QUANTIFIER STRENGTHS PREDICT SCOPAL POSSIBILITIES OF MANDARIN CHINESE *WH*-INDEFINITES

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Why can some NPs take scope where others cannot? In particular, why is it that indefinite NPs can often take wider scope than other NPs can in the same context (Fodor and Sag 1982)? For example, *a professor* in (1) can take scope over *every paper*, as shown in (1b). If *a* is changed to *every* as in (2), then that reading becomes unavailable, as shown in (2b).

(1) I read every paper that a professor in my department recommended. . . .
   a. $\forall x.\,(\textsc{paper}(x) \wedge \exists y.\,\textsc{professor}(y) \wedge \textsc{recommend}(y, x)) \Rightarrow \textsc{read}(\textsc{me}, x)$
      . . . Yet I skipped this paper because no professor recommended it.
   b. $\exists y.\,\textsc{professor}(y) \wedge \forall x.\,(\textsc{paper}(x) \wedge \textsc{recommend}(y, x)) \Rightarrow \textsc{read}(\textsc{me}, x)$
      . . . I understood her research interests very well when I finally finished.

(2) I read every paper that every professor in my department recommended. . . .
   a. $\forall x.\,(\textsc{paper}(x) \wedge \forall y.\,\textsc{professor}(y) \Rightarrow \textsc{recommend}(y, x)) \Rightarrow \textsc{read}(\textsc{me}, x)$
      . . . It only took a week because the professors' interests are so diverse.
   b. $*\forall y.\,\textsc{professor}(y) \Rightarrow \forall x.\,(\textsc{paper}(x) \wedge \textsc{recommend}(y, x)) \Rightarrow \textsc{read}(\textsc{me}, x)$
      . . . Yet I skipped this paper because no professor recommended it.

It is widely noted that quantifier scope in English is bounded by relative clauses, *if*-clauses, and perhaps tensed clauses in general. It is also well known that indefinite determiners such as *a*, *some*, and *a certain* are exempt from this restriction. We can try to explain this discrepancy in two ways. On one hand, maybe indefinite NPs take scope through a mechanism separate from (and more liberal than) that for "genuine quantifiers". The analysis of CHOICE FUNCTIONS (or more generally, unselective binding) that has become popular in the last decade represents this approach. On the other hand, although scope constraints clearly vary from determiner to determiner, maybe a single scoping mechanism can be parameterized to accommodate this variation.

In this paper, I take the latter view and explore the empirical consequences of a particular theory of quantification in which all quantifier scoping—including indefinite scoping—is driven by QUANTIFIER STRENGTHS that are lexically constrained. I introduce the theory in §1, then apply it in §2 to the scope of WH-INDEFINITES in Mandarin Chinese. Although my notion of quantifier strength arises most naturally in the study of CONTINUATION SEMANTICS (Barker 2002; de Groote 2001; Shan 2002; Shan and Barker 2002), the theory can be implemented in most grammatical formalisms, if perhaps with more stipulation and less inspiration. In §3, I show how my account of Mandarin *wh*-indefinite scope predicts scopal possibilities for sentences that are surprising to Lin's (2002) alternative account based on choice functions. Finally, in §4, I summarize continuation semantics and the broader project of which this work is a part.

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1. How strength determines scope

In this section, I introduce my notion of strength and explain how it determines quantifier scope. I use English sentences and generalizations for illustration.

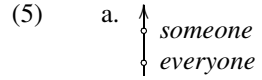
Quantifiers are conceived broadly here to include not just "genuine" ones (such as *every*) but also other instances of referential opacity such as indefinites (*a*), interrogatives (*who*), negation (*not*), and modal operators (*seem*). Each quantifier occurrence has a strength; certain island constituents also have strengths.[1] Strengths are totally ordered like numbers, and determine scope as follows.

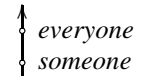
(3) a. Each quantifier is blocked by the (unique) minimal island that dominates it (at the surface) and is as strong as it or stronger.
b. Immediately under each island, the quantifiers blocked by it take scope, the stronger outscoping the weaker.
c. The entire utterance is an infinitely strong island.
d. The restriction of any quantifier is an island, exactly as strong as the quantifier.
e. If two quantifiers have equal strength, then the linearly preceding one is considered slightly stronger.[2]

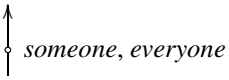
The sentence (4) is a simple example with two quantifiers, namely *someone* and *everyone*. It is ambiguous between a surface scope reading (4a) and an inverse scope one (4b). The greater-than sign > indicates that one quantifier's body logically includes another.

(4) Someone loves everyone.
a. $\exists > \forall$ 'There is someone who loves everyone.'
b. $\forall > \exists$ 'Everyone has someone who loves them.'

In the present framework, either *someone* is stronger than *everyone*, or *everyone* is stronger than *someone*, or they are equally strong. These three possibilities are depicted in (5). The vertical arrows point up towards the stronger quantifier.

