Whole as a Semantic Pluralizer

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Eun-Joo Kwak. 2008. *Whole* as a Semantic Pluralizer. *Language and Information 12.1*, 67–83. The semantics of *whole* involves distributivity, which may not be accounted for by the distributive operator for plurals or quantifiers. I review the pragmatic approach to *whole* by Moltmann (2005) and propose that the semantics of *whole* can be explained by the member specification function, which maps a group to its members. Although NPs with *whole* are morphologically singular, they become semantically plural with the application of the function. The distributive operator for plurals is introduced on a sentence with *whole*, which explains the distributivity of *whole*. (**Sejong University**)

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1. Introduction

The ordinary definite NP is denoted by the most salient individual(s) in the context. For example, *the floor* in (1a) is construed as the most salient floor in the given context.

(1) a. The floor is painted.

When it is predicated by the predicate *is painted*, the floor should be included in the set of being painted. As the predicate meaning applies to the individual denoted by *the floor*, there is no further entailment ragarding each part of the floor. Hence, (1a) may be used in a situation in which some part of the floor remains unpainted and as long as the unpainted part is small enough to be ignored. When ordinary definite NPs are accompanied by the quantifier *all* or the adjective *whole*, this unpainted part of the floor is not spared.

(1) b. All the floor is painted.

c. The whole floor is painted.

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Both (1b) and (1c) convey an entailment of completeness such that every part of the floor is painted. No matter how this reading is derived, it is clear that *the whole N* is similar to *all the N* rather than *the N*.

When *the N* and *all the N* are pluralized as in (2a) and (2b), their interpretations are similar.

(2) a. The students passed the entrance exam.

b. All the students passed the entrance exam.

c. The whole class passed the entrance exam.

No students who failed the entrance exam are allowed in (2a) and (2b). Interestingly, when *the whole* occurs with a collection term like *class*, which has students as its members in its internal structure, the sentence conveys completion as in (2a) and (2b). *The floor* and *the whole floor* have distinct readings even though they have the same noun *floor*. However, the plural definite *the students* and the singular collection term *the whole class* trigger similar readings with the entailment of completeness for the members in the denotation. Moreover, *the whole N* is similar to *all the N* under any circumstances.

Given the contrasts shown in (1) and (2), several questions must be answered. First, why does a definite NP with *whole* have a completeness entailment like *all the N*? If the completeness entailment is due to the distributivity of a predicate on the NP denotation, is *whole* a quantifier? If not, how does *the whole N* get distributivity? Second, why does *the whole* with a collection term have a similar reading to plural NPs in the form of *the N* and *all the N*? To derive similar readings, how are the denotations of the plural NPs related to that of the collection term?

To resolve these issues, I accept Moltmann (2005)'s argument that *whole* is not a quantifier. To derive a completeness entailment for *whole*, I argue that *whole* makes the NP it modifies semantically plural. The plurality of *the whole N* involves a distributive operator for the predicate and thus triggers the entailment of completeness because of distributivity. In this study, I also deal with the semantics of *whole* in the framework of discrete and dense structures and derive the interrelated readings of a collection term and its plural counterpart.

2. Two Sources of Distributivity

The introduction of plurality in semantics involves distributivity. Depending on the lexical property of a predicate, a singular individual may satisfy the action or state of the predicate. For instance, smiling applies only to a singular individual such as the student, and thus (3a) is construed to mean that the individual denoted by *the student* is part of the smiling set in the first order semantics.

(3) a. The student smiled.

b. The students smiled.

Given the property of *smiled*, when *the student* is pluralized as in (3b), it cannot be taken as the argument of *smiled*. Since smiling cannot apply to a plural individual, the smiling property needs to be distributed for each of the students. Hence, an implicit distributivity operator (D operator) is assumed for the predicate as in (4a), and the resulting interpretation is (4b).

(4) a. ^{D}smiled'(the_students')

b. $\forall$x[the_students'(x) $\rightarrow$ smiled'(x)]

The D operator has the effect of universal quantification such that for every x that is part of *the students*, x smiled. The universal force of the D operator ensures the application of the predicate to each of the students.

Another way to make a distributive relation hold between a predicate and its argument is the occurrence of a quantifier. Since the insertion of the D operator is limited to a sentence with a plural, (5a) does not carry the operator.

(5) a. The floor is painted.

b. All the floor is painted.

Without the D operator, distributivity is not part of the interpretation of (5a), which results in no entailment for each part of the floor. Hence, (5a) may be used in a situation in which some part of the floor remains unpainted. When (5a) is accompanied by the quantifier *all* as in (5b), the partially unpainted floor is no longer acceptable. The quantifier *all* incorporates universal quantification in its meaning, which makes the predicate apply to every part of the floor.[1]

Given the two sources of distributivity, plural arguments and quantifiers, let us turn to the interpretation of *the whole N*. First, *whole* does not occur with a plural. *Whole* may occur with the singular *floor* but not with the plural *students* as illustrated in (6a) and (6b).

(6) a. *The whole students smiled.

b. The whole floor is painted.

