A UNIFIED SEMANTIC ANALYSIS OF FLOATED AND BINOMINAL *EACH*

Mana Kobuchi-Philip
UiL-OTS, Utrecht University

mana.kobuchi@let.uu.nl

Abstract

This paper discusses a semantic analysis of three syntactic types of English *each*, namely, floated *each*, binominal *each*, and prenominal *each*. It is argued that floated *each* consists of two parts, a quantifier and an inaudible element which functions as its restrictor, which together form a tripartite quantificational structure when they compose with the predicate. Binominal *each* and an associated NP such as *two topics* (which is generally called the 'distributive share') are syntactically analyzed as forming a subject-predicate relation within a DP in which the NP undergoes so-called 'predicate inversion'. Semantically, binominal *each* is analyzed as having the same semantic value as floated *each*, while prenominal *each* is shown to have a different logical type from floated and binominal *each*. As can be seen from analogous constructions in some Romance languages, it does not lexically contain its restrictor.

1 Three types of *each*

English *each* can occur in several distinct syntactic contexts, three of which are exemplified in (1):[1]

(1) a. Prenominal *each*
[*Each* student] picked two topics.
b. Floated *each*
The students have [*each* picked two topics].
c. Binominal *each*
The students picked [two topics *each*].

Each exemplified in (1a) occurs in a prenominal position and forms a syntactic constituent with the following NP, whose head noun must be singular. *Each* exemplified in (1b) occurs in a preverbal position on the surface. This is a so-called floated quantifier (FQ), like floated *all* and floated *both*. In the syntax literature (e.g. Sportiche 1988), an FQ construction such as (1b) has generally been taken to be related to the prenominal quantifier construction in (1a) via a transformation. Under such a hypothesis, the FQ is underlyingly a determiner, only it is dislocated in the surface form.[2] On the other hand, in the semantics literature FQs have generally been analyzed as adverbial elements (e.g. Link 1983, Dowty and Brodie 1984, Roberts 1986, Junker 1990). *Each* exemplified in (1c) always occurs right-adjacent to an NP, which almost always contains a numeral. This *each* is generally referred to as binominal *each* (sometimes also as shifted *each*) (e.g. Safir and Stowell 1987, Choe 1987, Moltmann 1991, Zimmermann 2002a,b). In the syntax literature it has been shown that binominal *each* forms a syntactic constituent with the NP left adjacent to it.

---

[1] In this paper we do not discuss other types of *each* such as that in reciprocal *each other*.

[2] Under Sportiche's (1988) stranding account, the quantifier and its associating NP are generated as a DP in the VP-internal subject position (Spec VP), and in an FQ sentence the quantifier remains in this position when the NP moves to spec IP position so that EPP feature may be checked.

On the surface, then, prenominal *each* looks like a determiner, floated *each* looks like an adverb, and binominal *each* looks something that is neither a determiner nor an adverb. Nonetheless, it is not the case that *each* may occur just anywhere. Rather, the positions in which *each* appears are quite limited. The simplest hypothesis is that *each* has a single semantic value and logical type. Thus, the goal of all analyses of *each* is to show how its distribution can be captured while maintaining this basic assumption. This is the objective of this paper as well, though we will not quite reach it.

In attempting to formulate a unified analysis of each, it can be useful to start with the native speaker intuitions of a linguist. Consider the following observation of Vendler (1966):

(2) "….the phrase *each one of them* is somewhat redundant. It looks as if *each* here already implies *one* and draws our attention to individual elements…." (p. 76)

Vendler's observation suggests that something similar to the meaning of *one* may lie hidden in the lexical content of *each*. That is, *each* might actually mean something like 'each one'. Such a hypothesis becomes quite plausible when we consider the semantics of the floated numeral quantification in a language that has such FQ, namely Japanese. A Japanese numeral e.g. *san* 'three' systematically co-occurs with a classifier e.g. *nin* 'CL' (unit for counting human individuals). According to Kobuchi-Philip (2003), the classifier functions as the restrictor for the numeral, denoting a set of just atoms. Thus, numeral quantifier *san-nin* '3-CL' refers to 'three individuals (persons)'. This hypothesis can be extended to FQ *each* by analyzing it as consisting in the quantifier *each* plus a phonetically null, atom-denoting, restrictor. This is the hypothesis we will develop in this paper. Let us start by reviewing the background assumption of the hypothesis, that is, the analysis of Japanese numeral quantification proposed in Kobuchi-Philip (2003).

2 Japanese floated numeral quantifiers

As mentioned earlier, in the syntax literature it has frequently been suggested that the FQ is transformationally derived from a prenominal quantifier, i.e. that it is a dislocated determiner (e.g. Sportiche 1988, Kitahara 1992). However, in the case of the Japanese floated numeral quantifier (FNQ), there is strong evidence that, syntactically, the FQ must be an adverb. The reader is referred to Kobuchi-Philip (2003) for a review of the syntactic evidence supporting this claim. Here we give just one piece of particularly striking evidence, originally noted by Fukushima (1991). As shown in (3), the Japanese FNQ can be coordinated with an ordinary adverb:

(3) a. shoonin-ga [[**san-nin**] katsu [tashikani]]
witness-NOM 3-CL and certainly
sono jiko-o mokugekishita
the accident-ACC witnessed
(lit.) 'Witnesses [three and certainly] witnessed the accident.'
'Three witnesses certainly witnessed the accident.'