(5) a. 

b. 

c. 

Because rule (3e) breaks ties in favor of surface order, possibilities (5a) and (5c) both result in the surface scope reading (4a). Possibility (5b) gives the inverse scope reading (4b).

A more complex example is the sentence (6).

(6) Every representative of a company saw most samples. (Hobbs and Shieber 1987)

If we assume that each of the three quantifiers in (6) can be assigned a strength arbitrarily, then there are a total of six possible ways in which the strengths can be ordered relative to each other.[3] Each ordering gives rise to a reading, as shown in (7). Subscripting indicates that one quantifier's restriction logically includes another.

[1] This notion of strength is not the concept of feature strength in the minimalist program (Chomsky 1995).

[2] If two quantifiers *P* and *Q* have equal strength, but neither is linearly preceding because *P* contains *Q*, then *Q* must be inside *P*'s restriction island, so the issue of which quantifier to consider slightly stronger is moot. Under the rules given here, quantifier strengths always completely determine scope relations. Some readers may prefer to consider not the linearly preceding quantifier but the c-commanding one to be slightly stronger. Although the distinction between linear precedence and c-command is not crucial in this paper, it would not do to just change "linearly preceding" to "c-commanding" in this rule, because quantifier strengths are supposed to determine scope relations even if neither quantifier c-commands the other, as in *everyone's mother saw someone*. Also, linear precedence helps explain crossover and superiority in continuation semantics (Shan and Barker 2002).

[3] Actually, there are more than six possibilities if we consider cases where multiple quantifiers tie for the same strength. However, these cases do not generate new scopings.

(7) a. $\forall_\exists$ > most

$\forall$
$\exists$
most

b. $\forall_\exists$ > most

$\forall$
most
$\exists$

c. most > $\forall_\exists$

most
$\forall$
$\exists$

d. $\exists > \forall >$ most

$\exists$
$\forall$
most

e. $\exists >$ most $> \forall$

$\exists$
most
$\forall$

f. most $> \exists > \forall$

most
$\exists$
$\forall$

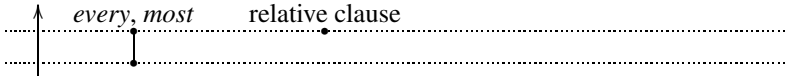
Because the restriction of *every* is an island that potentially blocks *a*, two distinct orderings (7a–b) give rise to the same scoping. A total of five readings are thus generated, consistent with Hobbs and Shieber's (1987) quantifier scoping algorithm.

So far, we have been assuming that strengths can be assigned arbitrarily. In order to characterize which scopal relations are possible and which are not, we need to constrain how strengths are assigned to quantifiers and islands. To this end, suppose that, for each quantifier and each island type, the grammar specifies an INTERVAL of strengths allowed. Such an interval is determined by its two (inclusive) endpoints; if the two endpoints happen to coincide, then the interval degenerates into a point and forces all occurrences of the quantifier or island type in question to have the same fixed strength.

As an illustration of what kinds of scope constraints can be encoded with such simple specifications, the constraint in (8) can be captured with the strength intervals shown in (9).

(8) The quantifiers *every* and *most* cannot scope over any containing relative clause.

(9)



For a quantifier to scope over a containing relative clause, the former must be stronger than the latter. The intervals in (9) rule out such an ordering and thus enforce (8).

Also expressible in terms of strength intervals is a generalization proposed by Fodor and Sag (1982), which for our purposes can be rephrased as (10).

(10) The only way indefinite NPs can scope over containing relative clauses is to take widest scope in the sentence.

If such a generalization is desired, it can be implemented as in (11).

(11)

Because the island strength of all relative clauses is fixed to be identical in (11), any quantifier must be either

- weaker than (or exactly as strong as) all relative clauses, in which case it scopes under all of them; or
- stronger than all relative clauses, in which case it scopes over all of them.

Thus *a* or *some* can scope over one containing relative clause only by scoping over all of them. This is essentially Barker's (2000, §3) analysis of English specific indefinites.

The theory presented so far always assigns at least one reading to any configuration of quantifiers and islands. Thus, it fails to explain why some quantificational sentences are not acceptable under any reading. Nevertheless, two crosslinguistic empirical predictions can

be made under my hypothesis that interval specifications constrain strength assignment. The first prediction is based on the fact that the strictly-stronger-than relation on intervals is transitive. Suppose that *P*, *Q*, and *R* are three quantifiers such that *P* always scopes over *Q* and *Q* over *R*. Such a regularity would signify that the interval for *P* is strictly stronger than that for *Q*, and the interval for *Q* is strictly stronger than that for *R*. But then the interval for *P* must be strictly stronger than that for *R*, so *P* must always scope over *R* as well. In short, we make the prediction (12).

(12) Let *P*, *Q*, and *R* be three quantifiers. If *P* always scopes over *Q*, and *Q* always scopes over *R*, then *P* always scopes over *R*.