Then, it is clear that *the whole N* does not carry the D operator for plurals. Despite the lack of the operator, (6b) involves some kind of distributivity because its interpretation is similar to that of (5b). The easiest solution for the similarity between (5b) and (6b) is to assume that *whole* itself is a quantifier with universal force.

Moltmann (1997), Moltmann (2005) and Morzycki (2001) argue against the simple solution for the distributive effect of *the whole N*. First, when a sentence includes more than one quantifier, it involves scope interaction between the quantifiers. For example, when the quantifiers *two students* and *each of the problems* occur in one sentence as in (7), there are two possible readings.

[1] We will not concern ourselves with the entities the predicate in (5b) applies to at this point. Obviously, being painted cannot apply to the floor as a whole, since it would lead to a reading that for every x that is a floor, it is painted. This amounts to the interpretation of the sentence *all the floors are painted.* The universal force of *all* in (5b) is to distribute the predicate denotation over every part of the floor. This is because distribution over parts needs a structure which has not only discrete individuals but also dense materials. Hence, a more detailed discussion is reserved for section 4.

(7) Two students solved each of the problems.

One is that each of the two students solved all the problems, and the other is that each of the problems was solved by one of the two students. *Two students* takes wide scope over *each of the problems* in the first reading, while it takes narrow scope in the second interpretation. This scope interaction is not allowed for *whole*.

(8) The whole family owns a car.

(8) has only one reading in which there is one car for the entire family. This is the reading that the quantifier phrase *a car* takes wide scope over *the whole family*. If *the whole family* is also a quantifier, it should induce another reading in which it takes wide scope over *a car*. However, this is not allowed for (8). Therefore, Moltmann and Morzycki argue that *whole* is not a quantifier.

Second, Moltmann (2005) argues that *whole* fails to bind variables.

(9) a. The family members each drove their own car.

b. The whole family drove its own car.

Each in (9a) binds the variable *their*, and triggers a universal reading such that for every x that x is part of the family members, x drove x's own car. In other words, it is asserted that each of the family members drove his or her own car. This variable-binding interpretation does not work for (9b), which implies that there was only one car for the entire family. This serves as further evidence for the non-quantificational nature of *whole*.

Finally, *the whole N* can act as the antecedent of unbound anaphoric pronouns unlike quantifiers. (cf. Morzycki 2001)

(10) a. ??Every student left. He never came back.

b. The whole class left. It never came back.

The quantifier *every student* in (10a) cannot bind a variable across the sentential boundary. The unbound variable *he* in the second sentence makes (10a) awkward. However, (10b), having the same structure as that of (10a), sounds natural, which in turn proves that *it* is bound by *the whole class* across the sentential boundary. Hence, *the whole class* should be treated as a non-quantifier.

Given the detailed and convincing arguments of the non-quantificational nature of *whole*, it is puzzling why *the whole N* has a reading similar to *all the N* as if it involved distributivity. Considering the fact that *whole* cannot occur with a plural noun, the D operator cannot be an option here. Therefore, the distributive effect of *whole* requires special treatment in semantics.

3. A Pragmatic Approach to the Semantics of *Whole*

One of the most thorough arguments on the semantics of *whole* is provided by Moltmann (2005). To derive distributivity for *whole*, Moltmann first argues for the non-quantificational property of *whole* as discussed in the previous section. And then, he considers the semantics of *whole* in the framework of his own 'part-whole' structure. Since Link (1983) proposes a 'complete join semi-lattice' structure for the semantics of plural and mass terms, most semanticists put forward arguments on plurals based on a lattice structure.[2] Instead of accepting an extensional mereological structure by Link, Moltmann has built his own structure for individuals with the notion of parts and wholes, following ancient and medieval philosophers including Plato and Aristotle.[3]

According to Moltmann, how to individuate entities is determined by integrity in a given context. When some expression conveys integrity, it refers to an integrated whole, which is similar to an atomic individual in classical semantics. For example, *the class* can refer to an integrated whole of the class, which is not further divided. On the other hand, when an expression does not carry integrity, it refers to parts of its ordinary reference. For instance, *the class* may be mapped to parts of the class, e.g., the students of the class, without integrity. Note that both integrated wholes and parts are context-dependent notions. The integrity condition for integrated wholes is checked in a given context, and how to divide into parts is also determined by the given context. The context-dependency of the structure is highly contrasted with the extensional approach of a lattice structure.

Given the contextual notions of parts and integrated wholes, Moltmann argues that the semantics of *whole* is to map collections to the sums of their members

(11) The whole class passed the entrance exam.

Occurring with *the class* in (11), *whole* maps the collection of the class to the sum of its members, e.g., the students. Moltmann admits that this mapping does not enforce a distributive interpretation. Suppose that there is no distributivity for *the whole N*. Then, *the N* and *the whole N* are semantically identical with the exception of the integrity of their references. This means that *whole* is vacuous. To avoid redundant use of *whole*, a pragmatic condition is triggered, i.e, to distribute the predicate over the members of *the whole N*. With this condition, *passed the entrance exam* in (11) applies distributively to all the proper parts of *the class*, instead of to the collection.

