Revisiting inverse scope: an experimental study of Chinese and English[1]

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Abstract

The current study tests the status of 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 (N=40) and native speakers of English (N=30), we show that Chinese in fact does not allow inverse scope in doubly-quantified sentences (contra Zhou & 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* competes with the indefinite article *a* and yields a strong specificity inference, and 3) confirm the permissibility of reconstruction in English relative clauses (cf. Aoun & Li, 2003), therefore providing support for a head-raising analysis of these constructions.

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 plausibly 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, (1a), and an "inverse" scope reading, (1b). 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 scope of the subject and object quantifiers. A similar ambiguity is observed for (2), where the linear order of the two quantifiers is flipped.

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

(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 (potentially different) shark that attacked him.

The inverse scope reading is attributed by May to QR, an operation occurring at the level of LF.[2]

It is important to note that the two readings of (1) are not logically independent of each other. Reinhart (1976, 1997), Cooper (1979), and in particular Ruys (1992, Chap. 1) point out that while the surface scope reading in (1a) does not entail the inverse scope reading in (1b), (1b) does entail (1a): 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, (2a), that entails the inverse scope, (2b): 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. In other words, a scenario with a single shark is compatible with both scope interpretations of (2).[3]

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 & Li, 1989, 2003; C.-T. J. Huang, 1982; S.-F. Huang, 1981; Lee, 1986, among others; 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 Aoun & Li's (1989) *Isomorphic Principle* (which itself is founded on C.-T. J. Huang, 1982):

(3)   *The Isomorphic Principle* (Aoun & Li, 1989:142, based on C.-T. J. Huang, 1982)
        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).[4]

(4)   you   yi-tiao-shayu   gongji-le   mei(-yi)-ge-haidao.
        have one-CL-shark   attack-PERF   every(-one)-CL-pirate

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[2] A popular alternative approach to QR for the wide-scope behavior of indefinites is based on choice functions (Kratzer, 1998; Reinhart, 1997; Winter, 1997; among many others). For our purposes, the mechanisms deriving scope ambiguities are not directly relevant; we assume QR for perspicuity.
[3] 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 option but not one that was tested in our experimental study.
[4] Sentence-initial numeral phrases like *yi-tiao-shayu* 'one-CL-shark' typically require the co-occurrence of the existential predicate *you* 'have'. We return to this point in our discussion of Experiment 1 below.

'One/a shark attacked every pirate.'

As discussed above, when an existential quantifier linearly precedes a universal quantifier as 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 Aoun & Li's 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. Note that the English equivalent of (4) can describe a multiple shark scenario, signaling the availability of inverse scope and thus the absence of a constraint like the Isomorphic Principle in this language.

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, 1986:144). 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 disproof.

In an attempt to empirically support the lack of inverse scope for doubly-quantified sentences in Chinese, Zhou & Gao (2009) experimentally investigated the possibility of these interpretations. In an offline judgment task, Zhou & Gao tested Chinese speakers in Beijing on the readings available for sentences such as (5).[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. It should be clear by now that Zhou & 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

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[5] The authors also conducted an eye-tracking experiment, reaching the same conclusion that inverse scope is available in Chinese; see Zhou & Gao (2009) for the details of this study.

robbed, for every robber there is a bank that he or she 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: the theoretical literature on Chinese inverse scope finds general consensus on its unavailability (stemming from C.-T. J. Huang, 1982), but the only quantitative data 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.[6] The crucial test case of inverse scope in such doubly-quantified sentences features '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 speakers do not allow inverse scope in doubly-quantified sentences, consistent with language-wide constraints such as 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 Chinese 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 judgments.[7] Assuming the soundness of Zhou & Gao's (2009) conclusion that inverse scope is available in Chinese (in contrast to the theoretical consensus that precedes it; e.g., Aoun & Li, 1989; C.-T. J. Huang, 1982), we expect to find that subjects judge sentences as true when they describe a scenario consistent only with an inverse interpretation.

