

## Chinese Scope: an experimental investigation

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**Abstract.** The current study tests the status of Mandarin Chinese inverse scope by focusing on the interpretations available for sentences where the quantifier ‘one/a’ scopes over ‘every’ at surface structure. By comparing the responses from native speakers of Chinese and native speakers of English, we show that Chinese in fact does not allow inverse scope in doubly-quantified sentences (contra Zhou and Gao, 2009). Further, our results 1) suggest that the Chinese prohibition on inverse scope does not straightforwardly emerge from numeral semantics or bi-clausal structure, 2) demonstrate that in English the numeral *one* yields a strong specificity inference in subject position (cf. the Single Reference Principle of Kurtzman and MacDonald, 1993), and 3) confirm the permissibility of reconstruction in English relative clauses (cf. Aoun and Li, 2003), therefore providing support for a head-raising analysis of these constructions.

**Keywords:** quantifier scope, Chinese, relative clauses, reconstruction

### 1. Introduction

Quantifier scope ambiguities feature prominently in many theories of the syntax-semantics interface, owing to the direct translation from structure to meaning that generates the candidate readings. In English, doubly-quantified sentences, i.e., sentences with two quantifier phrases, readily admit such ambiguities (May, 1977, 1985). For instance, the sentence in (1) is ambiguous between a “surface” scope reading, (1-a), and an “inverse” scope reading, (1-b). In the former, the surface word order corresponds to the scope relation at Logical Form (LF), whereas in the latter the reading derives from inverting the LF scope of the subject and object quantifiers. A similar ambiguity is observed for (2), where the linear order of the two quantifiers is reversed. The inverse scope reading is attributed by May to QR, an operation occurring at the level of LF.<sup>1</sup>

- (1) Every shark attacked a pirate.
- a. Surface scope (*every* > *a*):  
for every shark there is a (possibly different) pirate that it attacked
  - b. Inverse scope (*a* > *every*):  
there is one pirate that every shark attacked

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<sup>1</sup>A popular alternative approach to QR for the wide-scope behavior of indefinites is based on choice functions (Kratzer, 1998; Reinhart, 1997; Winter, 1997). For our purposes, the mechanisms deriving scope ambiguities are not directly relevant; we assume QR for perspicuity.

- (2) A shark attacked every pirate.
- a. Surface scope ( $a > every$ ):  
there is one shark that attacked every pirate
  - b. Inverse scope ( $every > a$ ):  
for every pirate there is a (possibly different) shark that attacked him

The two readings of (1) are not logically independent of each other. Reinhart (1976, 1997), Cooper (1979), and in particular (Ruys, 1992, ch. 1) point out that while the surface scope reading in (1-a) does not entail the inverse scope reading in (1-b), (1-b) does entail (1-a): if there is a single pirate that every shark attacked, it is necessarily the case that every shark attacked a pirate, albeit the same one. In other words, a scenario with a single pirate being attacked is compatible with both readings of (1). A similar entailment pattern holds in the case of (2), but here it is the surface scope reading, (2-a), that entails the inverse scope, (2-b): if there is a single shark that attacked every pirate, it is trivially true that for every pirate there is a shark that attacked him. Thus, a scenario with a single shark is compatible with both scope interpretations of (2).<sup>2</sup>

Although QR and related scope phenomena are robustly attested in English, not all languages exhibit QR and the corresponding scope ambiguities. Of interest to our current study is the status of scope ambiguities in Chinese. It is widely held that sentences with more than one quantifier phrase in Chinese are generally unambiguous, admitting only a surface scope interpretation (Aoun and Li, 1989, 2003; Huang, 1982; Lee, 1986; Huang, 1981, but see Section 4 for a fuller discussion of the facts). The observed scope rigidity of quantifiers, i.e., the absence of inverse scope readings, finds a theoretical description in the Isomorphic Principle of Aoun and Li (1989):

- (3) *The Isomorphic Principle* (Aoun and Li, 1989, pg. 142):  
Suppose A and B are quantifier phrases. Then if A c-commands B at S-Structure, A c-commands B at LF.

For a concrete example of the Isomorphic Principle at work, consider the sentence in (4).<sup>3</sup>

- (4) you yi-tiao-shayu gongji-le mei(-yi)-ge-haidao  
exist one-CL-shark attack-PERF every(-one)-CL-pirate  
'One/a shark attacked every pirate.'

<sup>2</sup>Uli Sauerland (p.c.) notes that without an existence presupposition on *every* there are scenarios where the entailment relation from  $every > a$  to  $a > every$  fails. In (1) and (2) such a scenario would feature no sharks and no pirates. With *every* taking wide scope the sentence would be vacuously true; with *a* taking scope the sentence would be false. This is a viable theoretical possibility but not one that was tested in our experimental study.

