自然言語量化子を含む文の曖昧性について
On the Ambiguity of Sentences with Natural Language Quantifiers

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ABSTRACT

自然言語量化子を２つ以上含む文は，量化子のスコープの違いに起因する曖昧性を持つが，更なる曖昧性を持つ場合もある。本稿では，自然言語量化子 *most* および *two* を含む文 *Most travelers visit two cities* とその受身形 *Two cities are visited by most travelers* の読みの非対称性を示し，議論する。*Most* ではなく *all* を使ったもの（*All travelers visit two cities*）では，能動形と受身形が同様の曖昧性を持ち，文の２つの意味は量化子（*all* と *two*）のスコープの曖昧性に帰着できる。しかし，*most* を使ったものでは，受身形が更に第３の読みをもち，能動形と受身形の読みは非対称となる。それらの読みについて経験的および論理的な観点から議論する。また基本文のバリエーションについての考察および，日本語データとの対照考察も行う。

Sentences with natural language quantifiers (*e.g. every, all, most, two, a few*) exhibit an ambiguity attributed to the scope ambiguity of the quantifiers used. However, the sentence may have further ambiguity. This paper investigates the readings of the pair *Most travelers visit two cities* and its passive version *Two cities are visited by most travelers* and shows the asymmetry between them. The version with *all* (i.e. *All travelers visit two cities* and its passive version) share the same ambiguity between the active and passive sentences, which is attributed to the scope ambiguity of the quantifiers *all* and *two*. In the case of the sentences in question, however, there is a third reading in the passive sentence. The details of the three readings and their distribution are investigated on empirical and logical bases. The paper also investigates several variations of the basic sentences (e.g. *Most of the travelers visited two cities; Most travelers are*

attracted to two cities) and discusses the different distribution of the readings. Furthermore, a contrastive analysis with relevant Japanese data is conducted.

1. Introduction

Sentence (1) involves two natural language quantifiers, all and two.

(1) *All* travelers visit *two* cities.

This sentence makes a generic statement about travelers. For practical purposes, let us suppose that the sentence describes the situation with travelers to Japan, every year.

Sentence (1) has two equally good readings:

(2) a. All travelers each visit two cities of their choice.

b. There are specific two cities that all travelers visit.

This ambiguity is attributed to the scope ambiguity of the quantifiers *all* and *two*. In the reading in (2a), *all* has a wider scope than *two*, whereas in the reading in (2b), it is the other way round.

The passive version of (1), which is (3) below, has the same ambiguity, although the reading in (2b) is preferred to that in (2a) unless a specific preceding context is given.

(3) Two cities are visited by all travelers.

When we replace *all* by *most*, the situation is different.[1]

(4) a. Most travelers visit two cities.

b. Two cities are visited by most travelers.

The active version (4a) has an ambiguity between (5a) and (5b).

(5) a. Most travelers each visit two cities of their choice.

b. There are specific two cities that (a certain set of) most travelers visit.

For the passive version (4b), however, the readings are nontrivial. Major comprehensive textbooks on semantics (e.g. Allan, 2001; Chierchia & McConnell-Ginet, 2000; Saeed, 2009) introduce natural language quantifiers, but do not discuss them in depth. Kearns (2000) introduces a variety of examples of sentences using natural language quantifiers, whereas Keenan and Papemp (2012) provide comparative data of natural language quantifiers. However, there is room for a closer investigation into natural language quantifiers on a logical basis.

In what follows, sentences (4a) and (4b) will be investigated in detail. Specifically, the readings of (4a) and (4b), as well as their variations, are investigated on empirical and logical bases. Also, a contrastive analysis with relevant Japanese data is conducted.

2. Preliminaries

We start by considering the logical formulae for the two readings of the version with *all*, (1) and (3), repeated here as (6a) and (6b) below. (Henceforth, in the example sentences italics are used for the purpose of highlighting quantifiers.)