b. Mary-ga raamen-o
M-NOM soup noodle-ACC
[[**san-bai**] katsu [kireini]] tairageta
3-CL and completely ate up
(lit.) 'Mary ate up soup noodles [three and completely].'
'Mary ate up three bowls of soup noodles completely'

In (3a), the FNQ *san-nin* 'three persons' is construed with the subject 'witness', but it is coordinated with the adverb *tashikani* 'certainly'. We might literally translate (3a) as "Witnesses three and certainly witnessed the accident." To capture its meaning with a grammatical English sentence, however, we must say something like "three witnesses certainly witnessed the accident." In (3b), the FNQ *san-bai* 'three bowls' is construed with the direct object 'soup noodles' and this FNQ is coordinated with an adverb *kireini* 'completely'. Again, literally, this sentence means "Mary ate up soup noodles three and completely." In sum, the fact that an FNQ can be coordinated with an adverb strongly suggests that the FNQ is itself an adverb.

Next, observe that the classifier in the Japanese FNQ is semantically significant in that it functions as the restrictor for the preceding numeral. Consider (4):

(4) a. gakusei-ga, go-**nin** kita. → 5: the number of persons
student-NOM 5-CL came
'Five **individual** students came.'

b. gakusei-ga, go-**kumi** kita. → 5: the number of groups
student-NOM 5-CL came
'Five **groups** of students came.'

The sentences in (4a) and (4b) form a minimal pair in which the only difference is the classifier. In (4a), the classifier is *nin*, a unit for counting people, and the sentence means that five individual students came. In contrast, in (4b), the classifier is *kumi*, a unit for counting groups, and the sentence means that five groups of students came. The NQ *go-nin* refers to five persons, and the NQ *go-kumi* refers to five groups. This shows that what the numeral counts is precisely what the classifier refers to. Our claim, then, is that the classifier actually denotes a set of objects, just like an ordinary noun, and functions as the restrictor for the numeral.

Next, we will show that the nuclear scope for the numeral in Japanese FNQ quantification is the predicate denotation. Consider the sentence in (5a):

(5) a. [narande hashitteita **suu-dai**-no torakku]$_{DP}$-ga
in a row running several-CL-*NO* truck-NOM
(prenominal NQ)
[**san-dai** gaadoreeru-ni butsukatta]$_{VP}$. (Inoue, 1978)
3-CL guardrail-to hit
(FNQ)
'Three of the several trucks that were driving in tandem hit the guardrail.'

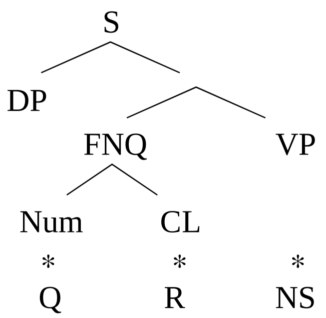
b. Conservativity test
Three *dai*-objects (i.e. machines) are *dai*-objects that hit the guardrail.

(5a) is an example of a special construction in which a prenominal NQ and an FNQ appear in the same clause.[3] The classifier in both NQs is *dai* which is a unit for counting machines. *San-dai* 'three dai', refers to three machines. Now, consider what the numeral 3 of the FNQ is counting. This sentence can be translated into English as "three of the several trucks that were driving in tandem hit the guardrail." Thus, 'three' counts the number of machines that hit the

[3] Note that the co-occurrence of a prenominal NQ and an FNQ in a single clause cannot be accounted for under the stranding account of the FQ, since under this account the quantifier appears either in the stranded position or the prenominal position (in case it moves along with the associating NP), but never both at the same time.

guardrail. That is, 'three' is the number of things that have the properties of being a machine and being a guardrail hitter. The classifier denotation and the predicate denotation intersect with each other, and the numeral of the FNQ indicates the number of elements in this intersection. Thus, the predicate denotation is the nuclear scope for FNQ quantification. This analysis is supported by the conservativity test in (5b). Note that the subject, 'several trucks that were driving in tandem', is not part of the meaning of 'three' at all. FNQ quantification has nothing to do with the material outside the verbal domain. To summarize, the Japanese FNQ is an adverb, and the three components of FNQ quantification are as shown in (6):

(6) Quantificational Analysis (Q=Quantifier, R=Restrictor, NS=Nuclear Scope)



The numeral, the classifier, and the predicate, function as the quantifier, the restrictor and the nuclear scope, respectively. Note that under this analysis the quantificational structure is directly mapped from the surface syntactic structure, strictly adhering to the principle of compositionality.

One point that calls for some elaboration is the observation that the classifier must denote a set of atoms. In other words, it must be a singular term. That the denotation of the restrictor is a set of atoms is a basic logical requirement for counting or enumeration in general (e.g. Kratzer 1989, Chierchia 1998, Landman 2000). Consider the verification of an English sentence such as (7a) with respect to a context containing boys a, b, c and d.[4] Under the traditional analysis of numeral quantification, for (7a) to be true there must be (at least) three elements in the set of boys which are also elements in the set of individuals who jumped. Now, assuming that the denotation of *boys* is as shown in (7b), which includes atoms and sums, consider two hypothetical verifications of (7a), namely (7c) or (7d):

(7) a. *Three boys jumped.*
b. [[boys]] = {a+b+c+d, a+b+c, a+b+d, a+c+d, b+c+d, a+b, a+c, a+d, b+c, b+d, c+d, a, b, c, d}
c. [[boys]] ∩ [[jumped]] = { a+b+c+d, c+d, d }
d. [[boys]] ∩ [[jumped]] = { c+d, c, d }

In both (7c) and (7d), there are three elements, thus numeral quantification yields truth. However, if we count the number of boys in these three elements, we find that in (7c) there actually are four of them, and in (7d) there are only two, rather than three. The discrepancy between the number of elements and the number of individuals are summarized in (8):

(8) 7c → number of quantified elements = 3 (namely a+b+c+d, c+d and d)
number of boys = 4 (namely a, b, c and d)

[4] Here we use a plus sign to represent the sum symbol. This corresponds to the plus sign within a circle in Link (1983), and the square union sign in Landman (2000).