<sup>3</sup>Sentence-initial numeral phrases like *yi-tiao-shayu* 'one-CL-shark' typically require the existential predicate *you*. We return to this point in our discussion of Experiment 1 below.

As discussed above, when an existential quantifier linearly precedes a universal quantifier like in (4), the surface scope reading entails the inverse scope reading. Thus, a scenario in which a single shark attacks the relevant pirates is compatible with both a surface and inverse interpretation of (4); such a scenario consequently gives no clues to the permissible scope relations in Chinese. However, a scenario in which there are multiple sharks attacking pirates corresponds only to the inverse interpretation of (4). This reading would result from QR of the object ('every pirate') over the subject ('one/a shark') at LF. But the Isomorphic Principle prohibits this operation: raising the object over the subject at LF would yield conflicting surface and LF scope relations. Assuming a constraint such as the Isomorphic Principle, we therefore predict that (4) cannot describe a multiple shark scenario. The Isomorphic Principle is absent in English, meaning that the English equivalent of (4) can describe a multiple shark scenario, signaling the availability of inverse scope.

Given the Isomorphic Principle and the theoretical literature that informs it, we have a clear prediction concerning the status of inverse scope in Chinese: it should not be allowed. Unfortunately, much of the work ostensibly investigating this prediction fails to take into account the entailment relations between surface and inverse scope interpretations (but see Lee, 1986, pg. 144). Whenever an inverse scope reading entails the corresponding surface scope reading, testing the availability of inverse scope fails: the scenario described by the inverse interpretation will always verify the surface interpretation. Thus, intuitions confirming the possibility of a superficially inverse reading in such a test can be explained by the surface reading alone. As we will see, the failure to consider these entailment patterns between readings leaves us without empirical foundations for either a prohibition on inverse scope or for its refutation.

In an attempt to empirically support the lack of inverse scope for doubly-quantified sentences in Chinese, Zhou and Gao (2009) used an offline judgment task to test Chinese speakers on the readings available for sentences such as (5).

- (5) mei-ge-qiangdao dou qiang-le yi-ge-yinhang  
 every-CL-robber DOU rob-PERF one-CL-bank  
 'Every robber robbed a bank.'

Given their subjects' willingness to have sentences like (5) describe inverse scope scenarios (in (5) such a scenario would have a single bank robbed), the authors conclude that inverse scope interpretations are in fact available (though dispreferred) in Chinese.<sup>4</sup> It should be clear by now that Zhou and Gao's conclusion does not follow from the results that they claim support it: the stimuli used in their judgment task all feature a universally quantified subject (e.g., 'every robber' in (5)) linearly preceding an existentially quantified object (e.g., 'one/a bank' in (5)). This configuration necessitates the inverse interpretation's entailing of the surface one: whenever an inverse reading is true a surface reading follows. In (5), if there is a single bank that every robber robbed, for every

<sup>4</sup>The authors also conducted an eye-tracking experiment, reaching the same conclusion that inverse scope is available in Chinese; see Zhou and Gao (2009) for the details of this study.

robber there is a bank that s/he robbed; whether or not this bank is the same across the robberies is irrelevant to the truth of the surface interpretation.

We are therefore left with uncertainty: in the theoretical literature on Chinese the general consensus is that inverse scope is unavailable (stemming from Huang, 1982), but the only quantitative study meant to empirically confirm or deny the availability of inverse scope in Chinese tests sentences wherein ‘every’ scopes over ‘one/a’ at surface. This ‘every’ over ‘one/a’ configuration cannot positively identify inverse scope readings due to the entailment patterns between the resulting surface and inverse interpretations.<sup>5</sup> The crucial test case of inverse scope in such doubly-quantified sentences should feature ‘one/a’ scoping over ‘every’ at surface (as in (4)); these are the sentences that we experimentally investigate in this paper.

As we show, Chinese speakers do not allow inverse interpretations for ‘one/a’ over ‘every’ configurations. We interpret these results as a demonstration that Chinese does not allow inverse scope in doubly-quantified sentences, a finding consistent with the Isomorphic Principle. To further confirm this claim of a prohibition on inverse scope in Chinese, we compare the results of Chinese speakers with those of American English, a language uncontroversially assumed to allow inverse scope (e.g., May, 1977). We begin with the study of Chinese in the next section.

## 2. Experiment 1: Chinese scope

To settle the conflict surrounding the availability of inverse scope in Chinese, we presented speakers of Mandarin with audio sentence-picture pairs featuring a doubly-quantified sentence and an image consistent with either the surface or the inverse interpretation of the sentence. Subjects provided truth-value judgments.<sup>6</sup> Assuming the soundness of Zhou and Gao’s conclusion that inverse scope is available in Chinese (in contrast to the theoretical consensus that precedes it; e.g., Aoun and Li, 1989; Huang, 1982), we expect to find that subjects judge sentences as true when they describe a scenario consistent only with an inverse interpretation.