The second prediction is a consequence of rule (3e), which uses linear precedence to break the tie when two quantifiers have equal strength. If two quantifiers *P* and *Q* always take surface scope with respect to each other, it would tell us that their strengths are fixed to be the same. (If their strengths were not fixed to be the same, we would expect inverse scope to be available in at least some environments.) But then any third quantifier *R* cannot be weaker than *P* yet stronger than *Q*, so the only way for *R* to take scope between *P* and *Q* is for it to be located linearly between *P* and *Q*. In short, we make the prediction (13).

(13) If *P* and *Q* always take surface scope with respect to each other, then *R* must appear overtly between *P* and *Q* in order to take scope between *P* and *Q*.

The two predictions (12) and (13) above are slight oversimplifications, because they only hold if we ignore islands and consider only those constraints on scope interpretation that are specified in terms of strength intervals. Still, the predictions supply us with an intuitive understanding of the notion of strength. Moreover, the second prediction (13) plays a prominent role as we turn below to my analysis of Mandarin *wh*-indefinites.

2. Scopal possibilities of Mandarin wh-indefinites

Wh-phrases in Mandarin Chinese, such as *shei* 'who' and *shenme* 'what', can be used as indefinite NPs in certain contexts including

- negation (*bu* 'not', *méi* 'not', *henshao* 'seldom');
- uncertainty (*haoxiang* 'seem'); and
- conditionals (*yaoshi* 'if').

These wh-indefinites (also known as existential polarity wh-phrases) have been studied by Li (1992), Lin (1996, 1998, 2002), and others. Below are some typical examples.

(14) 他{沒/不}吃什麼。
Ta méi/bu chi shenme
he not/not eat what
'He didn't/doesn't eat anything.'

(15) 他很少吃什麼。
Ta henshao chi shenme
he seldom eat what
'He seldom eats anything.'

(16) 他好像吃了什麼的樣子。
Ta haoxiang chi-le shenme de-yangzi
he seem eat-asp what seem
'It seems that he ate something.'[4]

[4]While I translate *haoxiang* as 'seem', I am not committed to treating it as a verb rather than, say, an adverb.

(17) 要是他吃了什麼，就得付錢。
Yaoshi ta chi-le shenme, jiu dei fu qian
If he eat-ASP what then must pay money
'If he ate anything, he must pay.'

Roughly speaking, *wh*-indefinites are licensed by nonveridical contexts: Lin (1996, 230) argues that a *wh*-indefinite is felicitous if and only if "the proposition in which [it] appears does not entail existence of a referent satisfying the description of [it]". For instance, (18) and (19) are bad as declarative sentences since, as such, they would entail that food exists.

(18) *他吃了什麼。
Ta chi-le shenme
he eat-ASP what
'He ate something.'

(19) *{每個/很多}人都吃了什麼。
Měi-ge/henduo ren dou chi-le shenme
every-CL/many person all eat-ASP what
'Everyone/many people ate something.'

Wh-indefinites are required to not only be licensed by a context but also take scope within that context. For instance, *shenme* 'what' in (14) is licensed by negation and must take scope within that negation. The sentence is not scopally ambiguous: it cannot mean 'There is something not eaten by him'. Similarly, (15) cannot mean 'There is something that he seldom eats'; (16) cannot mean 'There is something that he seems to have eaten'; and (17) cannot mean 'Something is such that if he eats it then he must pay'.

Although the scope of a *wh*-indefinite is not ambiguous in simple examples such as (14–17), ambiguity does arise in more complicated sentences. For example, in (20), the *wh*-indefinite *shenme* is licensed by both *haoxiang* 'seem' and negation, and can take scope under either licensor. Similarly, the *wh*-indefinite *shei* in (21) can take scope under either *haoxiang* 'seem' or *yaoshi* 'if'. Even with only one licensor, like *haoxiang* in (22) and *yaoshi* in (23), the scope of the *wh*-indefinite can still be ambiguous, as long as it stays within the licensing context.

(20) 他好像{沒/不}吃什麼的樣子。
Ta haoxiang méi/bu chi shenme de-yangzi
he seem not/not eat what seem
a. seem > ¬ > ∃ 'It seems that he didn't/doesn't eat anything.'
b. seem > ∃ > ¬ 'There seems to be something not eaten by him.'
c. *∃ > seem > ¬ 'There is something that seems not eaten by him.'