To argue for the pragmatic nature of the distributivity of *whole*, Moltmann points out that some sentences with *whole* do not undergo distributivity

(12) a. The whole group of soldiers surrounded the palace.

b. The whole police force was distributed over the region.

In each of the sentences in (12), the predicates do not have distributive interpretations for the parts of the collections. Rather, each member in the group of soldiers is asserted to be involved in the surrounding of the palace in (12a), and a similar

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[2] Detailed arguments on a lattice structure are given in section 4.

[3] Whether the context-dependent notions of parts and wholes have an advantage over the generally accepted lattice structure remains controversial. As this is beyond the scope of the current study, I will not discuss differences between the two structures in details. Refer to Pianesi (2002) for further research on this topic.

collective reading holds for *the whole police force* in (12b). Some sentences are ambiguous between distributive and collective readings.

(13) The whole collection is expensive.

Moltmann argues that (13) may assert the expensiveness of individual pieces in the collection or that of the collection as a whole. In the former reading, the predicate *is expensive* needs to be distributed over the members of the collection. However, the latter collective reading does not involve distributivity. Based on the optional nature of the distributivity of *whole*, Moltmann claims that *whole* has a pragmatic condition for distributivity.

Moltmann provides a convincing argument for the non-quantificational property of *whole*. However, his analysis based on pragmatics leaves some room for revision. First of all, Moltmann's argument that pragmatic distributivity needs to be introduced to block the vacuous application of *whole* cannot be defended independently. If we can assign a specific interpretation to *whole*, this argument loses its theoretical ground. Second, if the distributive reading of *whole* is really pragmatic, the same sentence may have a distributive or non-distributive reading depending on the context. However, the distributive or collective readings of *whole* seem to be determined by the properties of predicates. Occurring with a distributive predicate such as *pass the entrance exam*, a sentence with *whole* has a distributive reading only. On the other hand, the occurrence of a collective predicate like *surround* triggers a collective reading only. The change of context cannot induce the reversed interpretations for sentences with these predicates. This means that the optional nature of the distributivity of *whole* can be attributed to the properties of predicates rather than to the context. If the seemingly collective reading of *whole* involves distributivity, the pragmatic argument for *whole* is further weakened.

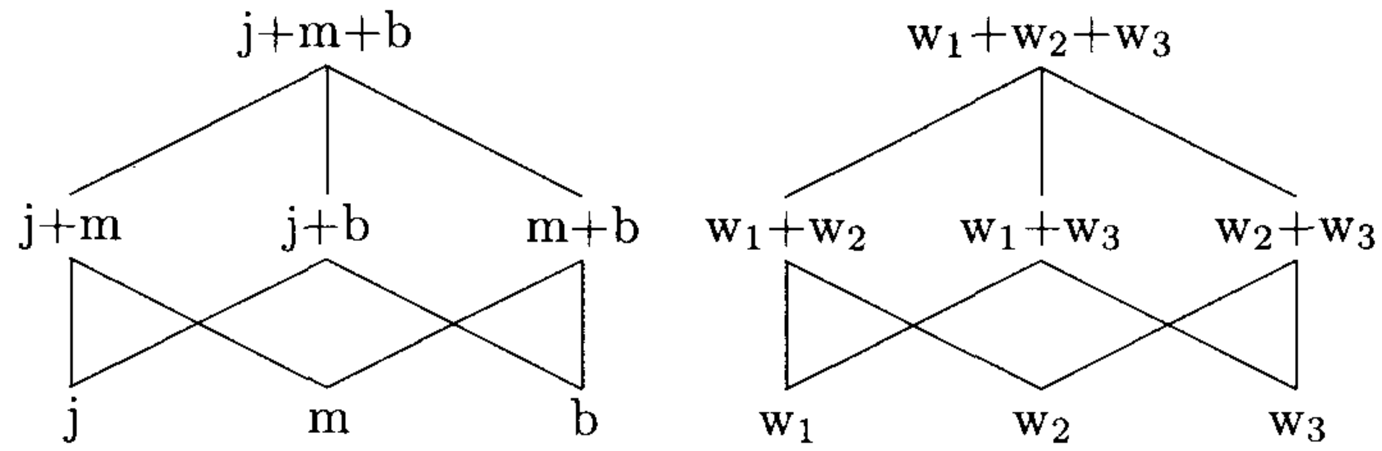
4. The Distributivity of *All*

4.1 Lattice Structures and Mapping Functions

Before moving to the topic of distributivity, let us consider how an interpretation domain is structured. Since distributive readings may occur with both count and mass terms, the domain we need here should include both individuals and materials. At first glance, the denotations of mass terms look different from those of count terms. The intuition behind this distinction is based on the non-countability of materials. However, mass terms behave like plural terms in many ways. One of the most convincing arguments for this similarity is provided by Quine (1960), who captured the cumulative reference property of plural and mass terms. If the property of being horses applies to the animals of one camp and to those of another camp, the property also applies to the animals in the two camps. In other words, the property of being horses applies to the cumulated reference of the animals in the two camps. As with plural terms, mass terms also show the cumulative reference property. If the property of being water applies to material m_1 and also to material m_2, the property applies to the cumulated reference of the two materials.