Participants

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

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. Pictures came from the Scope Fieldwork Project (http://udel.edu/~bruening/scopeproject/scopeproject.html). The 8
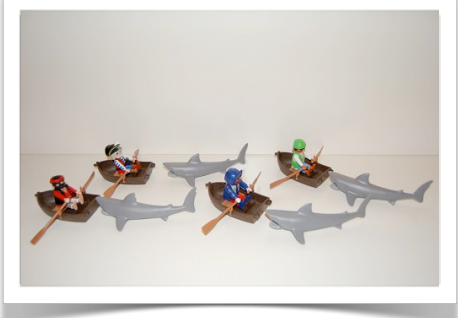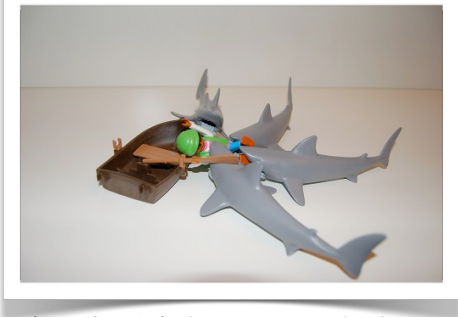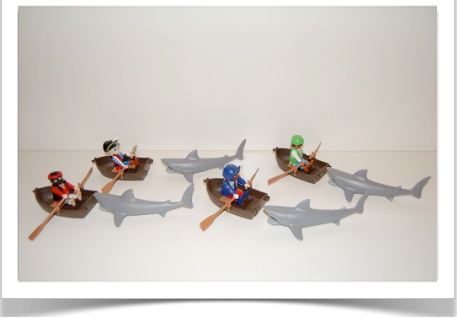
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[6] In fact, Hornstein (1995) goes as far as to say that only sentences in which *a* precedes *every* (but not sentences in which *every* precedes *a*) are truly ambiguous.
[7] In a pilot to Experiment 1 we asked Chinese subjects (N=132) to provide felicity judgments on a 1 to 7 scale; all patterns of results reported here are replicated in the initial rating data.

critical items featured doubly-quantified transitive sentences with the quantifiers *mei* 'every' and *yi* 'one/a' in subject or object position.[8]

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. Subjects saw one version of each of the 8 critical items, together with 8 fillers.

	EO	OE
SURFACE	每一条鲨鱼都攻击了一个海盗 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'	有一条鲨鱼攻击了每一个海盗 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'
INVERSE	每一条鲨鱼都攻击了一个海盗 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'	有一条鲨鱼攻击了每一个海盗 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'

Fig. 1 An example item from Experiment 1 (Chinese)

Design

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[8] The full list of items appears in Appendix A.

Subjects took the experiment online using the web-based experiment platform ExperigenRT (Pillot, Scontras, & Clemens 2012; Becker & 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 in the co-occurring image.

After training, 16 sentence-picture pairs were presented in a random order for each subject. Subjects completed a forced choice task, judging the sentence either TRUE or FALSE in the scenario displayed. Subjects saw one version of each of the 8 critical items together with 8 fillers.

Only native speakers of Chinese (Mandarin) were included in the analysis. We evaluated native-ness 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.

Results

Percent TRUE responses to each of the four conditions is 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 significant effects of ORDER ($\chi^2(1) = 8.56$, $p < 0.01$) and SCOPE ($\chi^2(1) = 42.3$, $p < 0.001$): OE sentences received fewer TRUE responses than EO sentences, and 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	%YES
EO	SURF.	100
OE	SURF.	76
EO	INV.	25
OE	INV.	0

Discussion

Consistent with previous reports on inverse scope interpretations in Chinese (e.g., C.-T. J. Huang, 1982; S.-F. Huang, 1981), here we see that INVERSE conditions receive fewer TRUE responses than their SURFACE counterparts. We also see that 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, Huang, Li, & Tang, 1997; Teng, 1995; and references therein). In fact, when we split our results on whether subjects hail from Taiwan or mainland China, we see that the ORDER effect 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 are inconsistent with the claim from Zhou & 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 peculiar properties of the Chinese sentences we tested: the Chinese indefinite article *yi* also doubles as the numeral 'one', and sentence-initial numeral phrases like *yi-tiao-shayu* 'one/a shark' require the particle *you* to precede them. This requirement necessitates *you* at the beginning of the sentences in the OE conditions (cf. Fig. 1). Note that *you* 'have' 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 and the bi-clausal syntax that goes along with it (Fang & Lin, 2008; Fang, 2010; C.-T. J. Huang, 1987; Li, 1990; also Aoun & Li, 1989, fn. 3). Both properties -- possible numeral semantics for the indefinite article and sentence-initial *you* 'have' -- 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 are 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.

Participants

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

Stimuli

Stimuli consisted of the 16 sentence-picture pairs from Experiment 1 plus 5 additional fillers. As before, two factors were manipulated: ORDER, corresponding to whether *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).[9]

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[9] A full list of items appears in Appendix B.

(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.

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

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, 21 sentence-picture pairs were presented in a random order for each subject. Subjects judged the sentences either TRUE or FALSE in the scenarios depicted.[10] Subjects saw only one version of each of the 8 critical items, and all 13 of the fillers. Only native speakers of English were included in the analysis; data from 30 subjects was analyzed.