7d	→	number of quantified elements	= 3	(namely c+d, c and d)
		number of boys	= 2	(namely c and d)

The problem is that all sentences of the form [three boys X-ed], where X is any predicate, are wrongly predicted to be true of any situation as long as the number of the elements is three, regardeless of the number of boys involved. In order for the noun phrase *three boys* to have its true meaning, the numeral *three* must count only individual boys, not any collection of boys. For this to happen, we must have a model in which x-many elements entail x-many individuals in them. In short, what is required is to exclude sums from the restrictor. Let us call this the 'atomicity condition' (on the restrictor of the numeral quantifier). In order to satisfy the atomicity condition, we must have an analysis of numeral quantification in which the restrictor includes only atoms, i.e. a denotation such as (9):

(9) { a, b, c, d }

In conclusion, the Japanese FNQ quantification has the following semantic properties:

(10) The semantic properties of Japanee FNQ quantification
  a. Japanese FNQs are adverbs of type <<e,t>,<e,t>>.
  b. FNQs contain a classifier, which functions as the restrictor, ans form a tripartite quantificational structure with the predicate.
  c. The restrictor denotes a set of atoms.
  d. FNQ quantification is computed within the verbal domain.

3 Floated *each*

Adopting the above account of Japanese numeral quantification, let us now consider English *each*. If we assume that the Japanese FNQ has the properties that it has because it is an ordinary sub case of FQs in general, as assumed in the literature, then we might expect the basic semantic properties of the Japanese FNQ to be found in all FQs. In other words, rather than treating the Japanese FNQ as an exception, let us consider the possibility that it is the norm. As with any norm, we expect to find marked exceptions in one language or another, but, generalizing from (10) above, we obtain the following hypotheses as to the general semantic properties of the FQ:[5]

(11) The hypothetical general semantic properties of FQ quantification
  a. FQs are adverbs of type <<e,t>,<e,t>>.
  b. FQs contain a nominal element that functions as the restrictor and forms a tripartite quantificational structure with the predicate.
  c. The restrictor denotes a set of atoms.
  d. FQ quantification is computed within the verbal domain.

The first claim of the hypotheses in (11a), which is taken for granted in much of the semantics literature, has abundant empirical motivation not only from Japanese but also from English and other Indo-European languages (e.g. Doetjes 1997). The second claim in (11b) calls for

[5] For example, in a language such as Straits Salish an adverbial quantifier occurs as a morpheme attached to a verb (Jelinek 1995). The precise quantificational mechanism of such a language must be examined and considered in comparison to other languages. Here, however, we limit the scope of our examination to English floated *each*.

some independent motivation, a matter we will address shortly. The third claim in (11c) is simply the atomicity condition discussed above. Finally, (11d) is a corollary of (11a-c).[6]

Let us now consider how English FQ *each* can be analyzed in accordance with (11b). Since there is no overt classifier adjacent to *each* in (12a) below, we must assume that element denoting the restrictor is phonetically null. Given this auxiliary assumption, (12a) is analyzed as (12c), on a par with the analysis of a Japanese FNQ, as schematically represented in (12b).

(12) a. The students each picked two topics.

```
     b. Host NP   [   Floated NQ       Predicate   ]      (Japanese)
                         /    \
                        n      CL
                        |      |           |
                        Q      R           NS

     c. The students  [    each          [picked two topics]].
                          /    \
                        each    one
                         |      |           |
                         Q      R           NS
```

Under this analysis, *each* is taken to be semantically a combination of a quantifier and its restrictor.[7] The inaudible element is taken to mean something like *one*. Thus, literally, *each* literally means 'each one', in accordance with Vendler's intuition. This analysis receives some indirect support from the following Romance language data:

(13) a. Les enfants ont *chacun* acheté deux bonbons. (French)
the children have each+one bought two candies
'The children each bought two candies.'

b. Los estudiantes escogiecon *cada uno* dos temas. (Spanish)
the students picked each one two topics
'The students each picked two topics.'

As shown here, in these languages the lexical element corresponding to English floated *each* is associated with an overt nominal element meaning 'one'. Assuming, then, that these two elements correspond to the first two components of quantification, it is reasonable to assume that they form a tripartite quantificational structure with the predicate, with the predicate functioning as the nuclear scope.

Pursuing this line of analysis, the constituent structure of an FQ sentence such as *the students each picked two topics* would form the semantic tree shown in (14a). For concreteness, we propose that the semantic value of *each* is as shown in the second line of (14b). The complete interpretation yields a distributive reading, as shown in (14c):

---

[6] We speculate that (11d) is the defining property of the FQ in general. That is, the FQ is distinct from the quantifier which composes syntactically with a nominal element (e.g. prenominal and/or determiner quantifier) in that it composes directly with the predicate.