Based on the close similarity between plural and mass terms, Link (1983) introduced the 'complete join semi-lattice' for a plural domain. Unlike a set, which is based on inclusion and intersection, a join semi-lattice structure is defined by a join operation '+' and an individual part-of relation '$\leq_i$.' In this new structure, the plural term *John and Mary* does not refer to the intersection of John's reference 'j' and Mary's reference 'm,' which will end up with the empty set. Instead, it refers to a 'sum' individual 'j+m,' a larger entity that is derived from the joining operation of j and m. Furthermore, an individual part-of relation exists between this newly generated sum individual j+m and the atomic individuals of j and m: j $\leq_i$ j+m and m $\leq_i$ j+m. Here is a join semi-lattice for three individuals j, m, and b.

(14) a. Lattice for Individuals b. Lattice for Materials



In the first tier in (14a), the atomic individuals j, m, and b are located. Two of these individuals may be joined together to make a sum individual like j+m, j+b, and m+b. In the third tier, all three individuals are joined to make the maximal sum j+m+b. Along with the lattice structure for plurals, Link also postulated another lattice structure for materials, which is defined by the join operation and a material part-of relation '$\leq_m$.' A cup of water w_1 and another cup of water w_2 may be poured into a basket to make a join material w_1+w_2. As with plurals, a material part-of relation holds between the sum material w_1+w_2 and their subparts w_1 and w_2: $w_1 \leq_m w_1+w_2$ and $w_2 \leq_m w_1+w_2$. A join semi-lattice for three materials w_1, w_2, and w_3 is represented in (14b), which has the same structure as the lattice for individuals.

The lattice structure for plurals is considered 'discrete' because it is generated from discrete entities of atoms. Discrete entities are identified by explicit boundaries in space that are separated from other entities. They cannot be divided into smaller entities. On the other hand, the lattice structure for materials is dense' in that materials do not have a discrete identity in space, and they may be divided into smaller materials without inducing any shift in their properties.

Although ordinary individuals and materials are sorted into two separate lattice structures, a homomorphism is assumed between these structures. Practically any count noun can be used as a mass term. (cf. Pelletier, 1979; Link, 1983; and Bach, 1986; among others)

(15) a. There was dog splattered all over the road.

b. Much missionary was eaten at the festival.

Basically, *dog* and *missionary* are count terms, and NPs with these expressions refer to discrete entities of individuals. However, *dog* in (15a) denotes the material of dog rather than an individual dog. Likewise, *missionary* in (15b) refers to the material body of missionary. To derive these material readings, *dog* and *missionary* should be shifted to mass terms. This meaning shift from discrete entities to materials is called 'universal grinding.' Here is the definition of the grinding function g as proposed by Landman (1991).

(16) The grinding function is g: C → M such that for every c∈C: g(c) = ∪{x∈M: xKc}, where K is the relation 'material part of.'

Mapping from the count domain C to the mass domain M, g is a function mapping from discrete individuals to the dense materials of which they are composed. This function is a homomorphism, preserving crucial ordering relations, so that if a is a part of the sum a+b, then the stuff making up a is a part of the stuff making up a+b.

Meaning shifts in the opposite direction are also available.

(17) At the café, they ordered three beers, two teas, and ice creams all round.

Beer, *tea*, and*ice cream* are mass terms and thus are not pluralized because of the density of materials. However, when they are pluralized as in (17), they may carry discrete readings such as bottles of beer and cups of tea. This shift from materials to discrete entities made from the materials is called 'universal packaging.' Landman defines the packaging function p based on the fact that if you grind down the result of packaging, you get the original material.

(18) The packaging operation is p: M → AT such that for every m∈M: g(p(m)) = m, where AT is the set of atoms out of which the count domain is built.

In each of the shifts, universal grinding and universal packaging, a change of meaning occurs without any overt marking in the form of a word. The cross-categorical interpretations for count and mass terms provide a basis for the interconnection of the lattice structure of individuals and that of materials. Hence, the mapping functions of homomorphisms, g and p, need to be introduced to connect these two structures.

4.2 Distributivity through the Grinding Function

In the interpretation domain with the two lattice structures, count terms usually denote individuals, while mass terms refer to materials. In some cases, the opposite may be true and thus two mapping functions, g and p, are needed. One of the representative cases that the grinding function g is to apply to derive a distributive reading.

Depending on coordinating patterns, distributivity may occur in sentences with coordination. Coordination is considered cross-categorially 'intersective' or 'boolean.' (cf. Keenan and Faltz, 1985; Partee and Rooth, 1983) For example, the conjunction of *big and heavy* is construed as the intersection of the set of big entities and the set of heavy entities. Below, (19a) is paraphrased as in (19b).

(19) a. The flag is big and heavy.

b. The flag is big and the flag is heavy.

Interestingly, the simple interpretation of the boolean conjunction is not triggered in some coordinating expressions. Although a boolean interpretation is absurd in reality, a coordinated relation may be possible. (cf. Krifka, 1990; Lasersohn, 1995; Winter, 1996, 1998; among others) For instance, when the predicate of *big and heavy* in (19a) is changed to *green and white* in (20a), intersection of the predicate denotations ends up with an empty set. This is supported by the awkwardness of the intersective paraphrase in (20b).[4]

(20) a. The flag is green and white.

b. *The flag is green and the flag is white.