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 each of the four sub-experiments in Experiment 2 (English)

ORDER	SCOPE	PLAIN	ONE	THERE	THERE+ONE
EO	SURF.	93	100		
OE	SURF.	100	86	88	92
EO	INV.	82	69		
OE	INV.	53	28	50	11

We begin by analyzing responses to the PLAIN items, (6a). 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 SCOPE grouped by subject and item. The interaction between ORDER and SCOPE is the only significant predictor in terms of improvement of data likelihood ($\chi^2(1) = 5.01$, $p < 0.05$): the OE INVERSE condition received reliably 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. 53% English PLAIN; $\chi^2(1) = 7.38$, $p < 0.01$).

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[10] As with Chinese in Experiment 1, here we piloted the English study using 1 to 7 felicity ratings (N=130). All patterns of results reported are replicated in the initial rating data.

Next, we analyze responses to the ONE items, (6b), in the same manner as above. A mixed logit model predicting response by ORDER and SCOPE, as well as their interaction, reveals significant effects of both ORDER ($\chi^2(1) = 10.17$, $p < 0.01$) and SCOPE ($\chi^2(1) = 7.94$, $p < 0.01$): 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; $\chi^2(1) = 3.16$, $p = 0.075$).

For the THERE items, (6c), note that 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 ($\chi^2(1) = 4.63$, $p < 0.05$): 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* preceding *every* at surface as in (6d). A mixed logit model predicting response by SCOPE reveals a significant effect of SCOPE ($\chi^2(1) = 34.17$, $p < 0.001$): 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 significant effect of language such that English speakers provide more TRUE responses to this condition (0.0% Chinese vs. 11% English THERE+ONE; $\chi^2(1) = 4.29$, $p < 0.05$).

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, (6a), subjects judged the sentence true 53% of the time. This 53% OE INVERSE acceptance rate characterizes the availability of inverse scope, a feature absent in Chinese. 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 straightforwardly 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 sub-experiment where the numeral *one* replaces indefinite *a*, (6b), subjects were less willing to judge an INVERSE sentence true than they were with *a* (53% *a* vs. 28% *one*). We might take this pattern to signal that numerals induce scope freezing and therefore resist inverse scope, 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 disappears with higher numerals. We therefore conclude

that *one* competes with *a* and engenders a specificity inference incompatible with inverse scope, i.e., incompatible with a situation in which *one* corresponds to many (Fig. 2): the use of *one* instead of *a* signals that only a single referent is intended. [11]

A shark attacked every pirate.
✘ One shark attacked every pirate.

Fig. 2 An example of the multiple-shark scenario

That the specificity associated with *one* is an inference and not an entailment finds support in the fact that 28% of the time subjects in our ONE sub-experiment accepted *one* in a multiple-referent scenario (e.g., Fig. 2). Contrast this pattern with that found in Experiment 1 for Chinese: no Chinese subject ever accepted a multiple-referent -- and therefore an inverse -- scenario for OE sentences. Unlike the tendency observed for English, in Chinese this option appears to be ruled out completely.

The second feature of note in our English results is that in the THERE sub-experiment where OE sentences enter into a bi-clausal existential construction, (6c), subjects were as likely to accept inverse scope as they were in the PLAIN version without the relative clause necessitated by *there-be*. The possibility of LF extraction out of the relative clause in the THERE items aligns with previous judgments on similar extractions (cf. Aoun & Li, 2003) and therefore supports a head-raising analysis of these constructions (over an operator movement analysis; Bhatt, 2002; Bianchi, 2002; Kayne, 1976, 1994; Vergnaud, 1974). Under a head-raising analysis, the NP *shark* reconstructs into the embedded clause where it interacts scopally with the other quantified expression (*every pirate*). This is schematized in (7), with irrelevant details omitted.

(7) $[_{DP}$ a $[_{NP}$ shark$_i$ $[_{CP}$ $[Op$ t$_i]_k$ that $[_{TP}$ t$_k$ … $]]]]$

We return to this point in the following section.

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[11] Ionin, Ebert, & Stolterfoht (2011) find a similar pattern for *one* vs. *a* indefinites: *a* is much more acceptable in multiple-referent scenarios.

4. General discussion

We began with the general consensus that Chinese does not allow inverse scope for doubly-quantified sentences (e.g., Aoun & Li, 1989, 2003; C.-T. J. Huang, 1982; S.-F. Huang, 1981; Lee, 1986; among others). But the status of Chinese inverse scope, both why and whether it is disallowed, has come under recent scrutiny. Zhou & Gao (2009) tested Chinese speakers on the interpretation of doubly-quantified sentences such as (5), repeated in (8) below:

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

Zhou & Gao 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'. 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 he or she robbed; *one/a > every* entails *every > one/a*. Hence Zhou & 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, we see that none of our Chinese subjects ever accepted an inverse interpretation. We take this result to suggest that inverse scope is in fact disallowed for doubly-quantified in Chinese, consistent with the literature preceding Zhou & Gao's study.