### 2.1. Participants

We recruited 40 subjects through a combination of email chains and advertisements on Chinese social media websites.

<sup>5</sup>In fact, Hornstein (1995) goes so far as to say that only sentences in which *a* precedes *every* (but not sentences in which *every* precedes *a*) are truly ambiguous.

<sup>6</sup>In a separate experiment we asked Chinese subjects (N=132) to provide felicity judgments on a 1 to 7 scale; see Tsai et al. (2014) for the details of this study.

## 2.2. Stimuli

Stimuli consisted of 16 sentence-picture pairs. Sentences were recorded by an adult male native speaker of Chinese from Beijing and normed to ensure neutral intonation.<sup>7</sup> Pictures came from the Scope Fieldwork Project (<http://udel.edu/bruening/scopeproject/scopeproject.html>). The 8 critical items featured doubly-quantified transitive sentences with the quantifiers *mei* ‘every’ and *yi* ‘one/a’ in subject or object position.<sup>8</sup>

We manipulated two factors: the first, ORDER, corresponds to whether ‘every’ precedes (EO) or follows (OE) ‘one/a’ at surface. The second factor, SCOPE, corresponds to whether the picture co-occurring with the sentence matches an INVERSE or SURFACE interpretation. An example item is given in Fig. 1. For reasons mentioned above concerning the entailment patterns between the INVERSE and SURFACE interpretations of EO sentences, only responses to the OE INVERSE condition provide a test of inverse scope.

## 2.3. Design

Subjects took the experiment online using the web-based experiment platform ExperigenRT (Pillot et al., 2012; Becker and Levine, 2010). After filling out a short demographic questionnaire, subjects completed three training sequences to familiarize them with the experiment and to ensure that they could hear the sentences being played and read the Chinese instructions. The training also served to reinforce that the domain of quantification for a given sentence was depicted completely.

After training, each subject saw 16 sentence-picture pairs in a random order (8 critical items and 8 fillers). Subjects had to judge the sentence either TRUE or FALSE in the scenario displayed.

Only native speakers of Chinese (Mandarin) were included in the analysis. We evaluated nativeness on the basis of two demographic questions: *What was the first language you learned?* (*Mandarin*), and *What is the language you speak most at home?* (*Mandarin*). Data from 19 subjects was included in the analysis.

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<sup>7</sup>We used neutral intonation in our audio stimuli to avoid possible prosodic cues for specific scope interpretations. However, even if the resulting intonation was not neutral in every case, Leddon et al. (2004) find that prosodic information does not provide reliable cues for disambiguating scope interpretations, at least in English.

<sup>8</sup>The full list of items appears in Appendix A.

	EO	OE
SURFACE	 <p>mei-yi-tiao-shayu dou gongji-le yi-ge-haidao every-one-CL-shark DOU attack-PERF one-CL-pirate 'every shark attacked a pirate'</p>	 <p>you yi-tiao-shayu gongji-le mei-yi-ge-haidao have one-CL-shark attack-PERF every-one-CL-pirate 'a shark attacked every pirate'</p>
INVERSE	 <p>mei-yi-tiao-shayu dou gongji-le yi-ge-haidao every-one-CL-shark DOU attack-PERF one-CL-pirate 'every shark attacked a pirate'</p>	 <p>you yi-tiao-shayu gongji-le mei-yi-ge-haidao have one-CL-shark attack-PERF every-one-CL-pirate 'a shark attacked every pirate'</p>

Figure 1: An example item from Experiment 1 (Chinese)

## 2.4. Results

Percentages of TRUE responses to each of the four conditions are given in Table 1. We fit a mixed logit model predicting response by ORDER and SCOPE, as well as their interaction; the model included random intercepts for subjects and items and random slopes for ORDER and SCOPE grouped by subject and item. We find a significant effect of SCOPE ( $\chi^2(1) = 14.8, p < 0.001$ ): INVERSE conditions received fewer TRUE responses than SURFACE. The OE INVERSE condition received no TRUE responses at all.