[7] Note that so-called adverbs of quantification such as *always* and *sometimes* can also be taken to consist of morphological combination of a quantifier and its restrictor:

(i) all + ways (ii) some + times
Q R Q R

(14) a. the students each picked two topics t

the students e   each picked two topics <e,t>

each <<e,t>,<e,t>>   picked two topics <e,t>

b. *picked two topics*: $\lambda x_e[\ p2t(x)\ ]$

| *each*: $\lambda P_{<e,t>}\lambda x_e \exists K[K \subseteq (AT \cap P) \wedge +K=x\ ]$

|/ (AT = the set of atomic individuals)

each picked two topics: $\lambda x \exists K[K \subseteq (AT \cap p2t) \wedge +K=x\ ]$

| *the students*: $\sigma(*student)$ (σ='supremum')

|/

the students each picked two topics: $\exists K[K \subseteq (AT \cap p2t) \wedge +K=\sigma(*student)\ ]$

c. If a, b, and c are the students in the domain of discourse,
then $\sigma(*student)=a+b+c$,
thus, $\exists K[K \subseteq (AT \cap p2t) \wedge +K=\sigma(*student)] = \exists K[K \subseteq (AT \cap p2t) \wedge +K=a+b+c\ ]$,
i.e. a = an individual two-topic picker
& b = an individual two-topic picker
& c = an individual two-topic picker

In the proposed semantic value of *each* in (14b), P represents an <e,t> element which denotes a set containing both atoms and sums. Here P picks up the value of the predicate *picked two topics*, i.e. the set of two-topic pickers. This could include two-topic pickers who are not students, but it also includes both the individual two-topic pickers and all their sums. AT, which represents a set of atomic individuals, intersects with this set and this intersection is the set which contains only the atomic individuals which are two-topic pickers. Thus, if a, b, and c are the students in the domain of discourse, and if the sentence is true, then these three elements are in the intersection. The formula in (14c) states that there is a set K which is a subset of the intersection. Thus, if we designate K to contain precisely a, b, and c, then the sum of the elements of this K turns out to be identical with the supremum denoted by *the students*. When the sentence is true, this is how its truth conditions are satisfied. Note here that AT is part of the lexical value of *each*, rather than being introduced by an additional operator. Under this analysis, the restrictor is part of the lexical content of the quantifier *each*. Its function is to form a singular term denotation out of a plural term denotation.

4 Binominal *each*

Next, let us consider binominal *each*, an example of which is shown in (15):

(15) The students picked [two topics each $]_{DP}$.
distributive key   distributive share

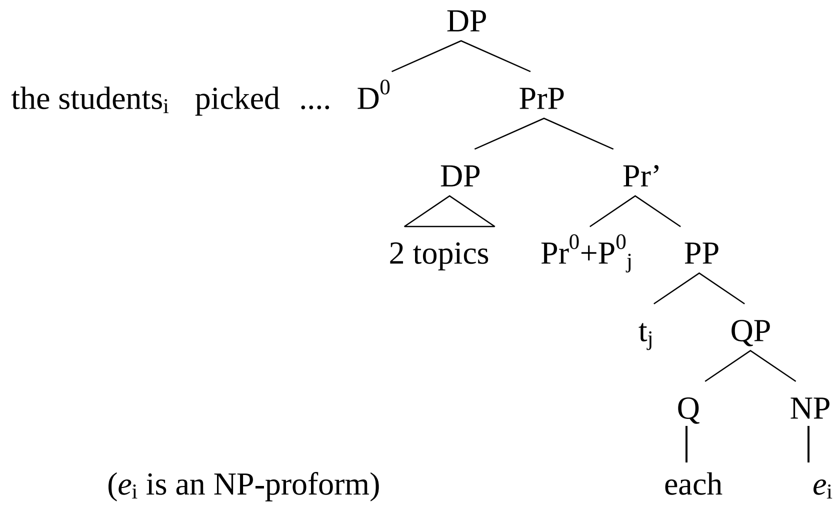
In such a sentence, the subject DP *the students* is generally called the 'distributive key' and the NP containing a numeral, namely *two topics*, is called the 'distributive share' (Choe 1987). In one of the few syntactic analyses of this construction, Safir and Stowell (1987) show that the NP containing the distributive share forms a syntactic constituent with *each*. Semanticists have handled binominal *each* in various ways (e.g. Choe 1987, Moltmann 1991, Zimmermann 2002a,b). Let us consider the most recent analysis, i.e., that of Zimmermann

(2002a,b). Here the nominal constituent containing the distributive share and *each* is analyzed as a DP as shown in (16a). The proposed syntactic analysis is as shown in (16b):

(16) Zimmermann (2002a,b)

a. The students picked [two topics each]$_{DP}$.

b.



c. Each student picked two topics.

According to Zimmermann, there is a small clause inside the DP *two topics each*, represented as a Predicate Phrase, and its subject is *two topics*. The predicate, on the other hand, is taken to be *each*, which has the proform complement *e*. This proform is coindexed with the distributive key, i.e. the subject *the students*. In this way, *each* and the distributive key are semantically related. Thus, Zimmermann basically treats the binominal *each* sentence (16a) as semantically equivalent to the corresponding prenominal *each* sentence in (16c).

It seems reasonable to assume that the nominal constituent *two topics each* is a DP, given that a verb such as *picked* is a transitive verb. Furthermore, the small clause analysis is certainly plausible. In the syntax literature, there is a substantial amount of research devoted to so-called 'predicate inversion' within DP, which assumes the presence of a small clause within DP. This line of analysis has proved to be quite useful in accounting for data in languages such as English and Dutch (Kayne 1994, Den Dikken 1995, 1998, Bennis, et al 1998, Corver 1998, 2001). Thus, Zimmermann's approach is attractive in principle. Nevertheless, we propose a modification.

