Universal Quantifiers

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Joh, Yoon-Kyoung. (2010). Universal Quantifiers. *Language Research* 46.2, 123-145.

This paper refutes the traditional approach that translates *all, every,* and *each* uniformly into a universal quantifier and claims that *every* and *each* correspond to ∀∃ in logic whereas *all* simply amounts to ∀. This contrast directly accounts for the grammatical number that the quantifiers are associated with. Furthermore, to address various different properties observed between *each* and *every*, I claim that *each* is necessarily translated into ∀∃ but *every* is optionally so. In arguing so, I further show that, in the case of *each*, what has been described as a collective reading has the ∃∀∃-structure while the collective interpretation of *every* can be expressed as ∃∀.

Keywords: universal quantifier, existential quantifier, distributivity, maximality, collectivity

1. Introduction

There are three lexical items that are usually translated into a universal quantifier in English. They are *all, every,* and *each.* Certainly, translating them into a universal quantifier is correct to some extent since all the sentences in (1) somehow express the universal quantificational force.

(1) a. All the boys attended the class.
b. Every boy attended the class.
c. Each boy attended the class.

However, this simple translation into a classical logic accounts for nothing about the differences among the three quantifiers. For one thing, the noun phrase modified by *all* is treated as plural while the noun phrase headed by *every* or *each* is considered as singular. This contrast is clear when we look at the grammatical number of the pronouns that they bind. As shown in (2), *all* binds a plural pronoun whereas *every* and *each* bind a singular pronoun.

(2) a. All the students$_i$ said they$_i$ are happy.
b. Every student$_i$ said he$_i$ is happy.

c. Each student$_i$ said he$_i$ is happy.

Another difference between *every* and *each*, on the one hand, and *all*, on the other, is that *all* can co-occur with inherently collective predicates but *each* and *every* cannot. As we can see in (3), *all* can be used with the predicate *surround the castle* but *every* and *each* produce ungrammatical sentences, combining with the predicate.

(3) a. All the students surrounded the castle.
b. *Every student surrounded the castle.
c. *Each student surrounded the castle.

It seems that *every* and *each* are homogeneous as opposed to *all* at this point but this is not the entire story. While *each* is distributive all the time, *every* seems to lose the sense of distributivity from time to time. In the sentence (4), *every* simply expresses exhaustiveness rather than distributivity. Yet, the examples in (5) show us that the relaxation that occurs with respect to *every* is not possible with *each*.

(4) I examined every possibility.

(5) a. It took every student to carry the piano upstairs.
b. *It took each student to carry the piano upstairs.

This paper will formally articulate the similarities and differences of the three English quantifiers that have been translated into a universal quantifier traditionally in a unified way. In doing so, I organize this paper as follows. First, in section 2, I discuss various properties of the quantifiers that are of interest in this paper. The quantifiers *all, every,* and *each* are essentially the same in terms of the universal quantificational force that they express but many differences are also observed. In section 3, I briefly introduce my previous work on distributivity. Spelling out the difference between distributivity and universality based on a linguistic fact discussed in section 3, I provide formal explanations to the questions why *every* and *each* pattern together as opposed to *all* and why *every* sometimes behaves differently from *each* in section 4. Section 5 concludes this paper.

2. Similarities and Differences of *all, every* and *each*

In this section, I will look at the parallelisms and differences of the quantifiers that have usually been represented with a universal quantifier. Beghelli and

Stowell (1996) discuss various properties of the quantifiers we are interested in. First of all, they describe the similarity that the quantifiers *all, every,* and *each* have as in (6). The most typical nature that the quantifiers commonly have is the universal quantificational force and the interpretation is provided in (6). In a context where the set of boys being quantified over is composed of Abraham, Bill, and Charles, the sentences in (6) are true if Abraham, Bill, and Charles all visited Jane at 1 o'clock and they are all false if Abraham, Bill, and Charles didn't visit Jane at 1 o'clock.

(6) a. All the boys visited Jane at 1 o'clock.
b. Every boy visited Jane at 1 o'clock.
c. Each boy visited Jane at 1 o'clock.

The quantifiers that have traditionally been treated as a universal quantifier all can co-occur with inherently distributive predicates and produce a distributive sense, as shown in (7). This is another characteristic that the quantifiers share.

(7) a. All the boys fell asleep.
b. Every boy fell asleep.
c. Each boy fell asleep.

However, they do not behave homogeneously all the time. As Beghelli and Stowell (1996) note, the quantifiers *each* and *every* are distributive as opposed to *all*. In (8), the universally quantified objects all permit a distributive construal but only *all* preferably derives a collective construal. That is, when *every* and *each* are used, the sentences are hardly judged to donote a situation that involves a single looking-event. For instance, in (8a), the most available reading is the Pope saw the assembled multitude at a single glance. However, in (8b) and (8c), it is preferred that the Pope looked at the members of his flock individually.

(8) a. The Pope looked at all the members of his flock.
b. The Pope looked at every member of his flock.
c. The Pope looked at each member of his flock.

Beghelli and Stowell (1996) further discuss that the contrast described in (8) is manifested as a grammatical difference in (9). The predicate *surround* requires a collective interpretation of the subject which must denote a plural group. Such a reading is possible with the quantifier *all* but not with the quantifiers *every* and *each* as shown in (9).

(9) a. All the boys surrounded the fort.
b. ?Every boy surrounded the fort.
c. ?Each boy surrounded the fort.

Related to this point, Beghelli and Stowell (1996) present another set of data described in (10) and (11). Only QPs combined with *every* and *each* can enforce a distributive sense when they take scope over *a different* N but, as shown in the (a) examples, QPs headed by *all* cannot.

(10) a. *All the boys read a different book.
b. Every boy read a different book.
c. Each (of the) boy(s) read a different book.

(11) a. *A (different) boy read all the books.
b. A (different) boy read every book.
c. A (different) boy read each book.

Another feature that distinguishes *every* and *each* from *all* is grammatical number. The quantifiers *each* and *every* are syntactically singular, although they might be construed as plural, at least semantically. They combine with morphologically singular noun phrases and bind singular pronouns as variables as illustrated in (12b) and (12c). However, the quantifier *all* is both grammatically and semantically plural. They combine with plural noun phrases and bind plural pronouns as shown in (12a).

(12) a. All the boys$_j$ said they$_j$ were tired.
b. Every boy$_j$ said he$_j$ was tired.
c. Each boy$_j$ said he$_j$ was tired.