(6) a. *All* travelers visit *two* cities.

b. *Two* cities are visited by *all* travelers.

As a preliminary step, let us consider the following version with *some* instead of *two*.

(7) a. *All* travelers visit *some* city.

b. *Some* city is visited by *all* travelers.

Sentence (7a) and (7b) involve two readings. That is: 1) All travelers visit some city of their choice, and 2) All travelers visit a specific city.

Using logical quantifiers, we get the logical formulae (8a) and (8b), which are accompanied by an informal description.

(8) a. $(\forall x)$ [Traveler $(x) \rightarrow (\exists y)$ [City $(y) \wedge$ Visit (x, y)]]

For any x, if x is a traveler then there exists y such that y is a city and x visits y.

b. $(\exists y)$ [City (y) $\wedge$ $(\forall x)$ [Traveler (x) $\rightarrow$ Visit (x, y)]]

There exists y such that y is a city and for any x if x is a traveler then x visits y.

The ambiguity between (8a) and (8b) is attributed to the scope ambiguity of the universal quantifier ($\forall$) and the existential quantifier ($\exists$). That is, the reading is determined by which quantifier has a wider scope than the other.

Now, sentence (6a) and (6b) with *two* also involve two readings. That is: 1) All travelers visit two cities of their choice, and 2) All travelers visit certain two cities.

Using logical quantifiers, we obtain the logical formulae (9a) and (9b), accompanied by an informal description.

(9) a. $(\forall x)$ [Traveler (x) $\rightarrow$ $(\exists y_1)(\exists y_2)$ [City (y_1) $\wedge$ City (y_2) $\wedge$ Visit (x, y_1) $\wedge$ Visit (x, y_2)]]

For any x, if x is a traveler then there exist y_1 and y_2 such that y_1 is a city, y_2 is a city, x visits y_1, and x visits y_2.

b. $(\exists y_1)(\exists y_2)$ [City (y_1) $\wedge$ City (y_2) $\wedge$ $(\forall x)$ [Traveler (x) $\rightarrow$ (Visit (x, y_1) $\wedge$ Visit (x, y_2))]]

There exist y_1 and y_2 such that y_1 is a city, y_2 is a city, and for any x if x is a traveler then x visits y_1 and x visits y_2.

Using restricted quantifiers 'All' and 'Two', we have the following version of the logical formulae. The notation for a restricted quantifier follows Kearns (2000). Logical formulae (10a) and (10b) correspond to (9a) and (9b), respectively:

(10) a. (All x: Traveler (x)) [(Two y: City (y)) [Visit (x, y)]]

For all x who is a traveler, there exist two y each of which is a city and such that x visits y.

b. (Two y: City (y)) [(All x: Traveler (x)) [Visit (x, y)]]

There are two y each of which is a city and such that for all x who is a traveler, x visits y.

The notations used in (10) are as follows. Restricted quantifiers such as 'All' involve not only a variable such as 'x' but also the restriction for that variable. In the notation used in (10) above, the item following a colon within the quantifier description gives the restriction for the variable at issue. For example, the representation '(All x: Traveler (x))' indicates a restricted quantification by 'All' over the variable 'x', and the description 'Traveler (x)' following it gives a restriction for each value for x. In the same format, the representation '(Two y: City (y))' indicates a restricted quantification by 'Two' over the variable 'y', and the following description 'City (y)' gives the restriction for each y. A restricted quantifier, just like an unrestricted quantifier, is followed by the condition which the restricted quantifier should meet. This condition is indicated within a pair of square brackets.

In the version with restricted quantifiers, the ambiguity between (10a) and (10b) is attributed to the scope ambiguity of the quantifiers 'All' and 'Two'.

