里，抢了好多东西。因为侍卫 1 和侍卫 2 挡住了海盗 1，他们都得到了奖品。

小老虎：嗯，让我看看。嗯，海盗，老虎都挡住了。

English translation of the story Two pirates attacked two tiger guards in order to rob a city. Pirate 1 (pointing to a pirate) firstly aimed at Tiger 1 (pointing to a tiger), but Tiger 1 stood in front of the entrance and blocked the pirate's way. Pirate 1 tried a second time, but this time he was barred by Tiger 2. Taking advantage of the situation, Pirate 2 crept into the city through a back door and robbed a lot of things. Because Tiger 1 and Tiger 2 both stopped Pirate 1, they were awarded a prize.

Puppet: Er, let me see. Er,
pirate, tiger *dou* barred-the-way-of.

Interpretations under consideration:

- (i) 'One and only one pirate was barred by both tigers.' (T under Subject context, F under Topic context)
- (ii) 'One and only one tiger barred the way of both pirates.' (F under Subject context, T under Topic context)
- (iii) 'Both tigers barred the way of both pirates. (F under Subject context, F under Topic context)

An Example of Topic Context

Story/context (in Chinese): 这个故事中有两只小鸡和两只小鸟。两只小鸡非常喜欢两只小鸟。小鸟也非常和气，也喜欢和别人做好朋友。两只小鸡有次私下聊天，说，只要小鸟能送他们一个礼物，无论是什么，他们就会非常非常喜欢。一只小鸡说，她还会主动亲那个送她礼物的小动物一下，另外一只小鸡马上接口说她也会。小鸟哥哥很勤劳，种了好多南瓜，有红的有黄的，于是就把南瓜送给了两只小鸡。两只小鸡很高兴，都亲了小鸟哥哥一下。懒惰的小鸟弟弟也想小鸡亲她啊，可是他什么礼物也没有，当然也没有机会亲两只小鸡了。不过，两只小鸡还是挺高兴的，因为他们都得到了小鸟哥哥这个好朋友。第二天，两只小鸡就把南瓜做成了鲜美的南瓜粥，请小鸟哥哥一起来喝。好，故事讲到这里，小老虎，你说说这个故事讲了什么？

小老虎：嗯，让我看看。嗯，
小鸡，小鸟都亲了。

English Translation of the Story In this story, there are two chickens and two birds. The two birds had colorful feathers and looked smart. They were popular among the animals. These two chickens (pointing to the chickens) wanted to be friends with the birds, and would like to receive any gifts the birds gave them. The chickens also said that if the birds gave them gifts, they would let the birds kiss them. The older bird planted a lot of pumpkins. The younger bird wandered around all day without planting any vegetables. Therefore, in the fall, the older bird had many pumpkins. He gave pumpkins to both chickens, and according to what the chickens had agreed on, the older bird kissed both chickens. The younger bird also wanted to be kissed, but since he did not have any gifts, he could not kiss the chickens. The two chickens liked the pumpkins very much and made very delicious pumpkin soup.

The story has finished. Mr. Tiger, could you tell us what happened in the story.

Puppet: Er, let me see. Er,
chicken, bird *dou* kiss.

Interpretations under consideration:

- (i) 'One and only one chicken was kissed by both birds.' (T under Subject context, F under Topic context)

- (ii) ‘One and only one bird kissed both chickens.’ (F under Subject context, T under Topic context)
- (iii) ‘Both birds kissed both chickens. (F under Subject context, F under Topic context)

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