Table 1: Percent TRUE responses by condition for Experiment 1 (Chinese)

ORDER	SCOPE	TRUE
EO	SURF.	100%
OE	SURF.	76%
EO	INV.	25%
OE	INV.	0%

## 2.5. Discussion

Consistent with previous reports on inverse scope interpretations in Chinese, INVERSE conditions receive fewer TRUE responses than their SURFACE counterparts. We also see a trend wherein Chinese speakers demonstrate a dispreference for ‘every’ in object position, which may be related to the fact that in Taiwanese, a closely related Chinese language widely spoken in Taiwan, definite expressions are degraded in the postverbal object position in certain constructions (James Huang, p.c.; see also Cheng et al., 1997; Teng, 1995, and references therein). In fact, when we split our results on the basis of whether subjects hail from Taiwan or mainland China, we see that the ORDER trend is driven primarily by speakers from Taiwan. For OE SURFACE conditions, mainland subjects judge the sentence true 80% of the time, whereas Taiwanese subjects judge the sentence true only 40% of the time.

Crucially, no subject judged the critical OE INVERSE condition as TRUE. Recall that this condition provides the unambiguous test case of the possibility for inverse scope, which means that no subject demonstrated the ability for inverse scope interpretations in Chinese. These results do not support the claim from Zhou and Gao (2009), who would predict a non-negligible proportion of TRUE responses to this condition. We therefore take these results to demonstrate that Chinese in fact does not allow inverse scope in doubly-quantified sentences, a finding consistent with much of the early literature on the topic.

Having found that Chinese does not allow inverse scope, we next ask why this should be the case. Here it bears noting two properties of the Chinese sentences we tested: the Chinese indefinite expression *yi* also doubles as the numeral ‘one’, and sentence-initial numeral phrases like *yi-tiao-shayu* ‘one/a shark’ require the predicate *you* to precede them. This requirement necessitates *you* at the beginning of the sentences in the OE conditions (Fig. 1). *You* ‘exist’ functions as an existential predicate elsewhere in Chinese. In fact, some analyses of *you* preceding the numeral ‘one’ (as in our OE stimuli) attribute to *you* the function of an existential main verb which takes an internal argument modified by a relative clause, hence participating in a bi-clausal structure (Fang and Lin, 2008; Fang, 2010; Huang, 1987; Li, 1990; Aoun and Li, 1989, fn. 3). Both properties – possible numeral semantics for the indefinite *yi* and sentence-initial *you* ‘exist’ – set the Chinese sentences

apart from their English counterparts, and thus potentially contribute to the lack of inverse scope in Chinese. To further confirm the current finding that inverse scope is disallowed in Chinese, and to better understand the source of this prohibition, in Experiment 2 we test the same materials in a language uncontroversially claimed to allow inverse scope: English.

### 3. Experiment 2: English scope

We ran the English equivalent of Experiment 1 on native speakers of American English. To evaluate the possible contribution of numeral semantics and the bi-clausal structure associated with existentials to the Chinese prohibition on inverse scope, we split Experiment 2 into 4 sub-experiments: English sentences featured either indefinite *a* or the numeral *one*, and sentences with *one/a* preceding *every* optionally included existential *there-be* constructions. The goals were two-fold: to see how speakers of a language with inverse scope behave with our experimental items in the default case, and to see if the patterns with *one* instead of *a* or with an existential construction align with the pattern observed in Experiment 1 for Chinese.

#### 3.1. Participants

We recruited 30 subjects through Amazon.com's Mechanical Turk Crowdsourcing Service. Subjects were compensated for their participation.

#### 3.2. Stimuli

Stimuli consisted of the 16 sentence-picture pairs from Experiment 1 plus 5 additional fillers. As before, two factors were manipulated: ORDER (*one/a* precedes, OE, or follows, EO, *every*), and INVERSE, corresponding to whether the co-occurring image matches a SURFACE or INVERSE interpretation of the sentence. Sentences were translations of the Chinese into one of four possible frames split on whether they feature indefinite *a* or the numeral *one*, and whether the OE construction is embedded under existential *there-be*. Example OE sentences, the possible translations of the Chinese OE sentence in Fig. 1, appear in (6).<sup>9</sup>

(6)	Sub-experiment	Example OE sentence
a.	PLAIN	A shark attacked every pirate.
b.	ONE	One shark attacked every pirate.
c.	THERE	There is a shark that attacked every pirate.
d.	THERE+ONE	There is one shark that attacked every pirate.

<sup>9</sup>A full list of items appears in Appendix B.

An adult male native speaker of American English recorded all of the sentences. Recordings were normed to ensure neutral intonation.

### 3.3. Design

Experiment 2 employed the same design as Experiment 1: subjects took the experiment online using ExperigenRT. After filling out a short demographic questionnaire and completing three training sequences, each subject saw 21 sentence-picture pairs in a random order (8 critical items and 13 fillers). Subjects judged the sentences either TRUE or FALSE in the scenarios depicted.<sup>10</sup> Only native speakers of English were included in the analysis; data from 30 subjects was analyzed.