(21) 好像要是誰走，李四就也要走的樣子。
Haoxiang yaoshi shei zou, Lisi jiu yie yao zou de-yangzi
seem if who leave Lisi then also want leave seem
'It seems that, if someone/anyone leaves, Lisi will also leave.'
a. seem > if > ∃
b. seem > ∃ > if
c. *∃ > seem > if

(22) 好像{每個/很多}人都吃了什麼的樣子。
Haoxiang měi-ge/henduo ren dou chi-le shenme de-yangzi
seem every-CL/many person all eat-ASP what seem
'It seems that everyone/many people ate something.'

a. seem > ∀/many > ∃
b. seem > ∃ > ∀/many
c. *∃ > seem > ∀/many

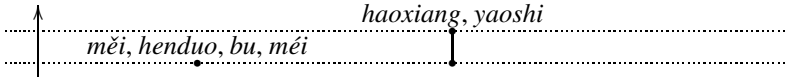
(23) 要是{每個/很多}人都吃了什麼，我就放心了。
Yaoshi měi-ge/henduo ren dou chi-le shenme, wo jiu fangxin-le
If every-CL/many person all eat-ASP what I then ease-ASP
'If everyone/many people ate something/anything, I will be at ease.'
a. if > ∀/many > ∃
b. if > ∃ > ∀/many
c. *∃ > if > ∀/many

With the data so far, it seems that a *wh*-indefinite may take scope anywhere within its licensing context. The negative judgments in (24b) and (25b), first noted by Lin (2002), then come as a surprise: of the three places (a–c) under *haoxiang* 'seem' where the *wh*-indefinite could take scope, why is the intermediate scoping (b) unavailable?

(24) 好像{每個/很多}人都不願意跟誰說話的樣子。
Haoxiang měi-ge/henduo ren dou bu yuanyi gen shei shuohua de-yangzi
seem every-CL/many person all not willing with who speak seem
'It seems that everyone/many people are unwilling to speak to someone/anyone.'
a. seem > ∀/many > ¬ > ∃
b.??seem > ∀/many > ∃ > ¬
c. seem > ∃ > ∀/many > ¬
d. *∃ > seem > ∀/many > ¬

(25) 好像{每個/很多}人都很少跟誰說話的樣子。
Haoxiang měi-ge/henduo ren dou henshao gen shei shuohua de-yangzi
seem every-CL/many person all seldom with who speak seem
'It seems that everyone/many people seldom speak to someone/anyone.'
a. seem > ∀/many > seldom > ∃
b. *seem > ∀/many > ∃ > seldom
c. seem > ∃ > ∀/many > seldom
d. *∃ > seem > ∀/many > seldom

A solution to this puzzle is suggested by prediction (13) on page 4. Suppose that the strengths of *měi* 'every', *henduo* 'many', *bu* 'not', and *méi* 'not' are all fixed to be the same. (This move is in accord with the frequently observed fact, for instance by Huang (1982) and Aoun and Li (1993), that Mandarin quantifiers tend to take surface scope.) Then, in order for a *wh*-indefinite (or any other quantifier) to take scope between two of these items, it would have to be located linearly between them as well. On the other hand, suppose that (clauses with) *haoxiang* 'seem' and *yaoshi* 'if' are islands whose strengths are allowed to vary. A *wh*-indefinite dominated by two of these islands would then have the option of taking intermediate scope. These ideas are implemented below with strength intervals.

(26) 

To see these interval specifications at work, let us return to the ambiguous sentence (20), which includes three quantificational items: the island *haoxiang* 'seem', the quantifier

bu/*méi* ‘not’, and the *wh*-indefinite *shenme* ‘what’. Enumerated in (27) are the three ways to order these items’ relative strengths that conform to the intervals in (26).[5]

(27) a. seem > ¬ > ∃ b. seem > ∃ > ¬ c. ∃ > seem > ¬

The three strength orderings in (27) give rise to the three scopings in (20), respectively. Case (c) is ruled out because the *wh*-indefinite occurs there within a veridical context. We hence correctly predict the two-way ambiguity in (20), and similarly for (21–23).

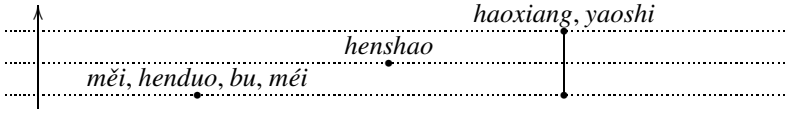
Turning to the surprising sentence (24), we note that there are four quantificational items: *haoxiang* ‘seem’, *měi*/*henduo* ‘every/many’, *bu* ‘not’, and *shei* ‘who’. Yet the intervals in (26) still only allow three strength orderings, depicted in (28).

(28) a. seem > ∀/many, ¬ > ∃ b. seem > ∃ > ∀/many, ¬ c. ∃ > seem > ∀/many, ¬

The strength orderings (28a), (28b), and (28c) give rise to the scopings (24a), (24c), and (24d), respectively. The last of these three possibilities is ruled out by the nonveridical context requirement. The intermediate scoping (24b) does not correspond to any valid strength orderings. We hence correctly predict that (24) is only two-way ambiguous; it is no longer surprising that (24b) is unavailable.

By treating *henshao* ‘seldom’ on a par with *bu* ‘not’, we can achieve an entirely analogous analysis of (25) that correctly rules out the intermediate scoping (25b). But we can do one better: as noted in (24b) and (25b), intermediate scope is worse with *henshao* ‘seldom’ than with *bu* ‘not’. We can capture this difference by postulating that *henshao* is an island required to be stronger than “ordinary” quantifiers such as *měi* ‘every’ and *henduo* ‘many’. More specifically, I add *henshao* to my analysis as follows.