For the reasons listed above, Beghelli and Stowell (1996) classify *every* and *each* as strong distributive quantifiers while terming *all* a weak distributive quantifier. They describe the difference as follows. Strong distributive quantifiers obligatorily generate distributivity and strong distributivity can arise under an inverse scope construal. On the other hand, weak distributivity is optional and cannot arise under an inverse scope construal.

Even though Beghelli and Stowell (1996) uniformly group *every* and *each* as strong distributive quantifiers, they do not behave the same all the time. Beghelli and Stowell (1997b) further examine five differences found between the two quantifiers. First, *every*, as opposed to *each*, can get a non-distributive universal interpretation, acting essentially like *all* as illustrated in (13).[1] Look-

[1] The examples are from Tunstall (1999).

ing at such examples, Vendler (1967) points out the difference between *every* and *each* as follows: the quantifier *every* stresses exhaustiveness while the quantifier *each* directs one's attention to the individuals.

(13) a. They showed him every consideration.
b. There is every prospect of success.

Second, *each*, unlike *every*, can occur in a Quantifier Float construction and in a Binominal construction, as illustrated in (14b) and (14c), respectively. However, as shown in (15), *every* cannot appear in such constructions.

(14) a. Each boy lifted two baskets.
b. The boys each lifted two baskets.
c. The boys lifted two baskets each.

(15) a. Every boy lifted two baskets.
b. *The boys every lifted two baskets.
c. *The boys lifted two baskets every.

A third difference between *each* and *every* is found with regard to a collective universal interpretation of the QPs headed by *every*. Even though QPs modified by *every*, like the case of *each*, usually force a distributive (non-collective) reading, as we saw above, this tendency seems to be relaxed from time to time as shown in (16). The sentence in (16b), in contrast to (16c), shows us that *every*, unlike *each*, can serve as a non-distributive universal quantifier.

(16) a. It took all the boys to lift the piano.
b. It took every boy to lift the piano.
c. *It took each boy to lift the piano.

The fourth difference between *every* and *each* concerns modification by *almost*. The particle *almost* qualifies any quantifier designating a fixed quantity that is construed as the end point of a scale but it cannot combine with *each*. As we can see in (17), however, *every* and *all* can be used with *almost*. This suggests that *all* and *every*, but not *each*, can indicate the end point of a scale, here the full set of apples.

(17) a. One boy ate almost all the apples.
b. One boy ate almost every apple.
c. *One boy ate almost each apple.

The fifth difference involves modification of the so-called universal quantifiers

by the negative particle *not*. While *not* can be used with a variety of quantifiers including *every* and *all*, it cannot combine with *each* as illustrated in (18).

(18) a. Not all the boys ate an ice-cream cone.
b. Not every boy ate an ice-cream cone.
c. *Not each boy ate an ice-cream cone.

In sum, at first glance, the quantifiers *all, every,* and *each* are all uniform in that they express the universal quantificational force and allow a distributive sense but, in this section, we have observed that many differences are also found among the quantifiers. It seems that *every* and *each* are grouped together as opposed to *all* but there are also circumstances where *all* and *every* pattern together in contrast to *each*.

3. Distributivity

In the previous section, I have discussed various properties of the quantifiers *all, every,* and *each*, focusing on the similarities and differences that they reveal. With the properties being discussed, it is clear that it is a naïve approach to translate them into a universal quantifier uniformly since the different patterns they portray are empirically significant. In the main section of this paper, I will explain why the similarities and differences emerge as they are. Yet, before doing so, I would like to introduce my previous work that analyzes distributivity with a pluralization operator that includes the $\forall\exists$-structure inside it.

J-W Choe (1987) identifies three components of distributivity. For example, in (19a), three elements are needed to project a distributive reading. The first element is the distributive antecedent (henceforth, SrtKy). It must be semantically plural as the noun phrase *the boys* in (19a). The second object is the Distributed Share (henceforth, DstrShr). In (19a), the DstrShr is the indefinite noun phrase *two birds*. The third element needed for a distributive interpretation is the relation-denoting expression. J-W Choe (1987) simply terms it a Relation. In (19a), the main verb *have* functions as the Relation. With the three essential components, the distributive interpretation illustrated in (19b) can be projected.

(19) a. The boys have two birds each.
b. $\forall z[z \in [[\text{the boys}]] \rightarrow \exists x[\text{two birds}(x) \,\&\, \text{have}(z, x)]]$

To treat all the constructions involving such a distributive reading, in my previous work, Y-K Joh (2008), I have proposed a pluralization operator in (20). In the denotation of the pluralization operator, there are three variables – *Z, P,*

and *R* – that mirror the three essential components of distributivity. *Z* is the SrtKy and *P* is the DstrShr. *R* expresses the Relation between the SrtKy and the DstrShr. The pluralization operator[2] with the three variables is evoked not only by an overt distributive particle but also by a covert distributivity marker.

(20) $[[*_{ij}]] = \lambda P_{<\alpha,t>}.\forall z[z_{<\alpha>} \in Z_{i<\alpha,t>} \rightarrow \exists x_{<\alpha>}[P(x) \,\&\, R_{j<e,<\alpha,t>>}(x)(z)]]$

Characteristically, the three variables *Z*, *P,* and *R* can be permuted to be the first semantic argument in the operator defined in (20). That is, the first constituent that combines with the operator does not have to be the DstrShr (*P*) but it can be the SrtKy (*Z*) or the Relation (*R*). The permutation is empirically attested by the three uses of a distributive quantifier that selects each variable as their first semantic argument. The distributive particle *each* can not only attach to the DstrShr as in (21c) but also to the SrtKy and the Relation as shown in (21a) and (21b), respectively. In my system, the first semantic argument of the pluralization operator is designed to correspond to the syntactic sister of the distributive quantifier and hence the first semantic argument is allowed to be permuted, as indicated in the parentheses below. You can refer to my previous work, Y-K Joh (2009), for further details.

(21) a. Each of the boys lifted two baskets.
$(\lambda Z.\forall z[z \in Z \rightarrow \exists x[P_i(x) \,\&\, R_j(x)(z)]])$

b. The boys each lifted two baskets.
$(\lambda R.\forall z[z \in Z_i \rightarrow \exists x[P_j(x) \,\&\, R(x)(z)]])$

c. The boys lifted two baskets each.
$(\lambda P.\forall z[z \in Z_i \rightarrow \exists x[P(x) \,\&\, R_j(x)(z)]])$

Another crucial feature in the extension of the pluralization operator is that it encompasses the ∀∃-structure inside it. It is usually understood that the distributive reading is generated when a universally quantified phrase provides the ∀-structure and an indefinite element presents the ∃-structure in the same sentence. Yet, this simple approach faces problems since distributivity can arise even when there is no indefinite element as shown in (22). As underlined in (22), the elements that act as the DstrShr in each sentence are definite and thus they cannot project the ∃-structure themselves. What the data in (22) suggest is that the ∃-structure must be part of the structure of the operator that projects distributivity. Therefore, in my system, the pluralization operator evoked by a covert or an overt distributivity marker contains the ∀∃-structure altogether.