### 3.4. Results

We split responses by sub-experiment; percent TRUE responses to each of the four conditions is given in Table 2.

Table 2: Percent TRUE responses by condition for Experiment 2 (English)

ORDER	SCOPE	PLAIN	ONE	THERE	THERE+ONE
EO	SURF.	93	100		
OE	SURF.	100	85	87	92
EO	INV.	88	69		
OE	INV.	56	28	50	11

We begin by analyzing responses to the PLAIN items, (6-a). We fit a mixed logit model predicting response by ORDER and SCOPE, as well as their interaction. We find a significant effect of effect of SCOPE ( $\chi^2(1) = 5.50, p < 0.05$ ) and an reliable interaction between ORDER and SCOPE ( $\chi^2(1) = 8.14, p < 0.01$ ): INVERSE conditions received fewer true responses than SURFACE, and the OE INVERSE condition received fewer TRUE responses than the other three conditions. A planned comparison between the English (PLAIN) and Chinese responses to the critical OE INVERSE conditions demonstrates that English speakers reliably provide more TRUE responses to this condition (0.0% Chinese vs. 56% English PLAIN;  $\chi^2(1) = 8.78, p < 0.01$ ).

Next, we analyze responses to the ONE items, (6-b). A mixed logit model predicting response by ORDER and SCOPE, as well as their interaction, reveals significant effects of both ORDER ( $\chi^2(1)$

<sup>10</sup>As with Chinese in Experiment 1, we also ran the English study using 1 to 7 felicity ratings (N=130); see Tsai et al. (2014) for the details of this study.

= 6.04,  $p < 0.05$ ) and SCOPE ( $\chi^2(1) = 6.26$ ,  $p < 0.05$ ): OE sentences received fewer TRUE responses than EO sentences, and INVERSE conditions received fewer TRUE responses than SURFACE. A planned comparison between the English (ONE) and Chinese responses to OE INVERSE conditions reveals a marginal effect of language such that English speakers provide more TRUE responses to this condition (0.0% Chinese vs. 28% English ONE;  $\chi^2(1) = 3.16$ ,  $p = 0.076$ ).

Turning to the THERE items, (6-c), the existential *there-be* construction only occurs in OE sentences where *a* precedes *every* at surface. We therefore have no ORDER manipulation within this sub-experiment. A mixed logit model predicting response by SCOPE reveals a significant effect of SCOPE ( $\chi^2(1) = 3.97$ ,  $p < 0.05$ ): INVERSE conditions received fewer TRUE responses than SURFACE. A planned comparison between the English (THERE) and Chinese responses to OE INVERSE conditions reveals a significant effect of language such that English speakers provide more TRUE responses to this condition (0.0% Chinese vs. 50% English THERE;  $\chi^2(1) = 4.29$ ,  $p < 0.05$ ).

As with the THERE items, there was no ORDER manipulation within the THERE+ONE sub-experiment: all sentences feature *one* linearly preceding *every* as in (6-c). A mixed logit model predicting response by SCOPE reveals a significant effect of SCOPE ( $\chi^2(1) = 17.9$ ,  $p < 0.001$ ): INVERSE conditions received fewer TRUE responses than SURFACE. A planned comparison between the English (THERE+ONE) and Chinese responses to OE INVERSE conditions reveals a marginal effect of language such that English speakers provide more TRUE responses to this condition (0.0% Chinese vs. 11% English THERE+ONE;  $\chi^2(1) = 3.49$ ,  $p = 0.062$ ).

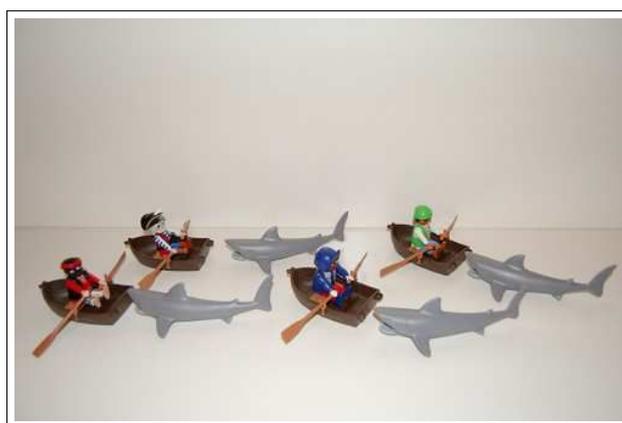
### 3.5. Discussion

Consistent with previous findings on English scope (e.g., Anderson, 2004; Tunstall, 1998), subjects demonstrated a dispreference for inverse interpretations: OE INVERSE sentences were judged particularly poorly. However, whereas no Chinese subjects judged OE INVERSE trials true, in the corresponding English PLAIN condition, (6-a), subjects judged the sentence true 56% of the time. This 56% OE INVERSE acceptance rate indicates the availability of inverse scope, a feature absent in Chinese.<sup>11</sup> Crucially, planned comparisons between each of the four English OE INVERSE conditions and the corresponding Chinese condition demonstrate that in Chinese this prohibition does not emerge from numeral semantics or bi-clausal structure, but rather suggest a global prohibition on inverse scope such as the Isomorphic Principle (Aoun and Li, 1989; Huang, 1982).