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 article and bi-clausal structure contributed by an existential construction. In every case, English speakers reliably accepted inverse interpretations more often than Chinese speakers. Again, 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) active in Chinese but not English.

Despite the consistency of our results with the Isomorphic Principle, we hesitate to conclude at this point that Chinese lacks inverse scope altogether. Aoun & Li (1989, 2003) suggest that passive sentences in Chinese do 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 yige nuren   zhuazou le.
           every man all by one   woman arrested
           'everyone was arrested by a woman'

(10)   yaoshi liangge xiansuo bei meigeren zhaodao …
           if   two   clues   by everyone 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, 2012:154)

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 & Gao's (2009) 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 like (10) and (11) with conditionals do appear to allow inverse interpretations; we therefore 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* yields a strong specificity inference inconsistent with multiple-referent scenarios. We believe this inference results from the competition between *one* and indefinite *a*, which carries no such inference. Second, 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 Aoun & Li's (2003) idea that such reconstruction is possible in English quantified expressions. In arguing for the head raising analysis of relative clauses, Aoun & Li's (2003: 98) use the following examples (from Bianchi, 1999), where (12c) is relevant for our discussion:

(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]

Our results show that the same analysis can apply to bi-clausal sentences such as (13).

(13)   There is a shark that attacked every pirate.

An outstanding question here deals with the variability we observe in the data: half of the English speakers find sentences like (13) 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. Researchers point out that in principle relative clauses could be built via head-raising, as we have illustrated above, or via operator movement (e.g., Hulsey & Sauerland, 2006).[12] Assuming, as Hulsey & Sauerland suggest, that English restrictive relative clauses are structurally ambiguous between the head-internal, raising structure and the matching structure, it is then possible that some speakers apply the head-raising analysis whereas other speakers apply the matching analysis. If this hypothesis is on the right track, our result provides novel support for the structural ambiguity brought out by Hulsey & Sauerland.

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[12] Hulsey & Sauerland (2006) actually propose a matching analysis of relative clauses, which are argued to have both an internal and an external head, but for our purposes it is only important that there is a contrast between head raising and the absence thereof.

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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. have 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. have 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	ORDER	SENTENCE
1	EO	Every pirate is leaning on a barrel.
	EO	Every pirate is leaning on one barrel.
	OE	There is a pirate who is leaning on every barrel.
	OE	There is one pirate who is leaning on every barrel.
	OE	A pirate is leaning on every barrel.
	OE	One pirate is leaning on every barrel.
2	EO	Every pirate caught a fish.
	EO	Every pirate caught one fish.
	OE	There is a pirate who caught every fish.
	OE	There is one pirate who caught every fish.
	OE	A pirate caught every fish.
	OE	One pirate caught every fish.
3	EO	Every pirate is holding a fishing pole.
	EO	Every pirate is holding one fishing pole.
	OE	There is a pirate who is holding every fishing pole.
	OE	There is one pirate who is holding every fishing pole.
	OE	A pirate is holding every fishing pole.
	OE	One pirate is holding every fishing pole.
4	EO	Every pirate fed a shark.
	EO	Every pirate fed one shark.

	OE	There is a pirate who fed every shark.
	OE	There is one pirate who fed every shark.
	OE	A pirate fed every shark.
	OE	One pirate fed every shark.
5	EO	Every pirate is holding a bottle.
	EO	Every pirate is holding one bottle.
	OE	There is a pirate who is holding every bottle.
	OE	There is one pirate who is holding every bottle.
	OE	A pirate is holding every bottle.
	OE	One pirate is holding every bottle.
6	EO	Every shark is biting a fish.
	EO	Every shark is biting one fish.
	OE	There is a shark that is biting every fish.
	OE	There is one shark that is biting every fish.
	OE	A shark is biting every fish.
	OE	One shark is biting every fish.
7	EO	Every shark attacked a pirate.
	EO	Every shark attacked one pirate.
	OE	There is a shark that attacked every pirate.
	OE	There is one shark that attacked every pirate.
	OE	A shark attacked every pirate.
	OE	One shark attacked every pirate.
8	EO	Every girl is petting a dog.
	EO	Every girl is petting one dog.
	OE	There is a girl who is petting every dog.
	OE	There is one girl who is petting every dog.
	OE	A girl petted every dog.
	OE	One girl petted every dog.