[2] Zimmermann (2002) uses the extension as the denotation of *jeweils* in German. However, in my system, it is the denotation of the pluralization operator that can be evoked by all kinds of distributive particles.

(22) a. Four students were busy reading the newspaper.
b. John and Mary invited their mothers to their place.
c. All the boys brought their fathers along.
d. All the boys forgot their books.
e. Those men in green married the ex-wives of their neighbors.
f. The men in the building are married to the girls across the hall.

Furthermore, what is noteworthy in my analysis of distributivity is that distributivity is induced by a pluralization operator, not by the D operator. The reason why the operator that projects the $\forall\exists$-structure is defined as a pluralization operator is due to a fact that Landman (2000) finds. Landman (2000) observes that distributivity is reduced to semantic plurality in terms of the fact in (23) below which can be proved as in (24). The essence of (23) is as follows. The grammar has only a single operation that forms semantically plural predicates out of semantically singular predicates: the *-operation yields plural nouns in the nominal domain while the same operation creates distributive interpretations in the verbal domain. That is, distributivity is not an independent object in the grammar but another instantiation of plurality occurring in the verbal domain.

(23) Fact: If P is a set of atoms then:
$\alpha \in {}^*P$ iff $\forall a \in AT(\alpha)$: $a \in P$

(24) Assume that P is a set of atoms. Assume that every atomic part of α is in P. By definition of *P, if every atomic part of α is in P then their sum is in *P. Hence $\cup(AT(\alpha)) \in {}^*P$. Since D is an atomic part-of structure, $\alpha = \cup(AT(\alpha))$. Hence $\alpha \in {}^*P$. Assume $\alpha \in {}^*P$. Since D is an atomic part-of structure, *P is itself also an atomic part-of sub-structure of D with set of atoms P. Hence If $\alpha \in {}^*P$, every part of α is also in *P. If every part of $\alpha \in {}^*P$, then every atomic part of α is in *P, and –since P is the set of atoms in *P- it follows that every atomic part of α is in P.

In terms of the fact in (23), Landman's theory generates a distributive reading of (25a) in a simply way without using a scope mechanism. First, as shown in (25b), *sing* is applied to the sum interpretation of *three boys*. As a result, we get a formula that says that there is a sum of singing events and a sum of three boys and that sum of boys is the plural agent of that sum of events. Then, we swap the arguments - there is a sum of boys and a sum of singing events of which that sum of boys is the plural agent. At last, the distributive construal comes about in terms of (23) above.

(25) a. Three boys sing.

b. Derivation for the distributive reading
Apply SING to the sum interpretation of THREE BOYS.
$\exists e \in$ *SING: $\exists x \in$ *BOY: $|x| = 3$ & *Ag(e) = x
$\exists x \in$ *BOY: $|x| = 3$ & $\exists e \in$ *SING: *Ag(e) = x
$\exists x \in$ *BOY: $|x| = 3$ & $\forall a \in AT(x)$: $\exists e \in$ SING: Ag(e) =a

Landman's (2000) theory reduces the complexity of grammar to a high extent by analyzing distributivity based on something already in the grammar. However, his theory is limited since he uses non-compositional steps such as argument swapping in deriving the distributive sense. To overcome the limitation, I define the pluralization operator in (20) as a type-driven object. In the pluralization operator, the variables *z* and *x* are of $<\alpha>$ type. The lower-case of the variables *z* and *x* indicates that they are singular. The variable *z* is necessarily a pure atom since it constitutes the sub-parts of a set plural in the denotation described above. However, the variable *x* is either a pure or an impure atom. The semantic type of the variables *Z* and *P* is $<\alpha,t>$. The former is the plural set while the latter is the atomic set. The relation-denoting variable *R* is of type $<e,<\alpha,t>>$. In all the variables, type $<\alpha>$ that can be either type $<e>$ or type $<v>$ expresses the parallel between the nominal domain and the verbal domain since either the nominal or the eventual adverbial can serve as the SrtKy and the DstrShr. The reason why the Relation variable *R* has α in its type is for its flexibility.

What is needed to note further is that, despite the fact that I define the denotation of the pluralization operator in a highly flexible manner, it is also constrained via indices. To get the compositional facts correctly, I assume two indices for the variables that remain free and are ready to be lambda-abstracted in order to be filled with a proper value. The indices capture the dependency character of distributivity and indicate which variables get which values.

For compositionality, we need one more tool in addition to the pluralization operator defined in (20). The additional mechanism we need to have is the rule in (26). Bittner (1994) puts for the lambda-abstraction rule in (26) to properly bind free variables with an index. Employing the rule in (26), we can account for how elements that occur far apart from one another can be combined compositionally.

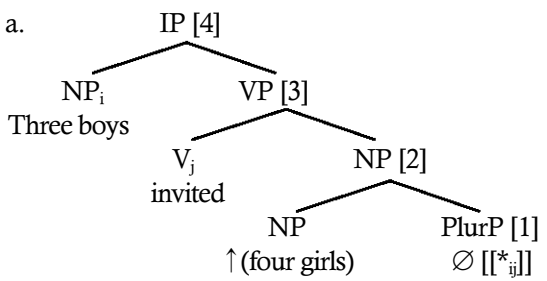
(26) Bittner's λ-abstraction rule
Let α have a translation [[α]] and let the index "i" be the index of either α or a sister of α, and let [[α]] contain a variable u with index "i." Then $\lambda u_i.[[\alpha]]$ is a translation of α.

Now, equipped with the pluralization operator in (20) and the semantic rule in (26), we can compositionally derive two kinds of distributive readings of the sentence in (27) below. The two distributive interpretations of (27) are as follows: (a) forward distributivity: 'each of the three boys invited a group of four girls' and (b) backward distributivity: 'each of the four girls was invited by a group of three boys.' That is, the mechanisms in my system can not only generate a forward distributive sense but also yield a backward one.

(27) Three boys invited four girls.