Here, quantifiers require a careful treatment. Specifically, 'All' is similar to '$\forall$'in that one entity is picked out and evaluated at one time. It is not that all entities are taken and evaluated at one time. The same holds for 'Two'. Thus, for (10a), the evaluation procedure is the following: the first entity of traveler is picked out and checked whether it meets the specified conditions, then the second entity of traveler is picked out and checked whether it meets the specified conditions, and so forth. For (10b), it means that the two cities in question (say y_1 and y_2) are each visited by all travelers. In the present case, there is a unique set of 'all travelers' who visit y_1 as well as y_2.

In the next section, we will consider the readings and logical formulae for the sentences, replacing *all* with *most*, and see what happens.

3. ‘Most travelers visit two cities’ and its variations

3. 1 Basic sentences

Below are the sentences we now consider.

(11) a. *Most* travelers visit *two* cities.

b. *Two* cities are visited by *most* travelers.

As a preliminary step, let us consider the following version with *some* instead of *two*.

(12) a. *Most* travelers visit *some* city.

b. *Some* city is visited by *most* travelers.

Sentence (12a) and (12b) involve two readings. That is: 1) Most travelers visit some city of their choice, and 2) Most travelers visit some specific city. These are analogous to those for (7a) and (7b).

Sentence (11a) and (11b), in contrast, involve three readings. There is one more reading in addition to the two readings analogous to those for (6a) and (6b), the version with *all*. Let us name the three readings R1-R3 as below. For practical purposes, let us suppose that we consider the travelers to Japan and that there are just one hundred of them every year.

(13) The three readings (R1-R3) involved in (11):

[R1] Most travelers visit two cities of their choice.

e.g.

Eight travelers (#1−#8) visit two cities. Others (#9 and #10) visit only one city. Specifically, Traveler #1 visits Tokyo and Osaka, Traveler #2 visits Osaka and Kyoto, ... Traveler #9 visits only Kyoto, Traveler #10 visits only Yokohama.

[R2] Most travelers (a certain group of people) visit two specific cities.

e.g. Travelers #1−#8 visit Tokyo and Osaka.

[R3] Two specific cities (e.g. Tokyo and Osaka) are each visited by most travelers.

Note. The group of ‘most travelers’ may overlap but need not be identical between the two cities.

e.g.

Tokyo is visited by seven travelers (#1−#7), Osaka is visited by six travelers (#5−#10). Kyoto is visited by three travelers (#2, #3, #9). Yokohama is visited by two travelers (#8, #10). Note that the first group of ‘most travelers’ (#1−#7) is not identical to the second (#5−#10).

Among the three readings mentioned above, R1 and R2 are the readings in (5a) and (5b), and R3 is what’s new here.

The active sentence (11a) has two readings, R1 and R2, whereas the passive version (11b) has three readings, R1−R3. Thus, the readings of active and passive sentences are asymmetrical.

3. 2 Logical formulae

Let us consider the logical formula for the above-mentioned three readings, R1−R3. We start with (10) and replace ‘All’ with ‘Most’, which is another natural language quantifier symbol which represents *most*:

(14) a. (Most x: Traveler (x)) [(Two y: City (y)) [Visit (x, y)]]

For most x who is a traveler, there exist two y each of which is a city and such that x visits y.

b. (Two y: City (y)) [(Most x: Traveler (x)) [Visit (x, y)]]

There are two y each of which is a city and such that for most x who is a traveler, x visits y.

How are (14a) and (14b) related to R1 through R3?

The logical formula (14a) represents R1, whereas (14b) represents R3, not R2. Note that in (14b), one value for y is taken at one time, and for that particular value (say y_1), the set of ‘most travelers’ is picked out. For the other value for y (say y_2), another set of ‘most travelers’ is picked out. The latter set may but needs not be identical to the former. In contrast, in the case of universal quantification over travelers (by ‘all travelers’), the difference does not arise. Even though the scope of 'All' is narrower than that of 'Two', there is a unique set of 'all travelers', and therefore readings R3 is reduced to R2.

Then, how is R2 represented in a logical formula?