In spite of the awkwardness of the boolean interpretation for *green and white*, (20a) sounds natural. This means that coordination has an additional reading other than the boolean construal. To derive the additional coordinating reading, non-boolean conjunction is introduced in (21).

(21) A conjunction of P_1 and P_2 holds of an entity x iff x can be subdivided into x_1 and x_2 such that P_1 holds of x_1 and P_2 holds of x_2.

Building on Link (1983), Link (1984), Krifka (1990) proposes that coordination is ambiguous between a boolean and non-boolean reading. In the non-boolean reading of predicate coordination, a conjunct applies only to part of the argument denotation and the other conjunct applies to the remaining part. The non-boolean reading in (20a) is paraphrased in (22).

(22) Part of the flag is green and the rest of it is white.

The conjunct *green* applies only to part of the flag, and *white* applies to the rest of the flag.

The boolean and the non-boolean readings of coordination are available because of the two lattice structures and the mapping relations between them. In a boolean reading, the conjoined predicate *big and heavy* in (19a) applies to the denotation of *the flag* so that the same atomic individual of the flag is taken as an argument of *big* and as that of *heavy*. However, in a non-boolean reading, *the flag* in (20a) cannot denote a discrete individual of the flag because a discrete individual is not divided further. The conjunct *green* in (20a) should hold of only part of the flag rather than the whole. The same partial reading should also be true for *white*. To induce this partial reading for the conjuncts, the denotation of *the flag* should be divided into two parts. Hence, the grinding function g needs to apply to *the flag* to derive its material counterpart.

Just as the non-boolean conjunction involves the application of g, the distributivity of *all* may also require g. When *all* has a plural as its argument, the interpretation is as straightforward as the universal quantification over the denotation of

[4] As discussed above, conjoined predicates are ambiguous between boolean and non-boolean readings. For more detailed arguments on this, see Winter (2001).

its plural argument. For example, occurring with *the flags*, *all* in (23a) distributes the predicate to every individual part in the sum of the flags. This amounts to assert that for every x that x is part of the flags, x is painted as in (23b).

(23) a. All the flags are painted.

b. $\forall x[x \leq_i \text{the\_flags'} \rightarrow \text{painted'}(x)]$

However, when *all* takes a singular argument as in (24a), the ordinary quantificational reading cannot be derived. Denoting an atom of flag, *the flag* cannot be distributive. Hence, a meaning shift occurs here to map the flag to its material counterpart with g. This shift triggers a universal quantificational reading of *all* as in (24b).

(24) a. All the flag is painted.

b. $\forall x[x \leq_m g(\text{the\_flag'}) \rightarrow \text{painted'}(x)]$

(24b) says that for every x that x is part of the material of the flag, x is painted. In other words, it asserts that every part of the flag is painted. With the application of g, *all* may have the same quantificational reading regardless of the plurality of its argument.

5. The Semantics of *Whole*

5.1 A Lattice Structure with Groups

Link (1983) proposes a lattice structure for individuals and materials, which is generated from atoms and sums, to deal with the semantics of plural and mass terms. In a later paper, Link (1984) argues that a lattice structure with atoms and sums is not rich enough to cope with diverse plural interpretations. One of the motivations that Link argues for the expansion of a lattice structure is the complex property of collection terms.

Unlike a singular NP or a plural one, a collection term like *a committee* has an ambivalent property. Although represented as a singular, a collection term is internally plural. Barker (1992) argues that a collection term may not be predicated by a singular NP.