First, consider the subject-predicate relation inside the small clause. If the subject is *two topics* and the predicate is *each*, then what would a maximally simple representation of this subject-predicate relation be? Consider (17):

(17) The underlying proposition in [two topics each] (according to Zimmermann)

Subject	two topics
Predicate	each
Proposition 1	Two topics are each.
Proposition 2	Two topics are (for) each (of the students)

Proposition 1 is incomplete. Including the proform *e* co-indexed with the distributive key, we arrive at Proposition 2. However, here we have to provide a significant meaning component, namely 'for' in order to make sense of Proposition 2. What we wish to claim here is that a much more natural and empirically sound analysis would be as follows:

(18) The underlying proposition in [two topics each] (according to our analysis)

Subject	each (one)
Predicate	two topics
Proposition	Each one is (a set of) two topics.

The basic intuition in (18) is that *each* is not directly related to the distributive key *the students*. Rather, *each* is again analyzed as containing a hidden lexical component meaning *one*, so that the meaning of binominal *each* is analogous to 'each one'. The motivation again comes from the French and Spanish data, where the binominal *each* construction overtly contains the meaning component 'one':

(19) a. Les enfants ont acheté deux bonbons *chacun*. (French)
the children have bought two candies each+one
'The children bought two candies each.'

b. Los estudiantes escogiecon dos temas *cada uno*. (Spanish)
the students picked two topics each one
'The students picked two topics each.'

The idea we are pushing here is that *each* understood literally as 'each one' refers to the unit of the distributive share which is distributed over the distributive key. The predication relation between *each* and the NP containing a numeral, then, is a proposition about the quantity of objects in the distributive share. This is quite distinct from Zimmermann's underlying proposition in (17). In (17), the distributive share is taken to be the subject, and the predicate is *are (for) each (of the students)*. This proposition is about the distribution itself and what the distributive share is distributed over.

Let us now consider more closely the claim that a binominal *each* sentence such as (19a) is semantically equivalent to a prenominal *each* sentence such as (19b):

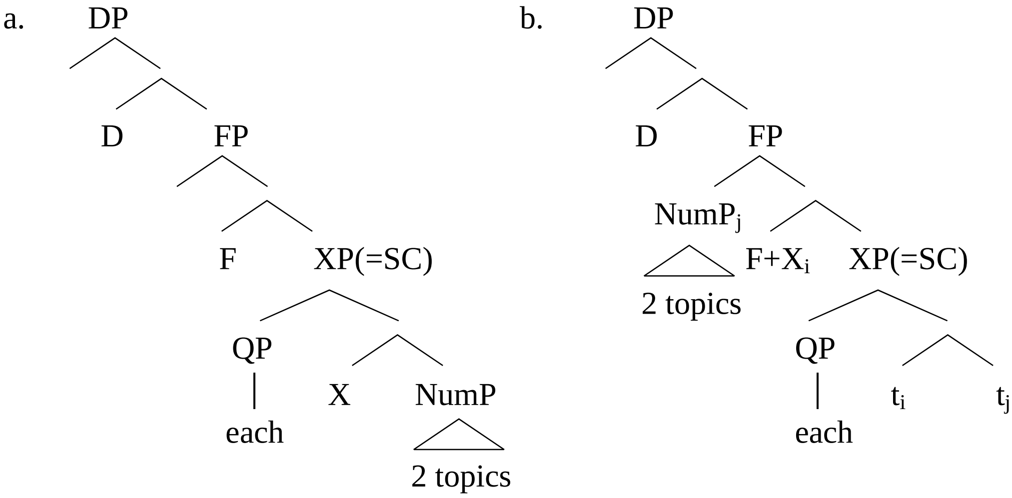
(19) a. The boys bought three sausages each.
b. Each boy bought three sausages.

This equation results precisely from the syntactic analysis in which *each* is associated with the distributive key by coindexation. Putting aside the fact this coindexation seems rather ad hoc and inconsistent with a strict interpretation of the principle of compositionality, the hypothetical equivalence of (19a) and (19b) clashes with native speaker intuitions that there is some difference between these two sentences.[8] Our analysis captures this intuition because we argue that, just as the surface forms suggest, prenominal *each* composes first with *student* while the binominal *each* composes first with *two topics*. Pursuing this line of reasoning, we are all the more motivated to formulate distinct semantic analyses for the two syntactic constructions.

In view of these considerations, we suggest that the syntactic structure of the binominal *each* construction is as shown in (20):

[8] One difference that can be identified is that the domain presupposition of *each* is already set by *the boys* in (19a) before interpreting *each*, whereas in (19b) quantification and presupposition accommodation must occur simultaneously (thanks to Bill Philip p.c. for pointing this out).