The semantic derivation in (28a) yields the forward distributive interpretation while the derivation in (28b) produces the backward distributive interpretation. In both cases, a covert distributive particle is responsible for projecting the ∀∃-structure. In (28a), the pluralization operator adjoins to the NP *four girls*[3] and the SrtKy is *three boys*. First, the pluralization operator applies to the element that it forms a constituent with, i.e., *four girls*. Then, lambda-abstraction occurs over the index *j* and the value of the Relation is filled via function application. Another occurrence of lambda-abstraction allows the SrtKy to be factored in. In (28b), the pluralization operator attaches to the NP *three boys* and the distributive antecedent is *four girls*. To generate the second reading, however, LF-movement must occur to let the two arguments be interpreted in the inverse fashion.

(28) a.

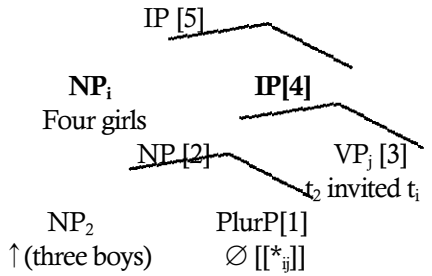


$[[1]] = \lambda P.\forall z[z \in Z_i \rightarrow \exists x[P(x) \ \& \ R_j(x)(z)]]$
$[[2]] = \forall z[z \in Z_i \rightarrow \exists x[\uparrow(4 \text{ girls})(x) \ \& \ R_j(x)(z)]]$
$[[2]] = \lambda R_j.\forall z[z \in Z_i \rightarrow \exists x[\uparrow(4 \text{ girls})(x) \ \& \ R_j(x)(z)]]$

[3] In the readings generated in (28), the DstrShr has the group denotation as indicated by the ↑ operator. The group formation takes place since the pluralization operator can only apply to atoms. That is, when the predicate that comes to function as the DstrShr is plural, a group-forming operation occurs and an impure atom is created out of the plural predicate. Then, the pluralization operator can apply to the impure atom and make it a plural. The lower-case variable *x* in the extension of the pluralization operator ensures that the DstrShr must be atomic and thus enforces group formation to take place when necessary.

$[[3]] = \forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{4 girls})(x) \ \& \ \exists e[\text{invited}(z, x, e)]]]$
$[[3]] = \lambda Z_i.\forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{4 girls})(x) \ \& \ \exists e[\text{invited}(z, x, e)]]]$
$[[4]] = \forall z[z \in [[\text{3 boys}]] \rightarrow \exists x[\uparrow(\text{4 girls})(x) \ \& \ \exists e[\text{invited}(z, x, e)]]]$

b.



$[[1]] = \lambda P.\forall z[z \in Z_i \rightarrow \exists x[P(x) \ \& \ R_j(x)(z)]]$
$[[2]] = \forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{3 boys})(x) \ \& \ R_j(x)(z)]]$
$[[2]] = \lambda R_j.\forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{3 boys})(x) \ \& \ R_j(x)(z)]]$
$[[3]] = \exists e[\text{invited}(x_2, y_i, e)]$
$[[3]] = \lambda x_2 \lambda y_i.\ \exists e[\text{invited}(x_2, y_i, e)]$
$[[4]] = \lambda R_j.\forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{3 boys})(x) \ \& \ R_j(x)(z)]](\lambda x_2 \lambda y_i.\exists e[\text{invited}(x_2, y_i, e)])$
$[[4]] = \forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{3 boys})(x) \ \& \ \exists e[\text{invited}(x, z, e)]]]$
$[[4]] = \lambda Z_i.\forall z[z \in Z_i \rightarrow \exists x[\uparrow(\text{3 boys})(x) \ \& \ \exists e[\text{invited}(x, z, e)]]]$
$[[5]] = \forall z[z \in [[\text{4 girls}]] \rightarrow \exists x[\uparrow(\text{3 boys})(x) \ \& \ \exists e[\text{invited}(x, z, e)]]]$

4. Account

In this section, I will formally account for why the similarities and differences of the three quantifiers *all, every,* and *each* are detected as they are based on the fact described in the previous section. More specifically, in this section, two questions will primarily be addressed. The first question is why *every* and *each* are grouped together as opposed to *all* and how the contrast can formally be stated while the universal quantificational force that they commonly express is maintained. The second issue will be why *every* is different from *each*, being more akin to *all* from time to time.

To begin with, let's look at the first question. In the section above, I have dealt with distributivity by a pluralization operator that has the ∀∃-structure inside it and that anticipates its three essential components to get their value one by one compositionally. For one thing, distributivity includes the universal quantificational force but it is not the entire meaning. When a covert/overt distributive particle is evoked, the universal quantifier is necessarily followed by the existential quantifier. Defining the pluralization operator to have not only the ∀-structure but also the ∃-structure inside it and allowing the arguments of

distributivity to be filled with a proper value compositionally, I basically distinguish distributive particles from universal markers. That is, I claim that distributivity markers such as *each* and *every* project the entire ∀∃-structure, as opposed to *all* which is simply translated into the ∀ quantifier.[4] Distributivity is semantically stronger than universality since the former is expressed by the universal quantifier followed by the existential quantifier while the latter can be expressed solely by the universal quantifier. Therefore, the quantifier *all* that delivers the meaning of universality (maximality) corresponds to ∀ in logic whereas *every* and *each* which express distributivity correspond to ∀∃, not ∀. Still, what is common about these quantifiers is that they all have the universal quantifier in them.

The logical difference between *every* and *each*, on the one hand, and *all*, on the other, straightforwardly explains the dichotomy found with regard to the grammatical number of the noun phrases that the quantifiers combine with and with regard to the pronouns that they can bind. That is, as discussed in section 2, *all* is grammatically treated as plural while *every* and *each* grammatically behave as singular. I would like to claim that the reason why distributive particles such as *every* and *each*, unlike *all*, are treated as singular naturally follows from the fact that distributivity is evoked by the pluralization operator that is structured with the universal quantifier taking scope over the existential quantifier.

As claimed in the previous section, distributivity amounts to plural predication. More specifically, plural predication amounts to applying singular predication distributively. Let me illustrate this point with examples. Landman (2000) accounts for the four sentences in (29) through a *-operator uniformly because, in Landman's system, what explains the equivalence of nominal predicates is the same as what explains the equivalence of verbal predicates.

(29) a. John is a boy and Bill is a boy and Henry is a boy iff John and Bill and Henry are boys.
b. The students are girls and the teachers are girls iff the students and the teachers are girls.
c. John built a boat and Bill built a boat and Henry built a boat iff John and Bill and Henry built a boat.
d. The boys meet and the girls meet iff the boys and the girls meet.