(25) a. the group of armchairs/*armchair

b. one committee of women/*woman

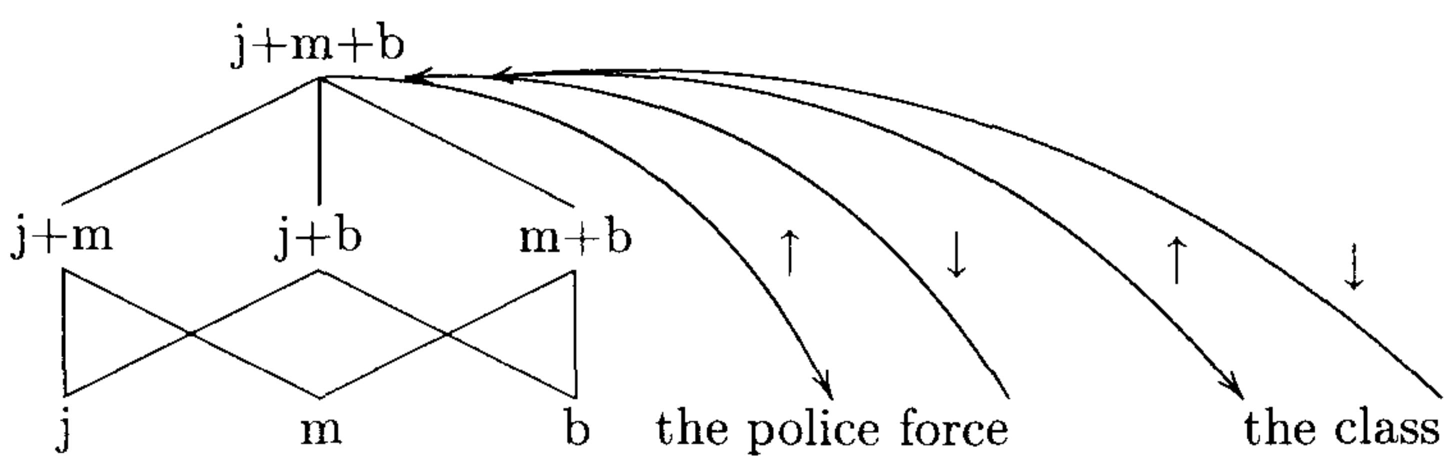
c. an army of children/*child

The group may take the plural member *armchairs* but not a singular one *armchair*. Likewise, *a committee* or *an army* may be predicated by the plural *women* or *children* but not a singular. This shows that in spite of its singular form, a collection term is semantically plural. Unlike an ordinary plural, a collection term may be pluralized as in *committees*. Collection terms are plural because they may have plural members, but they may be considered as singular as collection terms themselves are pluralized.

To deal with the dual nature of collection terms, the lattice structure for individuals needs to be expanded. Link (1984) and Landman (1989) assume two different categories of atoms, namely 'pure' and 'impure' atoms. Ordinary singular NPs refer to pure atoms, which do not have internal structures. However, collection terms refer to impure atoms, which are atomic but have an internal structure consisting of plural members. To implement a membership for a collection term, Link (1984) introduces a group formation function ↑, which maps a sum to a group, and Landman (1989) expands on the structure with a member specification function ↓, mapping a group to a sum of its members.

Let us assume that a police force consists of three officers j, m, and b and that the same group of people also take a class. In this situation, three individuals j, m, and b, and the groups of the police force and the class are assumed to be atoms in the domain represented in (26).

(26)



The sum j+m+b is mapped to the group the police force or the class with ↑.[5] Likwise, the groups of the police force and the class are mapped to their members j+m+b with ↓. In this new structure, a collection term like *the police force* denotes an atom like an ordinary NP such as *John*. However, it has a plural internal structure with its members, which is specified by ↓. The dual nature of a collection term is successfully represented in this structure.

5.2 *Whole as a Semantic Pluralizer*

Although pure atoms and groups are considered atomic in the new lattice structure, they are distinct entities. Thus, depending on the properties of predicates, only pure atoms are taken as arguments, or only groups are allowed in the argument positions. For example, *pass the entrance exam* is a distributive predicate that may predicate an individual but not a group. The distributive property is supported by the contrast between (27a) and (27b).

(27) a. The students passed the entrance exam.

b. ??The class passed the entrance exam.

[5] A sum of individuals j+m+b is mapped to two groups *the police force* and *the class* in (26), which is against the notion of function. Landman (1989) argues that the problem of mapping one to many is due to the intensional property of group. The same sum of individuals may act as different groups depending on a given situation. If we reinterprete the extensional structure of (26) in the intensional setting, this mapping problem does not occur.

Passing the entrance exam may be true for individual students but not for the class, a collection term that takes the students as its members. If (27b) is acceptable, passing the entrance exam is understood as a group property rather than a property for the members of the class. Similarly, when a group occurs with a collective predicate, it does not have an entailment for its members.

(28) a. The editorial board accepted the paper.

b. Mark, Alice, and Tim accepted the paper.

When the editorial board has the property of accepting the paper with the assertion of (28a), this property is not inherited to all of its members. Suppose that the editorial board consists of three members Mark, Alice, and Tim and that the paper was accepted with the agreement of only Mark and Alice. In this non-unanimous situation, (28a) is acceptable, but not (28b). Hence, Landman (1989) argues that groups have properties of their own that are independent of those of their members.

In spite of the sharp distinction between individuals and groups, a collection term may occur with a distributive predicate when occurring with *whole.* In contrast with the awkwardness in (27b), *the class* accompanied by *whole* may occur with a distributive predicate as in (28).

(29) The whole class passed the entrance exam.

The property of passing the entrance exam is asserted for each of the students in the class. Then, what *whole* contributes to the sentence is to shift the denotation of the collection term to the sum of its members so that the distributive predicate is distributed over the members. Hence, (29) has a similar interpretation to (27a), in which *the students*, the members of the class, is in the argument position.

Given the meaning shift produced by *whole*, I propose that *whole* be construed as the member specification function $\downarrow$, i.e., taking a group as an argument and mapping it to a sum of its members. Note that *whole* occurs with only a singular term. Since a group is also represented as singular, this fits with that fact that $\downarrow$ takes a group as an argument. Additionally, the occurrence of *whole* has the effect of distributing a predicate over the members of a group. This is also consistent with the mapping of $\downarrow$. Suppose that the class consists of three individuals, John, Mary, and Bill. Then, *the whole class* is interpreted as in (30).