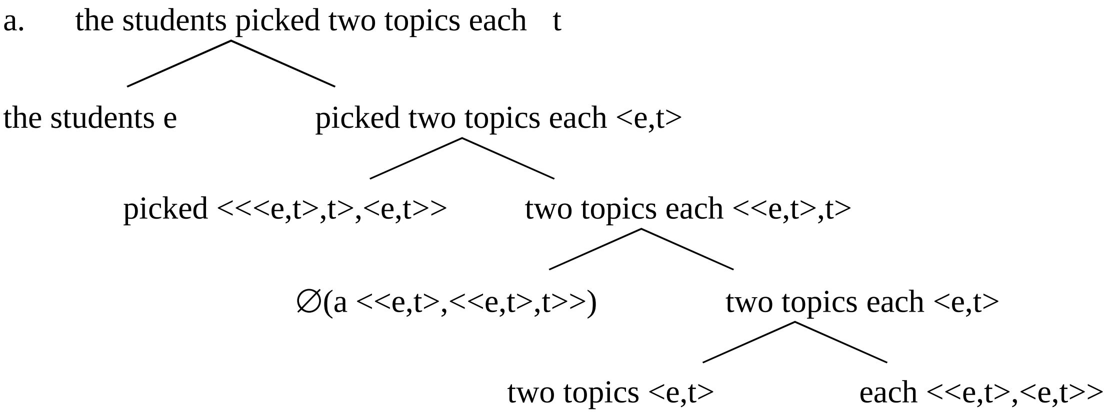
(20) Predicate inversion analysis : e.g. Kayne 1994, Den Dikken 1995, Corver 1998, Kobuchi-Philip 2004



Here, *each* is the subject and *2 topics* is the predicate in the small clause within DP, as shown in (20a). Subsequently, the predicate NumP is raised over the subject as an instance of predicate inversion, as shown in (20b).

When the syntactic structure in (20b) is semantically interpreted, the only structure visible to the interpretation mechanisms is the basic constituent structure shown in (21a). Here, we assume the presence of an inaudible determiner whose position corresponds to the head D position in (20b). Assuming the same denotation of *each* as floated *each*, we obtain the interpretation of the binominal *each* sentence as shown in (21b):

(21) a.



b. *two topics*: $\lambda x_e[\ 2t(x)\ ]$

| *each*: $\lambda P_{<e,t>}\lambda y_e \exists K[K \subseteq (AT \cap P) \wedge +K=y\ ]$

|/

two topics each: $\lambda y \exists K[K \subseteq (AT \cap 2t) \wedge +K=y\ ]$

| *a*: $\lambda P_{<e,t>}\lambda Q_{<e,t>}\exists x_e[P(x) \wedge Q(x)]$

|/

(*a*) *two topics each*: $\lambda Q \exists x[\exists K[K \subseteq (AT \cap 2t) \wedge +K=x\ ] \wedge Q(x)]$

| *picked*: $\lambda T_{<<e,t>,t>}\lambda v_e[T(\lambda s_e[(picked(s))(v)])]$

|/

picked two topics each: $\lambda v[\exists x[(AT\cap 2t) \wedge +K=x\ ] \wedge (picked(x))(v)]$
| *the students*: $\sigma(*student)$
|/
the students picked two topics each:
$$\exists x[\exists K[K\subseteq(AT\cap 2t)\wedge +K=x]\wedge(picked(x))(\ \sigma(*student)]$$

c. If a, b, and c are the students in the domain of discourse,
and α is a set of two topics and β is another set of two topics in the set K,
then $\sigma(*student)=a+b+c$, and $x = \alpha+\beta$,
thus, $\exists x[\exists K[K\subseteq(AT\cap 2t)\wedge +K=\alpha+\beta]\wedge(picked(x))(\ \sigma(*student)]$
$= \exists K[K\subseteq(AT\cap 2t)\wedge +K=\alpha+\beta]\wedge(picked(\alpha+\beta))(a+b+c)$

An example verification of the logical representation in the last line of (21b) is partially shown in (21c). The last line of (21c) can be described as follows: Suppose student a picked a set of two topics α, student b picked a set of two topics α, and student c picked a set of two topics β (e.g. α represents the Civil War and the slavery, β represents Vietnam War and the Hippie movement). Thus, K can be determined to contain α and β. Then, (picked (α+β)) denotes a set containing every α-picker and β-picker, and all their sums, which then include the sum a+b+c.

Note that, under this analysis, binominal *each* is of type <<e,t>,<e,t>>, just like floated *each*. In both cases, the quantifier is assumed to contain a hidden lexical component which denotes a set of atoms and which functions as the restrictor. However, while floated *each* syntactically composes with a verbal predicate, binominal *each* syntactically composes with an NP. This allows a unified analysis which is more strictly compositional since semantic interpretation is closely related to the surface form. In the next section we examine prenominal *each*, which turns out to be quite distinct from the two types of *each* we have discussed so far.

5 Prenominal *each*

Let us now consider prenominal *each*. Since we have shown how floated and binominal *each* can be taken to have identical semantic value, we might attempt to extend the analysis to cover prenominal *each* as well. However, prenominal *each* in fact looks quite distinct from floated and binominal *each*. Again, the clue comes from the Romance languages. Consider (22):

(22) Three types of *each* in French, Spanish and English

	Floated/Binominal	Prenominal
French	chacun	chaque (N)
Spanish	cada uno	cada (N)
English	each	each (N)

As we observed earlier, in French and Spanish, the lexical elements which correspond to English floated and binominal *each* are *chacun* and *cada uno*, respectively, which include the overt meaning component 'one'. However, this component disappears in the prenominal use of the same lexical item. This suggests a sharp distinction between floated and binominal *each*, on one hand, and prenominal *each*, on the other. Specifically, it seems to be the case that prenominal *each* does not contain a hidden lexical component denoting a set of atoms that functions as the restrictor. Recall now that the original reason for positing a hidden classifier-like element for floated *each* follows from our hypothesis that FQ *each* needed this restrictor in order for the three components of FQ quantification to apply within the verbal domain. Thus, if prenominal *each* does not contain a restrictor, an immediate question is what functions as the restrictor and the nuclear scope.