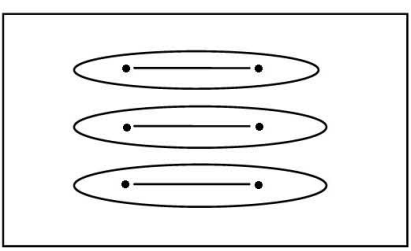
[4] Brisson (1998) claims that the function of *all* is to require a good-fitting cover for the domain restriction variable on the universal quantifier. That is, according to her, *all* intensifies the force of the universal quantifier that can be weakened pragmatically. In her analysis, *all* is not translated into the universal quantifier per se. However, even in her approach, what *all* does is to enforce the meaning of the universal quantifier. Thus, I would like to say that *all* is a universal quantifier if we have to translate it into classical logic although the exact semantics of *all* might be more than that.

As we can see with the examples in (29), the operation of pluralization on nouns gives us a way of saying long things in a short way. In (29a), if John is a boy and Bill is a boy and Henry is a boy, then we can shorten it and say that John and Bill and Henry are boys. The pluralization operation on verbs plays the same role. It allows us to say things in a short way that otherwise would be very long. In (29c), if John built a boat and Bill built a boat and Henry built a boat, we can briefly say that John and Bill and Henry built a boat.

With the opposite direction being considered, what the sentence with a distributive reading *John and Bill and Henry are boys* means is that each singularity in the denotation of the subject has the property of the main predicate which is singular in nature, i.e., John is a boy and Bill is a boy and Henry is a boy. This is what distributivity is all about. Plural predication comes about by applying singular predication distributively. The same applies to the verbal domain. If John and Bill and Henry built a boat, it means that each singularity involved built a boat, i.e., John built a boat and Bill built a boat and Henry built a boat. To rephrase, in the nominal domain, applying the plural noun *boys* to a sum of individuals is just the same as applying the singular noun *boy* to each of these individuals. In the same fashion, in the verbal domain, applying the plural verb *built a boat* to a sum of individuals is just the same as applying the singular verb *built a boat* to each of these individuals.

This way of looking at distributivity allows us to understand why noun phases combined with a distributivity marker are treated as singular both in morphological realization and in pronominal binding. By distributivity markers having the existential structure that follows the universal quantifier, in distributivity, the singular version of the predicate that serves as the DstrShr is associated with the singular predicate that functions as the SrtKy in a one-to-one fashion. Thus, distributivity can schematically be illustrated as in (30).

(30)



As shown in (30), in distributivity, the universally quantified distributive antecedent is construed in a one-to-one association with the predicate that is existentially quantified. Thus, in the one-to-one relation, the universally quantified noun phase is grammatically singular. Yet, overall, it is still true that there are multiple entities involved with the SrtKy and with the DstrShr. That is, both the universally quantified noun phrase and the existentially quantified noun

phrase in distributivity are plural conceptually. This is clear when we look at the illustration above vertically. Only under the one-to-one structure, they are understood to be singular and the grammatical number associated with *each* and *every* reflects the one-to-one structure that we can get when we look at the picture illustrated in (30) horizontally. However, merely having the universal quantifier, *all* is not only semantically but also grammatically treated as plural.

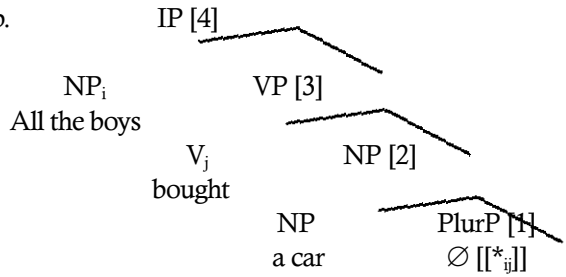
Translating *every* and *each* as $\forall\exists$ and translating *all* as $\forall$ nicely explains the grammatical number that they are associated with. Then, the question that might reasonably come to our mind next is why all of them can co-occur with a distributive predicate and is further able to generate a distributive construal, as we have observed in (7). That is, how can the sentence with the quantifier *all* have a distributive meaning if it only translates into $\forall$? I claim that the distributive reading that the sentences with *all* can have is projected differently from the distributive sense of the sentences with *every* and *each*.

In cases of *every* and *each*, the distributive reading of the sentence in which they occur is projected by themselves. That is, the $\forall\exists$-structure the sentences have are directly derived from the quantifiers *every* and *each*. However, it is not the case for *all*. The reason why *all* can occur with a distributive predicate and yield a distributive reading is because the distributive reading can be projected by a covert distributive particle. In other words, the distributive reading that arises in the sentence that contains *all* is not projected by the quantifier *all* itself, unlike the sentences with *each* and *every*, but the distributive reading in such a case is projected by a covert pluralization operator. Thus, even though *all* can appear in a sentence with a distributive meaning, it is not the quantifier *all* that is responsible for the $\forall\exists$-structure.

For instance, let's look at an example where the sentence with *all* can have a distributive interpretation. In (33a), both a collective reading and a distributive reading are possible. When the sentence has a distributive interpretation, the reading is projected by a covert pluralization operator that has the $\forall\exists$-structure in it as shown in (33b). Once the pluralization operator is evoked, each argument of the distributive relation is filled with a proper value compositionally via lambda abstraction that is followed by function application. At the surface, it seems that the quantifiers *all, every,* and *each* all allow for the distributive reading homogeneously but, at a deeper level, we can see that they are evoked differently.

(33) a. All the boys bought a car.

b.



[[1]] = $\lambda P.\forall z[z \in Z_i \rightarrow \exists x[P(x) \,\&\, R_j(x)(z)]]$
[[2]] = $\forall z[z \in Z_i \rightarrow \exists x[\text{a car}(x) \,\&\, R_j(x)(z)]]$
<Function Application>
[[3]] = $\lambda R_j.\forall z[z \in Z_i \rightarrow \exists x[\text{a car}(x) \,\&\, R_j(x)(z)]]$
<λ-abstraction>
[[4]] = $\forall z[z \in Z_i \rightarrow \exists x[\text{a car}(x) \,\&\, \exists e[\text{bought}(z, x, e)]]]$
<Function Application>
[[5]] = $\lambda Z_i.\forall z[z \in Z_i \rightarrow \exists x[\text{a car}(x) \,\&\, \exists e[\text{bought}(z, x, e)]]]$
<λ-abstraction>
[[6]] = $\forall z[z \in [[\text{all the boys}]] \rightarrow \exists x[\text{a car}(x) \,\&\, \exists e[\text{bought}(z, x, e)]]]$
<Function Application>

Next, I would like to move on the second question. If it is the case that both *every* and *each* are ∀∃ logically, why do they reveal different patterns? To repeat, in (34) to (36), *every* can be used felicitously but *each* cannot.