(29)



This refined analysis correctly predicts the judgments in (25) even without the tie-breaking rule (3e). In other words, the predictions hold even if strengths are permitted to deviate slightly from prescribed intervals.

Besides accounting for all data presented above, the strength intervals specified in (29) make two further predictions. First, in a sentence of the form

(30) . . . *P* . . . [. . . *Q* . . . [. . . *R* . . . *wh*-indefinite . . .] . . .] . . .
where *P*, *Q*, and *R* are quantificational items,

the *wh*-indefinite can take intermediate scope—that is, $P > Q > \exists > R$—provided that *Q* is *haoxiang* ‘seem’ or *yaoshi* ‘if’. In these two cases, *Q* can always be made strong enough to “catch” the *wh*-indefinite at a strength level not attained by *R*. The generalization is attested by the data below.

[5]Again (cf. footnote 3 on page 2) I omit cases with ties, which do not generate new scopings.

(31) 好像要是我不吃什麼，他就不做了的樣子。
Haoxiang yaoshi wo bu chi shenme, ta jiu bu zuo le de-yangzi
seem if I not eat what he then not make ASP seem
'It seems that, if I don't eat something/anything, he will stop cooking (it).'
a. seem > if > ¬ > ∃
b. seem > if > ∃ > ¬
c. seem > ∃ > if > ¬
d. *∃ > seem > if > ¬

(32) 要是他好像不吃什麼的樣子，(卻又不說明是什麼東西他不吃)，那我也只能擔心了。
Yaoshi ta haoxiang bu chi shenme de-yangzi, (que you bu shuoming shi shenme
If he seem not eat what seem but also not explain be what
dongxi ta bu chi), na wo yie zhi neng danxin le
thing he not eat that I also only can worry ASP
'If he seems to not eat something/anything, (yet doesn't explain what it is that he doesn't eat), then I can only worry.'
a. if > seem > ¬ > ∃ (parenthesized part bad)
b. if > seem > ∃ > ¬ (parenthesized part OK)
c. if > ∃ > seem > ¬ (parenthesized part bad)
d. *∃ > if > seem > ¬ (parenthesized part also bad)

(33) 我不願意說要是每個人都支持誰，我就支持他。
Wo bu yuanyi shuo yaoshi měi-ge ren dou zhichi shei, wo jiu zhichi ta
I not willing say if every-CL person all support who I then support he
'I am unwilling to say that, if everyone supports someone/anyone, then I will support that person.'
a. *¬ > if > ∀ > ∃
b. ¬ > if > ∃ > ∀
c.??¬ > ∃ > if > ∀
d. *∃ > ¬ > if > ∀

In (33) above, the narrow-scope reading (33a) fails because it would be semantically incoherent for *shei* 'who' to bind *ta* 'he'. Note also the unavailability of (33c), as expected on my account: This scoping can arise only if *shei* 'who' is stronger than *yaoshi* 'if' yet weaker than (or exactly as strong as) *bu* 'not'. But then *bu* must be stronger than *yaoshi*, which contradicts the strength intervals in (29).

The second prediction also concerns sentences of the form (30): if *Q* is *henshao* 'seldom', and *R* is one of the quantificational items discussed so far other than *henshao*, then again the *wh*-indefinite can take intermediate scope. This prediction is also borne out, as in the following examples.

(34) 他好像很少不願意跟誰說話的樣子。
Ta haoxiang henshao bu yuanyi gen shei shuohua de-yangzi
He seem seldom not willing with who speak seem
'He seems seldom unwilling to speak to someone/anyone.'
a. seem > seldom > ¬ > ∃
b. seem > seldom > ∃ > ¬
c.??seem > ∃ > seldom > ¬
d. *∃ > seem > seldom > ¬

(35) 他們好像很少說要是誰走，他們就走的樣子。
Tamen haoxiang henshao shuo yaoshi shei zou, tamen jiu zou de-yangzi
They seem seldom say if who leave they then leave seem
'They seem to seldom say that, if someone/anyone leaves, they will also leave.'
a. seem > seldom > if > ∃
b. seem > seldom > ∃ > if
c. *seem > ∃ > seldom > if
d. *∃ > seem > seldom > if

(36) 要是你們很少把每本書都交給誰保管，那就不用這麼大的箱子了。
Yaoshi nimen henshao ba měi-ben shu dou jiaogei shei baoguan, na jiu bu
If you.PL seldom BA every-CL book all give who store that then not
yong zhe-me da de xiangzi le
use this-much big DE box ASP
'If you seldom give every book to someone/anyone for storage, then you don't need a box this big.'
a. if > seldom > ∀ > ∃
b. if > seldom > ∃ > ∀
c. ?if > ∃ > seldom > ∀
d. *∃ > if > seldom > ∀

I do not have an explanation why (34c) and (35c) above are unacceptable. One possible reason is that the existential force of the *wh*-indefinite is buried under two nested downward-entailing contexts, making the scopings difficult to retrieve. Also, the intermediate scoping is predicted to disappear in (35) and (36) if *henshao* 'seldom' is replaced with *bu yuanyi* 'not willing', but the judgments are murky.