(30) $[[\text{the whole class}]] = \downarrow(\text{the\_class'}) = \text{j+m+b}$

By taking a collection term *the class* as an argument, *whole* maps it to a sum of its members, j+m+b. The members of the class j+m+b are the students in the class. Hence, *the whole class* has an interpretation similar to that of *the students.*

Although a collection term denotes a singular group, its members are plural. This means that a collection term with *whole* denotes a plural entity which is mapped from an atomic group. As discussed in section 2, the occurrence of a plural term triggers the application of the D operator on the predicate. With the introduction of the D operator, (29) is interpreted in (31).

(31) [[the whole class passed the exam]]

$= {}^{D}$passed_the_entrance_exam'($\downarrow$(the_class'))

$= \forall$x[x $\leq_i$ $\downarrow$(the_class') $\rightarrow$ passed_the_entrance_exam'(x)]

Since the D operator has the effect of universal quantification, (29) is interpreted that for every x that x is individual-part of the members of the class, x passed the entrance exam. Although distributivity is derived from different sources, *the whole class* and *all the students* have a similar interpretation. This is the universal quantification for individuals.

5.3 The Plurality of *Whole in Discrete and Dense Structures*

To capture the distributive reading of a collection term with *whole*, the semantics of *whole* is proposed as $\downarrow$. This fits nicely with collection terms, but it is problematic when *whole* occurs with an ordinary singular term.

(32) The whole floor is painted.

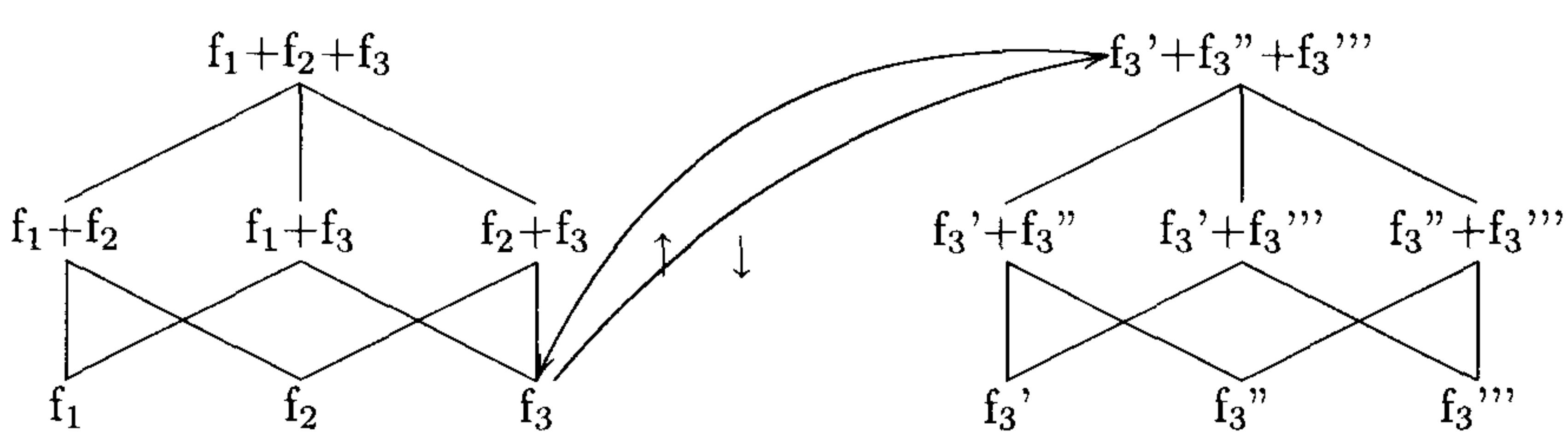
As the argument position of *whole* is limited to singular, it is taken by not only a collection term like *the class* but also an ordinary singular such as *the floor* as in (32). According to the proposed semantics of *whole*, *the whole floor* is interpreted as in (33).

(33) [[the whole floor]] = $\downarrow$(the_floor')

Unlike a collection term like *the class*, which has a sum of members, *the floor*, denoting a pure atom, does not have members in the discrete structure. This means that the function $\downarrow$(the_floor') does not have any value, which in turn should trigger awkwardness in (32). Obviously, this is not the case.

Link (1984) and Landman (1989) consider the functions $\uparrow$ and $\downarrow$ in the discrete structure, consisting of individuals only. Their framework is too restrictive to embrace grinding and packaging readings, which are based on the interconnection between the discrete and dense structures. If we expand the definitions for $\uparrow$ and $\downarrow$ to the discrete and dense structures, they will produce the structures found in (34).

(34)



Suppose that there are three floors f_1, f_2, and f_3, and that f_3 is divided into three parts f_3', f_3", and f_3'''. In the discrete structure, the three individuals f_1, f_2, and f_3 make a lattice, defined by the join operation. Also, the three parts f_3', f_3", and f_3''' make another lattice in the dense structure. When the three parts of the floor

f_3 are packaged, it amounts to an individual floor f_3. If we assume that ↑ and ↓ may apply in the extended domain of the discrete and dense structures, the packaging p(f_3'+f_3"+f_3''') is the group formation ↑(f_3'+f_3"+f_3''') in the structure, which returns the individual f_3. Similarly, when the individual floor f_3 is grounded into three parts, it amounts to the member specification. In other words, g(f_3) equals to ↓(f_3), which in turn maps to f_3'+f_3"+f_3'''.