(34) a. They showed him every consideration.
b. *They showed him each consideration.

(35) a. There is every prospect of success.
b. *There is each prospect of success.

(36) a. It took every boy to lift the piano.
b. *It took each boy to lift the piano.

The examples above show us that *every*, unlike *each*, can be used in a non-distributive way. This can be directly explained by claiming that the quantifier *each* is necessarily translated as ∀∃ but *every* is optionally translated into ∀∃. In the literature, it has been widely discussed that *each* is more strongly distributive than *every*. The reason is that the former is obligatorily ∀∃ but the latter is only optionally so. Arguing this way, I can deal with various properties discussed in section 2.

With the examples in (14) and (15), it was pointed out that *each* has three

uses. The distributive quantifier *each* not only can occur in the determiner position but can also appear in the floated position between the subject and the main verb and in the binominal position after the DstrShr. However, *every* only has one use, i.e., the determiner use. The reason is simply attributed to the fact that *each*, but not *every*, is a canonical distributive quantifier in English. Distributivity is an object with three essential components. Thus, it seems that only the genuine distributivity marker has the three uses that reflect the very property of distributivity, unlike the pseudo distributivity marker, *every*.[5]

The fact that *every* is only optionally translated into ∀∃ can further account for why the patterns in (17) and (18) arise. Just like *all*, *every* can be modified by the particles such as *almost* and *not*. The reason is because *every*, unlike *each*, does not necessarily evoke the ∀∃-structure. The particle *almost* can modify the quantifier that designates the end point of a scale. By not having to have the ∃-structure that follows the universal quantifier, *every* can indicate a quantity that is interpreted as the end point of a scale, i.e., the full set of entities. Also, for the same reason, *every* can be partially negated under the scope of the negative particle *not*. The entire ∀∃-structure cannot be partially negated. Only in association with ∀, partial negation can be expressed. Thus, negation only scopes under ∀∃, not over ∀∃. Yet, since *every* does not obligatorily induce the ∀∃-structure, it can be under the scope of the negative particle *not* and deliver the meaning of partial negation.

In (9), it was noted that *every* cannot co-occur with the inherently collective predicate. If it is truly the case that *every* is only optionally a distributivity marker, then what blocks it from appearing with the collective predicate? It seems that the example in (9) can be explained from the other side of the fact. The quantifier *every* as an optional distributivity marker can select the inherently collective predicate, but it is the collective predicate that opts out the quantifier *every*. Even though it is optional, *every* is also a distributive particle. Thus, the inherently collective predicate rules it out.

What about the grammatical number of *every*? In the discussion above, the grammatical number of *every* has been explicated based on the ∀∃-structure that it projects. Then, why isn't *every* grammatically treated as plural when it is not translated as ∀∃? The simple answer I can provide is that the syntactic number of *every* is somehow grammaticalized on the basis of the ∀∃-structure that it can induce. Thus, even in the circumstances where it does not project ∀∃, it is still understood as grammatically singular.

To complete the picture, there is one more question that needs to be discussed: how can the quantifier *each* that obligatorily induces the ∀∃-structure express the collective-like reading? Now, it is not surprising that *every* can be

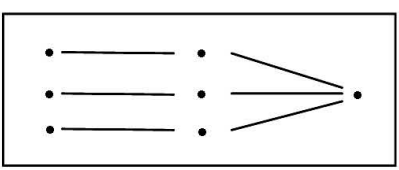
[5] Beghelli and Stowell (1996) have termed *all* a pseudo distributivity marker but, in my opinion, *every* is the pseudo distributive particle.

involved with a collective reading since I have claimed that it does not always evoke the ∀∃-structure. However, it seems puzzling how the sentence with *each* can have a collective-like sense if it is truly the case that *each* necessarily projects the ∀∃-structure, unlike *every*. As Zimmermann (2002) observes, the sentence in (37) can have a collective-like reading. That is, (37) is ambiguous: each boy could have kicked a different ball or the same ball could have been kicked by all the boys.

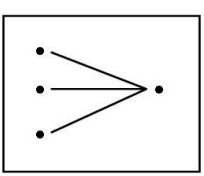
(37) Each of the boys kicked one ball.

In the discussion above, we have dealt with how *all* that is translated solely into ∀ can generate a distributive reading. This time, we need to explain the opposite side. How can *each* that is obligatorily translated into ∀∃ generate a collective interpretation? In order to answer this question, I argue that the collective-like reading that *each* generates is different from the true collective reading that quantifiers like *every* and *all* can produce. That is, as illustrated in (38), the collective reading that *each* is involved with is, strictly speaking, ∃∀∃ while the collective reading that can be expressed by quantifiers such as *every* and *all* is ∃∀.[6] As shown in the drawings, in the former, the distributive relation still holds whereas, in the latter, it is absent. That is, in case of *each*, the distributive relation is still alive but it turns out to be the case that each of the existentially quantified DstrShr that is connected to the SrtKy in a one-to-one fashion happens to be the same.

(38) a. The (so-called) Collective Reading of *Each* (∃∀∃)



b. The Ordinary Collective Reading (∃∀)



In fact, Landman (2000) elucidates the point with the example in (39). In addi-

[6] In fact, *every* can induce the ∃∀∃ interpretation as well as the ∃∀ reading principally. Yet, it seems that *every* prefers to project the latter, being more similar to *all*, as long as collectivity is concerned.

tion to the forward and inverse distributive readings illustrated in (28), Landman (2000) claims that (39) has more readings described in (40). In the readings, the distributive relations still hold but the DstrShr has wide scope. Thus, in (40a), each of the boys invited the "same" group of four girls while, in (40b), each of the girls was invited by the "same" group of three boys. These cases where the DstrShr has wide scope have often been equated with the collective reading. Yet, as Landman (2000) points out, the wide scope interpretation of the DstrShr is different from the simple collective reading since, in the former, but not in the latter, the distributive sense is in effect.

(39) Thee boys invited four girls.