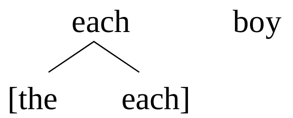
In fact, prenominal *each* must be followed by a singular noun. This is also the case in French and Spanish and a singular noun denotes a set of atoms (Link 1983, Landman 2000). This suggests that, in accordance with the traditional analysis, the singular noun adjacent to it functions as the restrictor for prenominal *each*. Assuming that prenominal *each* and the singular noun adjacent to it are a quantifier and its restrictor, the predicate must be the nuclear scope, as shown in (23):

(23) Each boy picked two topics.
Q DoQ NS

If this is the case, prenominal *each* does indeed seem to be a determiner. This explains why prenominal *each* cannot co-occur with a determiner, as illustrated in (24a), and this constraint applies to the analog of *each* in the Romance languages as well, as illustrated in (24b,c):

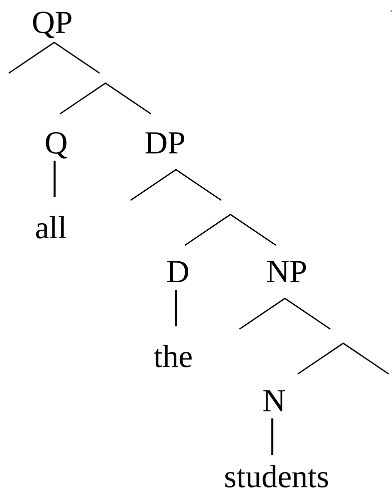
(24) a. *the each N
b. *le chaque N
c. *de cada N

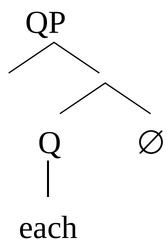
To account for the determiner status of prenominal *each*, we hypothesize that here *each* the quantifier has incorporated into the definite determiner, as shown in (25):

(25)


In the syntax literature, a quantifier such as *all* has been argued to occupy the head position of QP, which is generally assumed to be generated above DP as the top-most maximal projection within the nominal domain, as shown in (26a) below. Such a structure accounts for the word order of the phrase such as *all the students*:

(26) The internal structure of the nominal domain (Giusti 1991, Shlonsky 1991, etc.)

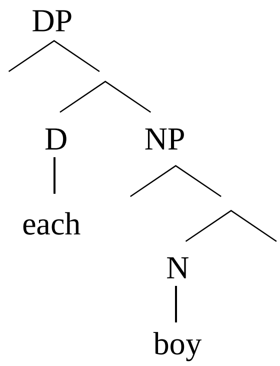
a.


b.


We could assume that floated and binominal *each* occupy the same Q-head position as shown in (26b) and that this QP is inserted in the appropriate positions in the sentence structure (a

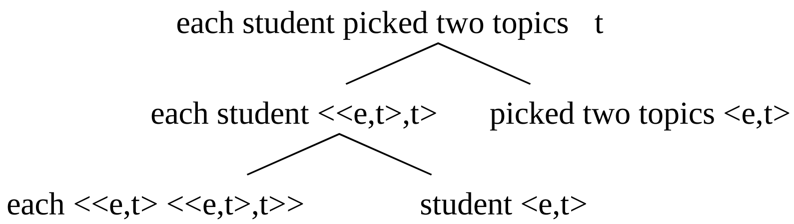
VP-adjoined adverbial position for FQ *each*, and subject position within DP for binominal *each*). However, since prenominal *each* combines with a noun and has lexically merged with the definite determiner, we suggest that prenominal *each* is not a Q-element but a D-element, as shown in (27):

(27)



The semantic tree for a sentence with prenominal *each* would look like (28a) below. We suggest that the denotation of prenominal *each* is as shown in the first line of (28b). The outcome is as shown in (28c):

(28) a.



b. *each*: $\lambda P_{<e,t>}\lambda Q_{<e,t>}$ [$P \subseteq Q$]
| *student* : λx_e [student(x)]
|/
each student: λQ[student(x) $\subseteq$ Q]
| *picked two topics*: λx_e[p2t(x)]
|/
each student picked two topics: λx [student(x)] $\subseteq$ λx[p2t(x)]

c. student : {a, b, c}
λx [student(x)] $\subseteq$ λx[p2t(x)] : a = an individual two-topic picker
& b = an individual two-topic picker
& c = an individual two-topic picker

Prenominal *each* first combines with a singular noun, in this case *student*. This denotes a set containing only atoms. If there are three students in the domain of discourse, then it denotes {a, b, c}. This singular noun functions as the restrictor and it intersects with the predicate denotation, though the intersection is itself the set denoted by the singular noun. That is, it is a subset of the predicate denotation. Thus, each member of the set dentoed by the singular noun, namely a, b, and c, is an atom and has the property of having picked two topics.

6 Summary and further questions

In this paper, we have examined three manifestations of the English lexical element *each*, namely, floated *each*, binominal *each* and prenominal *each*. On the basis of a general mechanism of FQ quantification induced from a recent semantic analysis of Japanese floated numeral quantifier, we have proposed that English floated *each* lexically contains an inaudible nominal element which denotes a set of atoms and which functions as the restrictor. As for binominal *each*, we modified the syntactic analysis suggested by Zimmermann (2002a,b) by means of a predicate inversion analysis. That allows for a simpler unified account of floated and binominal *each* that is more strictly compositional than previous accounts and that accords with native speaker intuitions. Prenominal *each*, however, turned out to be distinct from the other two types of *each* in the sense that, as suggested by Romance data, it does not contain the restrictor as a lexical component. Instead, prenominal *each* was analyzed as a determiner quantifier in the traditional sense except that, under our analysis it derives morphologically from FQ *each*. This derivation, which is probably historical rather than synchronic, is possible because the right-adjacent noun is singular and therefore can be a proper restrictor (satisfying atomicity condition).