3. An alternative account based on choice functions

I now turn to an alternative account of *wh*-indefinite scope, and show why some of the facts presented above are problematic for it.

In the last decade, CHOICE FUNCTIONS have become a popular tool for analyzing the semantics of indefinite and interrogative NPs such as *a student* and *which philosopher* (Kratzer 1998; Matthewson 1999; Reinhart 1997; Winter 1997). Briefly, a choice function is a function from sets (of individuals) to individuals, such that every nonempty set is mapped to an element of that set. Under the choice function analysis, the English NP *a student* denotes $f(\textsc{student})$, where STUDENT is the property of being a student (of type $\langle e,t\rangle$) and f is a free variable for a choice function (of type $\langle\langle e,t\rangle,e\rangle$). As usual in Montague grammar, the sentence

(37) A student left.

then denotes $\textsc{left}(f(\textsc{student}))$, where LEFT is the property of leaving (of type $\langle e,t\rangle$). At the matrix clause level, the free variable f is existentially closed and restricted to be a choice function; thus the top-level denotation of the sentence (37) is

(38) $\exists f.\ \textsc{cf}(f) \wedge \textsc{left}(f(\textsc{student}))$,

where $\textsc{cf}(f)$ means that f is a choice function (formally, $\forall p.\,(\exists x.\ x \in p) \Rightarrow (f(p) \in p)$). By contrast, the more traditional generalized quantifier analysis for (37) holds that *a student* denotes the property-set

(39) $\lambda p.\ \exists x.\ \textsc{student}(x) \wedge p(x)$,

of type $\langle\langle e,t\rangle,t\rangle$. Through Quantifying In (Montague 1974), Quantifier Raising (May 1977), Flexible Types (Hendriks 1993), or some other mechanism, this property-set comes to be applied to the property LEFT, giving the top-level denotation

(40) $\exists x.\ \textsc{student}(x) \wedge \textsc{left}(x)$

for the sentence (37). In this simple example, the denotations (38) and (40) are in the end equivalent under standard set-theoretic assumptions.

The most important feature of the choice function approach is that it distinguishes indefinite determiners (such as *some* and *a*) from other determiners (such as *every* and *most*). As mentioned in the introduction, this distinction can help explain why indefinite NPs are apparently insensitive to island constraints that restrict the scopal possibilities of quantified NPs. The explanation offered by the choice function approach is that indefinites are not (always) "genuine quantifiers", but rather (may) take apparent scope through a separate mechanism that is not subject to syntactic constraints like scope islands.

In the literature, choice functions are often associated with what I call the FUNCTIONAL analysis of indefinites. The functional analysis is the idea that indefinites can denote functions applied to hidden bound variables. The need for such denotations is best illustrated by the following example due to Schlenker (1998).

> Context: Every student in my syntax class has one weak point—John doesn't understand Case Theory, Mary has problems with Binding Theory, etc. Before the final, I say:
>
> (41) If each student makes progress in a certain area, nobody will flunk the exam.
>
> [Suppose that] every student made progress in some area he was already good at, but I still flunked some of the students. It seems that in such a situation I could have uttered (41) without lying.

The reading of (41) in question is that there exists a certain mapping from students to areas such that, if the students each make progress in their respective areas, nobody will flunk. This reading is not directly expressible in first-order logic, but can be expressed naturally using existential quantification over functions, roughly as in (42).

(42) $\exists f_{\langle e,e\rangle}.\ ((\forall x.\ \textsc{progress}(x, f(x))) \Rightarrow (\forall x.\ \textsc{pass}(x)))$

Note that *a certain area* in (41) is taken here to denote an existentially quantified variable f over functions, applied to a hidden argument x.

Lin (2002) proposes an account of Mandarin *wh*-indefinite scope based on choice functions and the functional analysis. I will not review the technical details of the proposal here, which involve revising some constraints on interpretation advocated by Chierchia (2001). It suffices to summarize that Lin's theory predicts the following four scopal possibilities.

(43) A *wh*-indefinite may take scope
   a. within its minimal containing clause, when interpreted as a quantifier;
   b. immediately under the closest quantifier that c-commands it, when interpreted as a choice function that is existentially bound immediately under that quantifier and that has a hidden variable bound by that quantifier;
   c. immediately under the maximal context that licenses it, when interpreted as a choice function that is existentially bound immediately under that context and that does not have a bound hidden variable; or

d. immediately under the maximal context that licenses it but functionally dependent (a la (42)) on the closest quantifier that c-commands it, when interpreted as a choice function that is existentially bound immediately under that context and that has a hidden variable bound by that quantifier.