(40) a. $\exists x \in {}^*BOY: |x| = 3 \wedge \exists y \in {}^*GIRL: |y| = 4$
$\wedge \forall a \in AT(x): \exists e \in INVITE: Ag(e) = a \wedge Th(e) = \uparrow(y)$
b. $\exists x \in {}^*BOY: |x| = 3 \wedge \exists y \in {}^*GIRL: |y| = 4$
$\wedge \forall b \in AT(y): \exists e \in INVITE: Ag(e) = \uparrow(x) \wedge Th(e) = b$

My system where a distributive particle such as *each* evokes the entire ∀∃-structure can account for the reading in which the DstrShr has wide scope compositionally.[7] The readings described in (40a) and (40b) can be generated when the pluralization operator has the variable *Z* as the first semantic argument and the DstrShr moves scope-wise and naturally has wide scope as shown in (41a) and (41b), respectively. The semantic derivations for the readings in (40) are almost the same as those described in (28) but a particular thing to note is that the DstrShr that has moved to the front of the sentence combines with the rest of the sentence via predicate modification and existential closure ends the semantic derivation. Other than that, just like the cases in (28), two occurrences of lambda abstraction allow the arguments of the distributive relation to be filled with a right value compositionally.

(41) a. Forward distributivity where the DstrShr has the wide scope
$[[\varnothing\text{-D}]] = \lambda Z.\forall z[z \in Z \rightarrow \exists y[P_i(y) \,\&\, R_j(y)(z)]]$
[[three boys]]
$= \forall z[z \in [[\text{three boys}]] \rightarrow \exists y[P_i(y) \,\&\, R_j(y)(z)]]$
<Function Application>
$\Rightarrow \lambda R_j.\forall z[z \in [[\text{three boys}]] \rightarrow \exists y[P_i(y) \,\&\, R_j(y)(z)]]$
<λ-abstraction>
[[three boys invited]]

[7] In my previous work, Y-K Joh (2009), the data have been discussed to point out an advantage that we can get by allowing the permutation of the first semantic argument inside the pluralization operator. In this paper, I illustrate them to show how the distributive quantifier *each* can yield the ∃∀∃-structure.

$= \forall z[z \in [[\text{three boys}]] \rightarrow \exists y[P_i(y) \;\&\; \exists e[\text{invited}\ (z, y, e)]]]$
<Function Application>
$\Rightarrow \lambda P_i.\ \forall z[z \in [[\text{three boys}]] \rightarrow \exists y[P_i(y) \;\&\; \exists e[\text{invited}\ (z, y, e)]]]$
<λ-abstraction>
$[[\text{four girls}]] = \lambda Y.4\ \text{girls}\ (Y)$
[[three boys invited four girls]]
$= \lambda Y.4\ \text{girls}\ (Y) \;\&\; \forall z[z \in [[\text{three boys}]]$
$\rightarrow \exists y[\uparrow Y(y) \;\&\; \exists e[\text{invited}\ (z, y, e)]]]$
<Predicate Modification>
$\Rightarrow \exists Y.4\ \text{girls}\ (Y) \;\&\; \forall z[z \in [[\text{three boys}]]$
$\rightarrow \exists y[\uparrow Y(y) \;\&\; \exists e[\text{invited}\ (z, y, e)]]]$
<Existential Closure>

b. Backward distributivity where the DstrShr has the wide scope
$[[\varnothing\text{-D}]] = \lambda Z.\forall z[z \in Z \rightarrow \exists y[P_i(y) \;\&\; R_j(y)(z)]]$
[[four girls]]
$= \forall z[z \in [[4\ \text{girls}]] \rightarrow \exists y[P_i(y) \;\&\; R_j(y)(z)]]$
<Function Application>
$\Rightarrow \lambda R_j.\forall z[z \in [[4\ \text{girls}]] \rightarrow \exists y[P_i(y) \;\&\; R_j(y)(z)]]$
<λ-abstraction>
[[invited four girls]]
$= \forall z[z \in [[4\ \text{girls}]] \rightarrow \exists y[P_i(y) \;\&\; \exists e[\text{invited}\ (y, z, e)]]]$
<Function Application>
$\Rightarrow \lambda P_i.\ \forall z[z \in [[4\ \text{girls}]] \rightarrow \exists y[P_i(y) \;\&\; \exists e[\text{invited}\ (y, z, e)]]]$
<λ-abstraction>
$[[\text{three boys}]] = \lambda Y.3\ \text{boys}\ (Y)$
[[three boys invited four girls]]
$= \lambda Y.3\ \text{boys}\ (Y) \;\&\; \forall z[z \in [[4\ \text{girls}]]$
$\rightarrow \exists y[\uparrow Y(y) \;\&\; \exists e[\text{invited}\ (y, z, e)]]]$
<Predication Modification>
$\Rightarrow \exists Y.3\ \text{boys}\ (Y) \;\&\; \forall z[z \in [[4\ \text{girls}]]$
$\rightarrow \exists y[\uparrow Y(y) \;\&\; \exists e[\text{invited}\ (y, z, e)]]]$
<Existential Closure>

Now, we can easily account for how the sentence in (37) can have the reading where 'the same ball was kicked by all the boys involved.' This reading has been referred to as a collective reading but, in fact, it is a construal where the DstrShr has the wide scope interpretation. To yield the reading, as illustrated in (42), first of all, the quantifier *each* is translated into a pluralization operator that has the ∀∃-structure and then it directly applies to the distributive antecedent *the boys*. Lambda-abstraction over *j* occurs and function application allows the value of the *R* to be filled. Next, another lambda abstraction takes place

and the formula generated as a result combines with the phrase *one ball* via predicate modification. When existential closure ends the derivation, we get the very reading that (37) can have: there is one (particular) ball and each of the boys kicked it.

(42) $[[\text{each}]] = \lambda Z.\forall z[z \in Z \rightarrow \exists y[P_i(y) \,\&\, R_j(y)(z)]]$
$[[\text{each (of) the boys}]]$
$= \forall z[z \in [[\text{the boys}]] \rightarrow \exists y[P_i(y) \,\&\, R_j(y)(z)]]$
<Function Application>
$\Rightarrow \lambda R_j.\forall z[z \in [[\text{the boys}]] \rightarrow \exists y[P_i(y) \,\&\, R_j(y)(z)]]$
<λ-abstraction>
$[[\text{each of the boys kicked}]]$
$= \forall z[z \in [[\text{the boys}]] \rightarrow \exists y[P_i(y) \,\&\, \exists e[\text{kicked}(z, y, e)]]]$
<Function Application>
$\Rightarrow \lambda P_i.\ \forall z[z \in [[\text{the boys}]] \rightarrow \exists y[P_i(y) \,\&\, \exists e[\text{kicked}(z, y, e)]]]$
<λ-abstraction>
$[[\text{one ball}]] = \lambda Y.1\ \text{ball}(Y)$
$[[\text{each of the boys kicked one ball}]]$
$= \lambda Y.1\ \text{ball}(Y) \,\&\, \forall z[z \in [[\text{the boys}]] \rightarrow \exists y[Y(y) \,\&\, \exists e[\text{kicked}(z, y, e)]]]$
<Predicate Modification>
$\Rightarrow \exists Y.1\ \text{ball}(Y) \,\&\, \forall z[z \in [[\text{the boys}]] \rightarrow \exists y[Y(y) \,\&\, \exists e[\text{kicked}(z, y, e)]]]$
<Existential Closure>