Two other properties of the English data warrant further consideration. First, in the English ONE and THERE+ONE sub-experiments where the numeral *one* replaces indefinite *a*, (6-b,d), subjects were less willing to judge an INVERSE sentence true than they were with *a*: 56% (PLAIN) vs. 28% (ONE) and 11% (THERE+ONE). We might take this pattern to signal that numerals induce

<sup>11</sup>Anderson (2004) also finds a 50% acceptance rate for inverse scope in English, which means that our experimental design did not unduly depress the rate of acceptance.

scope freezing and therefore resist inverse scope altogether, perhaps contributing to the ban on inverse scope in Chinese. However, ongoing work investigating the possibility of English inverse scope with other numerals shows that this freezing effect is specific to *one* and vanishes with higher numerals (inverse scope is easier to get in sentences like *two sharks attacked every pirate* than in *one shark attacked every pirate*). Another possibility is that in English *one* competes with *a* and engenders a specificity inference incompatible with inverse scope in OE sentences, i.e., incompatible with a situation in which *one* corresponds to many (Fig. 2): the use of *one* instead of *a* would therefore signal that only a single referent is intended.<sup>12</sup>



- ✓ A shark attacked every pirate.  
 ✗ One shark attacked every pirate.

Figure 2: An example of the multiple-shark scenario

If *one* is generally interpreted as specific along the lines sketched above, then we expect this specificity effect also in object position: subjects should resist many-referent uses of *one* and thus more readily accept inverse scope when *every* precedes *one* as in our EO conditions. Consider the responses for the EO INVERSE items from the PLAIN and ONE sub-experiments, exemplified in (7) when describing the situation in Fig. 2.

- (7) a. Every shark attacked a pirate. (EO INVERSE PLAIN; 88% TRUE)  
 b. Every shark attacked one pirate. (EO INVERSE ONE; 69% TRUE)

Were *one* interpreted with a specificity inference not attributed to indefinite *a*, (7-b) should receive more TRUE responses than (7-a). But we find a trend in the opposite direction: *a* more readily admits a specific interpretation in object position. The specificity effect associated with numeral *one* therefore applies only when *one* linearly precedes *every*, i.e., when it appears in subject position, as in the OE items. Instead of triggering a specificity inference in the general case, we suggest a

<sup>12</sup>Ionin et al. (2011) find a similar pattern for *one* vs. *a* indefinites: *a* is much more acceptable in multiple-referent scenarios.

processing explanation along the lines of the Single Reference Principle (Kurtzman and MacDonald, 1993): listeners build an online parse of the sentences they hear; when they encounter *one* at the start of a sentence, they imagine just a single referent associated with it. This single-referent parse is incompatible with a one-as-many scenario as in Fig. 2, accounting for participants' unwillingness to judge OE sentences with *one* as true in inverse, multi-referent scenarios. The Single Reference Principle is also active with *a* (accounting for the 56% acceptance rate for OE INVERSE sentences with *a*), but its effect is less strong, presumably because *one* is phonologically more salient than *a* so the pressure to build an initial, single-referent parse with *one* is more noticeable.

The second feature of note in our English results concerns the high acceptance rate for inverse scope across a relative clause boundary. In the THERE sub-experiment where OE sentences enter into a bi-clausal existential construction, (6-c), subjects were as likely to accept inverse scope as they were in the PLAIN version without the relative clause. The possibility of scope flexibility in the THERE items is consistent with previous judgments on similar extractions (cf. Aoun and Li, 2003) and therefore supports a head-raising analysis of these constructions (over an operator movement analysis; Bhatt, 2002; Bianchi, 2002; Zwart, 2000; Kayne, 1976; Vergnaud, 1974). Under a head-raising analysis, (8-a), the NP *shark* reconstructs into the embedded clause where it interacts scopally with the other quantified expression (*every pirate*).

- (8) a. [DP a [NP shark<sub>i</sub> [CP t<sub>i</sub> [C' that [IP t<sub>i</sub> attacked every pirate]]]]] (*head-raising*)  
 b. [DP a [NP shark [CP Op<sub>i</sub> [C' that [IP t<sub>i</sub> attacked every pirate]]]]] (*operator movement*)

Were one to adopt the analysis of English relative clauses in (8-b), the universal quantifier in the relative clause island would not be able to raise above the relative clause head, and the nominal head would not be able to reconstruct into the relative clause for interpretive purposes because it originates outside of the island. We return to this point in the following section, which concludes.