In every Mandarin sentence examined in this paper, the *wh*-indefinite is always in the "lowest" position (that is, c-commanded by all other quantifiers), so options (43a) and (43b) coincide.[6] Furthermore, option (43d) seems neither desirable nor intended. The option is undesirable because, if it were present, then (44), the Mandarin *wh*-indefinite counterpart of (41), would have a reading analogous to (42), which it does not.[7]

(44) 好像要是每個人都學會什麼，大家就都能及格了的樣子。
Haoxiang yaoshi měi-ge ren dou xuehui shenme, dajia jiu dou neng jige
seem if every-CL person all learn what people then all can pass
le de-yangzi
ASP seem
*'It seems that, if each person learns a certain respective area, nobody will flunk.'

The option (43d) also seems unintended by Lin, for he never mentions it, even though it is entailed by his theory as far as I understand. Thus I will assume henceforth that it is somehow ruled out. We are then effectively left with the two scopal possibilities below.

(45) A *wh*-indefinite may take scope immediately under
a. the closest quantifier that c-commands it; or
b. the maximal context that licenses it.

For sentences of the form (30), if we assume that the third quantifier R is "genuine", then the two options in (45) predict that

(46) a. Narrow scope ($P > Q > R > \exists$) is always available;
b. Intermediate scope ($P > Q > \exists > R$) is never available; and
c. Wide scope ($P > \exists > Q > R$) is always available.

Prediction (46a) agrees with the data examined so far and my theory. Prediction (46b) happens to be the case in examples (24–25), but it is far from holding universally, as shown by the availability of intermediate scope in examples (31–34). Finally, prediction (46c) is also problematic, given that the wide scope reading (33c) is unacceptable.

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[6]Lin also considers sentences such as the following.

是不是每一家報紙都刊登了柯林頓和誰有染的每一則消息？
Shi-bu-shi měi-yi-jia baozhi dou kandeng-le [Kelindun he shei you ran] de měi-yi-ze xiaoxi
Be-not-be every-one-CL newspaper all print-ASP Clinton with who have affair DE every-one-CL story
a. q > ∀ > $\forall_\exists$
b. ?q > ∀ > ∃ > ∀
c. q > ∃ > ∀ > ∀

(According to Lin, there is some speaker variation on how acceptable the intermediate scoping (b) is. Also, note that the narrow scoping (a) above conflates two readings: one where a headline might read "Clinton had an affair with someone" and one where a headline might read "Clinton had an affair with Monica".)

In these cases, options (43a) and (43b) no longer coincide: they give rise to scopings (a) and (b) above, respectively. This paper does not deal with these sentences, but they can be accommodated within my theory of quantifier strengths by postulating relative clauses as an island in Mandarin, just as done for English in (9).

[7]Simply that *wh*-indefinites cannot be interpreted functionally does not mean that other indefinites cannot either. Indeed, the functional reading in (44) improves if *shenme* 'what' is replaced with *mou yi fangmian* 'a certain area'. The situation in English is analogous: Schwarz (2001) notes that the functional reading is available for *a certain* but not *a* and *some(one)*.

4. Discussion

This paper presents a theory of quantifier scope and its application to Mandarin *wh*-indefinites. The theory is based on a notion of strength that is intuitively reminiscent of past work hypothesizing hierarchies (such as VanLehn 1978), strengths (Moran 1988), expert systems (Kuno, Takami, and Wu 1999), and projections (Beghelli and Stowell 1997) for scope taking. My account makes superior predictions on some new data I provide.

The present approach, specifically the scoping rules in (3), directly falls out from an ongoing project to study linguistic applications of continuations, a well-known and widely applied idea in computer science. Linguists can view continuations as a generalization of Montague's (1974) treatment of quantification, as well as a schema that enables strictly compositional analyses of long-distance dependencies like quantification (Barker 2002), anaphora (Shan and Barker 2002), and interrogatives (Shan 2002). Computer scientists use continuations as a powerful technique to semantically characterize referential opacity in programming languages (Danvy and Filinski 1990; Meyer and Wand 1985), as well as a non-confluent proof system for classical logic (de Groote 2001).

Because continuations operate at the syntax-semantics interface, they promise to unite factors that have traditionally been regarded as either morphosyntactic or pragmasemantic in nature. In suggesting that the same scope-taking mechanism underlie both referential and quantificational uses of indefinite NPs, I mean not to deny the distinction between these uses made by Fodor and Sag (1982), but to point out a particularly parsimonious way in which the linguistic system can serve the needs of both.

References

Aoun, Joseph, and Yen-hui Audrey Li. 1993. *Syntax of scope*. Cambridge: MIT Press.

Barker, Chris. 2000. Notes on higher-order continuations. Manuscript, University of California, San Diego.

———. 2002. Continuations and the nature of quantification. *Natural Language Semantics*. To appear.