As a matter of fact, this is the kind of reading that approaches that treat distributivity with a scope mechanism couldn't deal with. For instance, Lakoff (1970) could not derive such a reading described in (43b) for the sentence in (43a). The sentence in (43) has the reading where each of the charities was given a $25 donation by the "same" group of five insurance associates. As described, the group-denoting DstrShr has wide scope with respect to the distributive antecedent *several charities*. Lakoff (1970) couldn't properly treat such a case since he solely relies on the scope mechanism to produce a distributive reading. Yet, unlike his system, my analysis that creates distributivity and scope with two different mechanisms permits an expression to have wide scope and, at the same time, be the DstrShr.

(43) a. Five insurance associates gave a $25 donation to several charities.
b. five insurance associates (group) > several charities (distributive) > a $25 donation

With respect to the wide scope reading of the DstrShr, one more intriguing observation has been made. Zimmermann (2002) claims that when *each* is used in the binominal position as in (44), the so-called collective reading – i.e.,

the wide scope interpretation of the DstrShr – that was present in (37) is blocked. That is, in contrast to (37), the sentence in (44) is unambiguous and only has the reading where 'each boy kicked a different ball.' Interestingly, this contrast is borne out in my analysis.

(44) The boys kicked one ball each.

The difference naturally comes from my analysis as follows. In the case of the determiner-quantifier *each*, the first semantic argument is the SrtKy and hence the DstrShr does not have to be the syntactic sister of the pluralization operator. As a result, the DstrShr is free to move to the front of the sentence and takes wide scope via predicate modification. Yet, for *each* used in the binominal position as described in (44), the first semantic argument of *each* is the DstrShr so that the DstrShr is required to be the syntactic sister of the pluralization operator evoked by *each*. It means that the DstrShr that forms a constituent with the binominal *each* cannot move since the pluralization operator directly applies to it via function application. Thus, the sentence in (44) is unambiguous with respect to the scope of *one ball*.

This theoretical move predicts that the floated-quantifier *each* in (45) allows for the semantic ambiguity found in (37), unlike (44), since, with *each* being attached to the main verb, the DstrShr is supposed to move to the front of the sentence freely. That is, the DstrShr is not required to be the syntactic sister of the pluralization operator when the operator is evoked by a floated-quantifier *each*. Remarkably, the sentence in (45) is judged to be ambiguous, as predicted.

(45) The boys each kicked one ball.

Lastly, before concluding this paper, I would like to point out some advantages of my account in comparison to the attempts that previous works have made. Throughout this paper, I have explicated various properties of the quantifiers *all, every,* and *each*. There were two previous works that have dealt with them. Working on the first question that I have addressed above, Beghelli and Stowell (1996) classify *every* and *each* as strong distributive quantifiers as opposed to the weak distributive quantifier *all*. Since they characterize strong distributive quantifiers as quantifiers that generate distributivity obligatorily, under their system, it is not explained how *every* produces a collective reading. However, this is not a problem in my account since I have claimed that, in the case of *every*, the existential quantifier that usually follows the universal quantifier can optionally be deleted.

On the other hand, to cope with the differences between *each* and *every*, Tunstall (1999) characterizes *each* as a quantifier requiring a completely distributive event structure while defining *every* as a quantifier requiring a partially distribu-

tive event structure. Yet, I would like to note that her approach is not entirely satisfactory, either, since, in her analysis, it is still unknown why and how *every* can be used in circumstances where distributivity is not implicated at all as we have seen in (13). Accounting for a fuller range of data involved with the quantifiers *all, every,* and *each*, I believe that my account presented in this paper has sufficed to make some progress, compared to the previous studies.

5. Conclusion

In this paper, I have claimed that translating the quantifiers *all, every,* and *each* uniformly into a universal quantifier is inadequate since a number of differences are observed among the quantifiers. Refuting the traditional approach, I have coped with two issues largely. One concerns the differences between *every* and *each*, on the one hand, and *all*, on the other. The other issue deals with the dissimilarities found between *every* and *each*.

First, I have captured the difference between *every* and *each*, on the one hand, and *all*, on the other, by claiming that the former logically corresponds to $\forall\exists$ while the latter is simply $\forall$. The semantics of *every* and *each* is stronger than the meaning of *all*. That is, I have insisted that a distributive relation is projected by a pluralization operator that has both the universal structure and the existential structure inside it and that anticipates the three arguments it is composed of to be filled with a right value compositionally. In terms of it, the distributive quantifiers *every* and *each* are directly translated into the $\forall\exists$-structure and naturally derive the distributive sense. However, in contrast to *every* and *each*, when the sentence with *all* has the distributive reading, the reading is evoked by a covert distributive particle, not by *all*. The logical dichotomy between *every/each* and *all* further accounts for why the quantifier phase headed by *every* or *each* is treated as singular grammatically while the quantifier phrase combined with *all* is construed as plural. The quantifiers *every* and *each* are grammatically treated as singular because, for them, the universally quantified distributive antecedent has to be construed in a one-to-one relation with the DstrShr that is existentially quantified as opposed to *all* that is simply translated into $\forall$.

Yet, unlike *each, every* is only optionally translated into $\forall\exists$. This leads us to conclude that only *each* is the genuine distributive particle while *every* can be characterized as a pseudo distributivity marker. This contrast helps us to understand why only *each* has the three uses which directly reflect the very characteristic of distributivity, i.e., distributivity is an object that consists of three arguments. Furthermore, the difference also explicates why *every*, but not *each*, can widely be used in a non-distributive way. Describing the difference between *every* and *each* based on the optionality of the existential structure, I have

also argued that the collectivity-like property involving *each* is different from the collective reading that *every* and *all* can be associated with and have shown that the analysis for the collectivity-like property of *each* is further supported by the semantic difference observed between *each* used in the determiner position as well as in the floated position and the binominal *each*.

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Received: August 29, 2010
Revised version received: November 26, 2010
Accepted: December 3, 2010