In R2, there is a certain set of people who visit both of the two cities in question. This means that there is a certain set of cities which has two elements and both of which are visited by the same set of 'most travelers'. Thus, the logical formula will be the following:

(15) $(\exists y_1: \text{City } (y_1))(\exists y_2: \text{City } (y_2))[(\text{Most } x: \text{Traveler } (x)) [\text{Visit } (x, y_1) \wedge \text{Visit } (x, y_2)]]$

There exists y_1 which is a city and there exists y_2 which is a city such that for most x who is a traveler, x visits y_1 and x visits y_2.

In a more general format:

(16) $(\exists s: \text{Set } (s))[|s| = 2 \wedge \forall y \in s \, [\text{City } (y)] \wedge (\text{Most } x: \text{Traveler } (x))[\forall y \in s \, [\text{Visit } (x, y)]]]$

There exists a set s such that the following three conditions hold: 1) the cardinality of s is two, 2) for any element y of s, y is a city, and 3) most travelers visit every element of s.

In the format in (16), we could accommodate a general case by changing the cardinality of s accordingly. Note that (16) is essentially different from (17) below. In fact, (17) represents the reading R3 instead.

(17) $(\exists s: \text{Set } (s))[|s| = 2 \wedge \forall y \in s \, [\text{City } (y) \wedge (\text{Most } x: \text{Traveler } (x))[\text{Visit } (x, y)]]]$

There exists a set s such that the cardinality of s is two and for every element y of s, y is a city and for most x who is a traveler x visits y.

In (17), there are two conditions for the set s. Here, the second and the third conditions for s given in (16) are grouped together. In (17), ∀ has a wider scope than Most, and as a result the set of 'most travelers' are determined for each y. This leads to R3.

In summary:

- The sentence (11a) has two readings, (14a) and (14b).
- The sentence (11b) has three readings, (14a), (14b), and (16).

The following investigates a few variations of the basic sentences.

3. 3 Variation 1

The first variation to consider is (18a) and (18b). Whereas (11a) and (11b) are generic sentences in the present tense, (18a) and (18b) are their non-generic past tense version. To make the sentences sound better, 'most travelers' in (11) is changed into 'most of the travelers'.

(18) a. Most of the travelers visited two cities.

b. Two cities were visited by most of the travelers.

Just like (11), (18a) has two readings, R1' and R2', whereas (18b) has three readings, R1'–R3' below:

[R1'] Most of the travelers visited two cities of their choice.

[R2'] Most of the travelers (certain group of people) visited two specific cities.

[R3'] Two specific cities (e.g. Tokyo and Osaka) were each visited by most of the travelers.

Note. The group of 'most travelers' may overlap but need not be identical between the two cities.

3. 4 Variation 2

The second variation to consider is (19a) and (19b).

(19) a. *Most* travelers are attracted to *two* cities.

b. *Two* cities attract *most* travelers.

These are generic sentences just like (11a) and (11b), but a psychological verb *be attracted* is used instead of *visit*. Thus, 'most travelers' are not the agent but the experiencer in terms of the thematic role. For both (19a) and (19b), R1 is o.k.(nearly perfect), R2 is perfect, and R3 is impossible. R1 is much better than it is for (11a) and (11b). The minor problem with R1 is plausibly the weak motivation for mentioning the specific small number *two*. This could be attributed to a pragmatic factor. If ‘a few’ is used instead of ‘two’ for the purpose of solving the just-mentioned problem, R1 is in fact fine.

In summary, the distribution of the reading for (19a) and (19b) is different from that of the reading for (11a) and (11b). Among other things, the R3 reading is missing in (19a) and (19b).

To mention in passing, if we replace *most* by *the majority of* as below, we get R3, besides R1 and R2.

(20) a. The majority of travelers are attracted to two cities.
b. Two cities attract the majority of travelers.

The set of ‘the majority of travelers’ attracted to the two cities may be different. The difference between the version with *most* and that with *the majority of travelers* is left open here.