#### 4. General discussion

We began with the consensus that Chinese does not allow inverse scope for doubly-quantified sentences (e.g., Aoun and Li, 1989, 2003; Huang, 1982; Lee, 1986; Huang, 1981, among others). But the status of Chinese inverse scope, both why and whether it is disallowed, has come under recent scrutiny. Zhou and Gao (2009) tested Chinese speakers on the interpretation of doubly-quantified sentences and conclude that despite its dispreferred status, an inverse scope interpretation is in fact available in Chinese. Their study and its results face a serious entailment problem, however, because their doubly-quantified test sentences all feature 'every' preceding 'one/a' as in (5). This configuration of quantifiers felicitously describes the supposed inverse interpretation solely on the basis of surface scope: if one bank was robbed by every robber then it is trivially the case that for every robber there is a bank that s/he robbed; *one/a* > *every* entails *every* > *one/a*. Hence Zhou and Gao's conclusion that Chinese has inverse scope is not well-founded.

The crucial test case for inverse interpretations of doubly-quantified sentences features ‘one/a’ preceding ‘every’; in this configuration the inverse interpretation does not entail the surface one. We therefore tested the possibility of inverse interpretations for these sentences. In Experiment 1, none of our Chinese subjects ever accepted an inverse interpretation. We take this result to suggest that inverse scope is disallowed for doubly-quantified sentences in Chinese, contrary to Zhou and Gao’s claim.

To better understand why Chinese should prohibit inverse scope, in Experiment 2 we tested speakers of American English on translations of the materials from Experiment 1. Direct translations of the Chinese proved problematic, owing to two properties of the Chinese sentences that potentially drive the observed prohibition on inverse scope: numeral semantics for the indefinite numeral expression and bi-clausal structure contributed by an existential construction. In every case, English speakers reliably accepted inverse interpretations more often than Chinese speakers. To repeat: Chinese speakers never accepted an inverse interpretation.

Comparing the results of our two experiments, we see that the Chinese prohibition on inverse scope in doubly-quantified sentences cannot straightforwardly emerge from numeral semantics or bi-clausal structure. Instead, the diverging pattern between each of our English paradigms and the paradigm in Chinese suggests a global prohibition on inverse scope such as the Isomorphic Principle (Huang, 1982; Aoun and Li, 1989) .

Despite the consistency of our results with the Isomorphic Principle, we hesitate to conclude at this point that Chinese lacks inverse scope altogether. Aoun and Li (1989, 2003) suggest that passive sentences in Chinese may exhibit scope ambiguities; they give (9) and (10) as examples of such sentences (although native speakers’ judgments seem to vary):

- (9) meige ren dou bei yi-ge nuren zhuazou le  
 every man DOU by one-CL woman arrest PERF  
 ‘Everyone was arrested by a woman.’
- (10) yaoshi liang-ge xiansuo bei mei-ge-ren zhaodao ...  
 if two-CL clues by every-CL-person found  
 ‘If two clues were found by everyone ...’

Similarly, Jiang (2012) argues that Chinese numeral phrases can scope over the antecedent of a conditional, giving rise to a wide-scope (in addition to a narrow-scope) interpretation as in (11).

- (11) ruguo ni neng dai yi-ge-nusheng lai wo-de party de-hua ...  
 if you can bring one-CL-girl come my party if  
 ‘If you can bring one girl to my party ...’
- a. Wide scope: [one girl > if]  
 b. Narrow scope: [if > one girl] (modified from Jiang, 2012, pg. 154)

While we believe that further study is required to determine what readings are available and how they arise for these cases, note that (9) runs into the entailment problem familiar from our discussion of Zhou and Gao’s materials: if there is one woman who arrested everyone, then it is indeed the case that everyone was arrested by a woman. Therefore (9) does not evidence true inverse scope. Still, sentences with conditionals like (10) and (11) do appear to allow inverse interpretations; for this reason, we limit the scope of our claim to just doubly-quantified sentences in Chinese.

In addition to the findings related to Chinese scope, our investigation of English revealed two ancillary facts. First, the numeral *one* in subject (but not object) position yields a strong specificity inference inconsistent with multiple-referent scenarios. We attribute this position-specific specificity inference to a processing pressure such as the Single Reference Principle (Kurtzman and MacDonald, 1993). Second, English existential sentences featuring relative clauses readily admit inverse interpretations. This observed ability for scope-bearing elements to interact across a relative clause boundary provides support for a head-raising analysis of these constructions under which the head may reconstruct to a position internal to the relative clause. This lends new support to the idea from Aoun and Li (2003) that such reconstruction is possible in English quantified expressions. In arguing for the head-raising analysis of relative clauses, Aoun and Li use the following examples (from Bianchi, 1999), where the ambiguity of (12-c) is relevant for our discussion. Our results show that the same analysis can apply to bi-clausal *there-be* sentences.