Beghelli, Filippo, and Tim Stowell. 1997. Distributivity and negation: The syntax of each and every. In *Ways of scope taking*, ed. Anna Szabolcsi, chap. 3, 71–107. Dordrecht: Kluwer.

Chierchia, Gennaro. 2001. A puzzle about indefinites. In *Semantic interfaces: Reference, anaphora and aspect*, ed. Carlo Cecchetto, Gennaro Chierchia, and Maria Teresa Guasti, chap. 2, 51–89. Stanford, CA: Center for the Study of Language and Information.

Chomsky, Noam. 1995. *The minimalist program*, chap. 4 (Categories and transformations), 219–394. Cambridge: MIT Press.

Danvy, Olivier, and Andrzej Filinski. 1990. Abstracting control. In *Proceedings of the 1990 ACM conference on Lisp and functional programming*, 151–160. New York: ACM Press.

Fodor, Janet Dean, and Ivan A. Sag. 1982. Referential and quantificational indefinites. *Linguistics and Philosophy* 5:355–398.

de Groote, Philippe. 2001. Type raising, continuations, and classical logic. In van Rooy and Stokhof (2001), 97–101.

Hendriks, Herman. 1993. Studied flexibility: Categories and types in syntax and semantics. Ph.D. thesis, Institute for Logic, Language and Computation, Universiteit van Amsterdam.

Hobbs, Jerry R., and Stuart M. Shieber. 1987. An algorithm for generating quantifier scopings. *Computational Linguistics* 13(1–2):47–63.

Huang, Cheng-Teh James. 1982. Logical relations in Chinese and the theory of grammar. Ph.D. thesis, Department of Linguistics and Philosophy, Massachusetts Institute of Technology.

Kratzer, Angelika. 1998. Scope or pseudoscope? Are there wide-scope indefinites? In *Events and grammar*, ed. Susan Rothstein. Dordrecht: Kluwer.

Kuno, Susumu, Ken-ichi Takami, and Yuru Wu. 1999. Quantifier scope in English, Chinese, and Japanese. *Language* 75(1):63–111.

Li, Yen-hui Audrey. 1992. Indefinite *wh* in Mandarin Chinese. *Journal of East Asian Linguistics* 1(2):125–155.

Lin, Jo-wang. 1996. Polarity licensing and *wh*-phrase quantification in Chinese. Ph.D. thesis, University of Massachusetts, Amherst.

———. 1998. On existential polarity *wh*-phrases in Chinese. *Journal of East Asian Linguistics* 7(3):219–255.

———. 2002. Choice functions and scope of existential polarity *wh*-phrases in Mandarin Chinese. Presented at GLOW in Asia 2002.

Matthewson, Lisa. 1999. On the interpretation of wide-scope indefinites. *Natural Language Semantics* 7(1):79–134.

May, Robert C. 1977. The grammar of quantification. Ph.D. thesis, Department of Linguistics and Philosophy, Massachusetts Institute of Technology. Reprinted by New York: Garland, 1991.

Meyer, Albert R., and Mitchell Wand. 1985. Continuation semantics in typed lambda-calculi (summary). In *Logics of programs*, ed. Rohit Parikh, 219–224. Lecture Notes in Computer Science 193, Berlin: Springer-Verlag.

Montague, Richard. 1974. The proper treatment of quantification in ordinary English. In *Formal philosophy: Selected papers of Richard Montague*, ed. Richmond Thomason, 247–270. New Haven: Yale University Press.

Moran, Douglas B. 1988. Quantifier scoping in the SRI core language engine. In *Proceedings of the 26th annual meeting of the Association for Computational Linguistics*, 33–40. Somerset, NJ: Association for Computational Linguistics.

Reinhart, Tanya. 1997. Quantifier scope: How labor is divided between QR and choice functions. *Linguistics and Philosophy* 20(4):335–397.

van Rooy, Robert, and Martin Stokhof, eds. 2001. *Proceedings of the 13th Amsterdam Colloquium*. Institute for Logic, Language and Computation, Universiteit van Amsterdam.

Schlenker, Philippe. 1998. A note on Skolem functions and the scope of indefinites. Presented at North East Linguistic Society 29.

Schwarz, Bernard. 2001. Two kinds of long-distance indefinites. In van Rooy and Stokhof (2001), 192–197.

Shan, Chung-chieh. 2002. A continuation semantics of interrogatives that accounts for Baker's ambiguity. In *SALT XII: Semantics and linguistic theory*, ed. Brendan Jackson, 246–265. Ithaca: Cornell University Press.

Shan, Chung-chieh, and Chris Barker. 2002. Explaining crossover and superiority as left-to-right evaluation. Draft manuscript, Harvard University and University of California, San Diego; `http://semanticsarchive.net/Archive/TBjZDQ3Z/`.

VanLehn, Kurt A. 1978. Determining the scope of English quantifiers. Master's thesis, Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology.

Winter, Yoad. 1997. Choice functions and the scopal semantics of indefinites. *Linguistics and Philosophy* 20(4):399–467.

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