3. 5 Variation 3

Next, we examine the case with the pair *most* and *all*. For practical purposes, let us suppose that there are a total of ten cities in the discourse.

(21) a. *Most* travelers visit *all* cities.
b. *All* cities are visited by *most* travelers.

Unlike the case with ‘two cities’, there is a unique set of ‘all cities’. Thus, there are two readings, R2” and R3” below. Reading R1” is reduced to R2”, given a unique set of ‘all cities’:

[R2”] Most of the travelers (certain group of people) visit all cities.

[R3”] All cities are each visited by most travelers.

Note. The group of ‘most travelers’ may overlap but need not be identical among different cities.

Sentence (21a) has reading R2”. Sentence (21b) has readings R2” and R3”.

The logical formulae, (22a) and (22b), accompanied by an informal description, represent the readings [R2”] and [R3”], respectively.

(22) a. (Most x: Traveler (x))[(All y: City (y))[Visit (x, y)]]
For most x who is a traveler, for all y which is a city x visits y.
b. (All y: City (y))[(Most x: Traveler (x))[Visit (x, y)]]
For all y which is a city, for most x who is a traveler, x visits y.

3. 6 Variation 4

Next, we examine the case with the pair *most* and *most*. Again, for practical purposes, let us suppose that there are a total of ten cities.

(23) a. *Most* travelers visit *most* cities.
b. *Most* cities are visited by *most* travelers.

Just like (11), (23a) has two readings, R1’” and R2’”, whereas (23b) has three readings, R1’”− R3’” below:

[R1’”] Most travelers visit most cities of their choice.

e.g. Travelers #1−#4 visit cities #1−#7, and travelers #5−#7 visit cities #4−#10. Travelers #8−#10 visit only one city of their choice.

In this case, seven travelers out of ten visit most cities of their choice.

[R2’”] Most travelers (certain group of people) visit specific most cities.

e.g. Travelers #1−#7 visit cities #1−#7.

[R3’”] A specific set of ‘most cities’ (e.g. #1−#7 out of ten cities) are each visited by most travelers.

Note. The group of ‘most travelers’ may overlap but need not be identical between different cities.

e.g. City #1 is visited by travelers #1−#7, city #2 is visited by travelers #4−#10, … , city #7 is visited by travelers #3-#8, etc.

Note that the example for R1’” above illustrates the difference between R1’” and R3’”. In the example, cities #4−#7 are visited by seven travelers (i.e. #1−#7), but other cities are visited by a few travelers. Thus, this is not an example for R3. See McCawley (1993, pp. 43−44) for a relevant discussion.

Logical formulae (24a) and (24b) below represent the readings R1'" and R3'", respectively.

(24) a. (Most x: Traveler (x))[(Most y: City (y)) [Visit (x, y)]]

For most x who is a traveler, for most y which is a city x visits y.

b. (Most y: City(y))[(Most x: Traveler(x)) [Visit(x, y)]]

For most y which is a city, for most x who is a traveler, x visits y.

4. Japanese data

In this section, we consider the Japanese versions, using a few different particles such as *wa* (topic) and *o* (accusative).

4. 1 Basic sentences

First, the version with the topic marker *wa* will be examined.

(25) a. Taihan-no ryokoosha-wa futatsu-no toshi-o otozureru

most (of the) traveler-TOP two city-ACC visit

'Most travelers visit two cities.'

b. Futatsu-no toshi-wa taihan-no ryokosha-ni-yotte

two city-Topic most traveler-by

otozure-rareru

visit-Passive

'Two cities are visited by most travelers.'

As in the English version (11), three readings, repeated below as (26), are involved:

(26) The three readings involved in (25):

[R1] Most travelers visit two cities of their choice.

[R2] Most travelers (certain group of people) visit two specific cities.

[R3] Two specific cities (e.g. Tokyo and Osaka) are each visited by most travelers.

Note. The group of 'most travelers' may overlap but need not be identical between the two cities.