The analysis given here is based on some novel assumptions. Obviously, these assumptions themselves require more thorough examination. Furthermore, under our analysis the denotations of floated and binominal *each* are very different from that of prenominal *each*. The syntax and the syntax-semantics interface issues of prenominal *each* must be investigated further. Specifically, future research questions posed by our analysis are: How can determiner *each* be analyzed as deriving from the internal components of floated *each*? What properties of UG makes this possible or obligatory? These are entirely new questions since in all prior research it was assumed, without question, that FQs derive from determiners.

References

Bennis, H., Corver, N., Den Dikken, M.: 1998, Predication in nominal phrases, *The Journal of Comparative Germanic Linguistics* **1**, 85-117.

Chierchia, G.: 1998, Reference to kinds across languages, *Natural Language Semantics* **6**, 339-405.

Choe, J.-W.: 1987, *Anti-quantifiers and a theory of distributivity*. Ph.D. Diss. University of Massachusetts, Amherst.

Corver, N.: 1998, Predicate movement in pseudopartitive constructions, *in* A. Alexiadou and C. Wilder (eds), *Possessors, predicates, and movement in the determiner phrase*. Amsterdam: John Benjamins, pp. 215-257.

Corver, N.: 2001, On predicate numerals, *in* T. van der Wouden and H. Broekhuis (eds), *Linguistics in the Netherlands* 2001. Amsterdam: John Benjamins, pp. 65-76.

Den Dikken, M.: 1995, Copulas, *GLOW Newsletter* **34**, 20-21.

Den Dikken, M.: 1998, Predicate inversion in DP, *in* A. Alexiadou and C. Wilder (eds), *Possessors, predicates, and movement in the determiner phrase*, Amsterdam: John Benjamins, pp. 177-214.

Doetjes, J.: 1997, *Quantifiers and selection: on the distribution of quantifying expressions in French, Dutch and English*. Ph.D. Diss. Leiden University.

Dowty, D. and B. Brodie: 1984, The semantics of ‘floated’ quantifiers in a transformaionless grammar, *in* M. Cobler, S. Mackaye, and M. T. Wescoat (eds), *WCCFL* **3**, 75-90.

Fukushima, K.: 1991, *Generalized floating quantifiers*. Ph.D. Diss. University of Arizona.

Giusti, G.: 1991, The categorial status of quantified nominals, *Linguistische Berichte* **136**, 438-454.

Inoue, K.: 1978, *Nihongo-no bunpookisoku*, Tokyo: Taishuukan.

Jelinek, E.: 1995, Quantification in Straits Salish, *in* E. Bach, E. Jelinek, A. Kratzer and B. Partee (eds), *Quantification in natural languages*, Dordrecht: Kluwer, pp. 487-540.

Junker, M-O.: 1990, Floating quantifiers and Georgian distributivity, *in* M. Ziolkowski, M. Noske, and K. Deaton (eds), *CLS* **26**, 211-219.

Kayne, R.: 1994, *The antisymmetry of syntax*. Cambridge, MA: MIT Press.

Kobuchi-Philip, M.: 2003, *Distributivity and the Japanese floating numeral quantifier*. Ph.D. Diss. CUNY Graduate Center.

Kobuchi-Philip, M.: 2004, Syntactic and semantic licensing condition of the floating (numeral) quantifier, a talk at Linguistic Perspectives on Numerical Expressions Workshop, Utrecht.

Kratzer, A.: 1989, An investigation of the lumps of thought, *Linguistics and Philosophy* **12**, 607-653.

Landman, F.: 2000, *Events and plurality*, Dordrecht: Kluwer.

Link, G.: 1983, The logical analysis of plural and mass terms: A lattice-theoretical approach, *in* R. Bäuerle, C. Schwarze, and A. von Stechow (eds.) *Meaning, use, and interpretation of language*, Berlin: de Gruyter, pp. 303-323.

Link, G.: 1987, Generalized quantifiers and plurals, *in* P. Gärdenfors (ed.) *Generalized quantifiers. linguistic and logical approaches*. Drdrecht: Reidel, pp. 151-180.

Moltmann, F.: 1991, On the syntax and semantics of binary distributive quantifiers, *NELS* **22**, 279-292.

Roberts, C.: 1986, *Modal subordination, anaphora and distributivity*. Ph.D. Diss. University of Massachusetts at Amherst.

Safir, K. and T. Stowell: 1987, Binominal *each*, *NELS* **18**, 426-450.

Shlonsky, U.: 1991, Quantifiers as functional heads: A study of quantifier float in Hebrew, *Lingua*. **84**, 159-180.

Vendler, Z.: 1966, *Linguistics in Philosophy*. NY: Cornell University Press.

Zimmermann, M.: 2002a, A compositional analysis of anti-quantifiers as quantifiers, *in* B. Jackson (ed.) *SALT* **12**, 322-338.

Zimmermann, M.: 2002b, *Boys buying two sausages each*. Ph.D. Diss. University of Amsterdam.