- (12) a. Every doctor will examine two patients. [every > 2, 2 > every]  
 b. Every doctor will examine the two patients. [2 > every]  
 c. I phoned the two patients that every doctor will examine tomorrow. [every > 2, 2 > every]

An outstanding question here deals with the variability we observe: half of the English speakers find bi-clausal sentences with relative clauses ambiguous, but the other half do not. There are two possibilities. First, some speakers are simply less apt to see scope ambiguities, which would account for the latter group (and also for the similar ambiguity acceptance rate for sentences without relative clauses; cf. Table 2). The second option posits two different grammars of relativization in English (Hulsey and Sauerland, 2006): one that employs an operator movement strategy under which an ambiguity is not generated, and head-raising that generates the ambiguity. Assuming that English relative clauses are structurally ambiguous, it is then possible that some speakers apply the head-raising analysis whereas other speakers do not. If this hypothesis is on the right track, our results provide novel support for the structural ambiguity brought out by Hulsey and Sauerland.

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**Appendix A: Experiment 1 items (Chinese)**

ITEM	ORDER	SENTENCE
1	EO	每一个海盗都挨着一个木桶 every-one-CL-pirate DOU lean-PROG one-CL-barrel
	OE	有一个海盗挨着每一个木桶 exist one-CL-pirate lean-PROG every-one-CL-barrel
2	EO	每一个海盗都钓走了一条鱼 every-one-CL-pirate DOU catch-RES-PERF one-CL-fish
	OE	有一个海盗钓走了每一条鱼 exist one-CL-pirate catch-RES-PERF every-one-CL-fish
3	EO	每一个海盗都握着一支鱼竿 every-one-CL-pirate DOU hold-PROG one-CL-fishing-pole
	OE	有一个海盗握着每一支鱼竿 have one-CL-pirate hold-PROG every-one-CL-fishing-pole
4	EO	每一个海盗都喂了一条鲨鱼 every-one-CL-pirate DOU feed-PERF one-CL-shark
	OE	有一个海盗喂了每一条鲨鱼 have one-CL-pirate feed-PERF every-one-CL-shark
5	EO	每一个海盗都握着一瓶酒 every-one-CL-pirate DOU hold-PROG one-CL-alcohol
	OE	有一个海盗握着每一瓶酒 have one-CL-pirate hold-PROG every-one-CL-alcohol
6	EO	每一条鲨鱼都咬住了一条鱼 every-one-CL-shark DOU bite-RES-PERF one-CL-fish
	OE	有一条鲨鱼咬住了每一条鱼 have one-CL-shark bite-RES-PERF every-one-CL-fish
7	EO	每一条鲨鱼都攻击了一个海盗 every-one-CL-shark DOU attack-PERF one-CL-pirate
	OE	有一条鲨鱼攻击了每一个海盗 have one-CL-shark attack-PERF every-one-CL-pirate
8	EO	每一个女孩都轻拍了一只狗几下 every-one-CL-girl DOU light-pat-PERF one-CL-dog few-times
	OE	有一个女孩轻拍了每一只狗几下 have one-CL-girl light-pat-PERF every-one-CL-dog few-times

**Appendix B: Experiment 2 items (English)**

ITEM	SUB-EXPT.	ORDER	SENTENCE
1	PLAIN	EO	Every pirate is leaning on a barrel
	ONE		Every pirate is leaning on one barrel
	PLAIN	OE	A pirate is leaning on every barrel
	ONE		One pirate is leaning on every barrel
THERE	OE	There is a pirate who is leaning on every barrel	
THERE+ONE		There is one pirate who is leaning on every barrel	
2	PLAIN	EO	Every pirate caught a fish
		OE	A pirate caught every fish
3	PLAIN	EO	Every pirate is holding a fishing pole
		OE	A pirate is holding every fishing pole
4	PLAIN	EO	Every pirate fed a shark
		OE	A pirate fed every shark
5	PLAIN	EO	Every pirate is holding a bottle
		OE	A pirate is holding every bottle
6	PLAIN	EO	Every shark is biting a fish
		OE	A shark is biting every fish
7	PLAIN	EO	Every shark attacked a pirate
		OE	A shark attacked every pirate
8	PLAIN	EO	Every girl is petting a dog
		OE	A girl petted every dog