The distribution of the readings is different between the English and Japanese versions. Sentence (25a) has R1 and R2, whereas (25b) has R2 and R3. To be noted, R1 is missing in (25b).

Next, the version with a nominal case marker *ga* will be examined:

(27) a. Taihan-no ryokoosha-ga futatsu-no toshi-o otozureru.

most traveler-NOM two city-ACC visit

'Most travelers visit two cities.'

b. Futatsu-no toshi-ga taihan-no ryokosha-ni-yotte otozure-rareru.

two city-NOM most traveler-by visit-Passive

'Two cities are visited by most travelers.'

In this version, the possible readings are identical to those for the English sentences in (11).

Next, a pair of active sentences are considered. Sentences (28a) and (28b) are the scrambled versions of (25a). In (28b), the direct object *futatsu-no toshi* ('two cities') is topicalized.

(28) a. Futatsu-no toshi-o taihan-no ryokoosha-ga otozureru.

two city-ACC most (of the) traveler-NOM visit

'Two cities, most travelers visit them.'

b. Futatsu-no toshi-wa taihan-no ryokoosha-ga otozureru.

two city-TOP most (of the) traveler-NOM visit

'Two cities, most travelers visit them.'

'Two cities are visited by most travelers.'

Sentence (28a), just as (25a), has the readings R1 and R2. Sentence (28b) has the readings R2 and R3, just as (25b), excluding R1.

In light of (25), (27), and (28) above, we could analyze the readings of the Japanese sentences as follows.

i) R1 is included in both active and passive versions by default.

ii) R3 is excluded in the active version by default.

iii) The versions with *futatsu-no toshi-**wa*** exclude R1 and includes R3, because of the topicalization function of wa for *futatsu-no toshi* ('two cities').

4. 2 Contrastive analysis

Table 1 summarizes the investigated possible readings for sentence variations.

Table 1 Sentence variations and their readings.
('E' and 'J' indicate' English' and 'Japanese', respectively.)

Sentence	Reading
(11a) E, active	R1, R2
(11b) E, passive	R1, R2, R3
(25a) J, active, −*wa* …	R1, R2
(25b) J, passive, −*wa* …	—, R2, R3
(27a) J, active, −*ga* …	R1, R2
(27b) J, passive, −*ga* …	R1, R2, R3
(28a) J, active, scrambling, −*o* …	R1, R2
(28b) J, active, scrambling, −*wa* …	—, R2, R3

First, we compare the pair in (11) and that in (27). The English active/passive sentences and the Japanese active/passive sentences with *ga* have the same distribution of the readings.

Next, we compare (11) and (25). When a Topic marker wa is used for *futatsuno toshi* ('two cities') in (25b), R1 is excluded. This is presumably because the reference of *two cities* should be made specific, as in R2 and R3, due to the topicalizing function of *wa*.

Next, we examine (28a) and (28b). When compare (28a) and (25a), we see that scrambling has no effect on the readings. When we compare (28a) and (28b), we see that R1 is excluded and R3 is added. (28b) has the same reading as (25b). From these we could argue that when the topic marker is used for *futatsu-no toshi* ('two cities'), either in the active or the passive sentence, the reference of *two cities* should be made specific. This excludes R1 and allows for R2 and R3. It is nontrivial that R3 is added in (28b), an active sentence. This may indicate that a higher priority is given to the effect of *wa* than to the default readings of an active sentence.

5. Conclusion

The sentence *Most travelers visit two cities* and its passive version are asymmetrical regarding their possible readings. The active sentence has two readings, whereas the passive sentence has one more reading. The ambiguity is not simply attributed to the scope ambiguity of the quantifiers *most* and *two*. This article investigated the readings of the basic sentences and their variations, including Japanese data on empirical and logical bases. Different distributions of the reading were observed and analyzed.

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Note

This paper assumes, in the framework of generalized quantifier theory, that most is a synonym of more than half.

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