Given the extended definitions of ↑ and ↓, (32) is assigned an interpretation as in (35).

(35) a. [[the whole floor]] = ↓(the_floor') = f_3'+f_3"+f_3'''

b. [[the whole floor is painted]] = ^{D}painted'(↓(the_floor'))
= ∀x[x $\leq_m$ ↓(the_floor') → painted'(x)]

As when it occurs with a collection term, *whole* is defined as ↓. Although '(the_floor') does not have any value in the discrete structure, it is mapped to parts of the floor in the dense structure. Hence, '(the_floor') denotes a sum of material parts f_3'+f_3"+f_3'''. Note that discrete individuals and dense materials are treated identically in the lattice structure. A sum of materials is understood as plural like that of individuals. The plurality of ↓(the_floor') motivates the introduction of the D operator on the predicate, and thus (32) has the interpretation in (35b): for every x that x is material-part of the members of the floor, x is painted. With the extended concepts of ↑ and ↓, *whole* is uniformly definied as ↓, regardless of its argument category.

5.4 A Collective Reading with *Whole*

By defining *whole* with the member specification function, a distributive reading with *whole* is successfully derived in the extended domain of discrete and dense structures. As discussed in section 3, a sentence with *whole* may trigger a collective reading.

(36) a. The whole group of soldiers surrounded the palace.

b. The whole police force was distributed over the region.

When *whole* occurs with a collective predicate like *surround the palace*, *the whole N* does not lead to a distributive reading. (36a) does not have an absurd reading that each of the soldiers surrounded the palace. A more appropriate reading is a collective one such that the group of soldiers as a whole surrounded the palace. Similarly, an individual police officer cannot have the property of being distributed over the region in (36b). Only the police force as a whole may have the collective property. The member specification function of *whole* does not seem to work in these collective readings.

Before moving further to the semantics of *whole*, let us consider how the collective reading of a predicate is derived. Link (1983) and Landman (1989) argue that a plural involves distributivity to assign an entailment for each individual in the sum. When a plural occurs with a distributive predicate like *pass the entrance exam*, it has a distributive reading over each atomic individual of the sum.

(37) a. The students passed the entrance exam.

b. The students carried the piano upstairs.

For instance, every atomic individual in the denotation of *the students* is asserted to have passed the entrance exam in (37a) because of the D operator. When the predicate is changed to a collective one as in (37b), the same distributivity cannot hold for individuals. Carrying the piano is understood as a collective activity of the students. To assign a consistent property to a plural, Landman argues that an entailment for atomic individuals in a collective reading is 'involvement' in a collective activity. In other words, what is distributed to every student in (37b) is his or her involvement in carrying the piano.

Landman's involvement property in a collective activity is further elaborated by Brisson (2003) in the framework of event semantics. Brisson proposes a bleached-out activity predicate called 'DO', which is a subcomponent of the meaning of verbs. (see Dowty, 1979; Pustejovsky, 1991) Depending on the predicates, the precise meaning of DO may be explicitly represented by the meaning of the predicate. For example, a predicate like *sweep the floor* takes the act of moving a broom back and forth across the floor as part of its DO. On the other hand, a predicate like *build a raft* may include a variety of acts for its DO such as hammering or sawing wood. What DO consists of for each predicate is considered as part of the lexical meaning of the predicate.

As for the insertion of the D operator, Brisson argues that two positions are available: a VP node and a V node. When the D operator is inserted on a VP node, it has an ordinary distributive reading such that the predicate denotation is distributed over the denotation of the subject. When the D operator is inserted on a V node, the DO of the predicate is distributed rather than the predicate itself. This corresponds to a collective reading.

Given the internal distributivity of a collective predicate, the logical form of (36a) is represented as in (38).[6]

(38) [[the whole group of soldiers surrounded the palace]]

= ^{D}DO surrounded the palace(↓(the_group_of_soldiers'))

As with a distributive predicate, *whole* is defined as ↓. It introduces the D operator, occurring with a collective predicate. However, the D operator is inserted on DO in the V node rather than on the collective predicate itself. Then, what is asserted for each member in the group of soldiers in (38) is his or her participation in the surrounding activity. With the notion of Brisson's DO, the semantics of *whole* remains ↓ with distributive and collective predicates. Different entailments are attributed to the semantics of distributive and collective predicates, which are independently motivated.

[6] Brisson's (2003) analysis is based on neo-Davisonian semantics, which states the relation between an event and its thematic relations with nominal arguments. An overview of the event semantics is needed to provide a formal interpretation of (38). Though this issue is important, it is outside of the objectives of this study.

6. Conclusion

The occurrence of *whole* has the effect of distributivity in a sentence. However, deriving the distributive reading for *whole* is problematic. First, *whole* occurs only with a singular term, and thus the D operator for plurals is not a relevant option for *whole*. Second, *whole* is not a quantifier, which is supported by a lack of scope interaction and binding variables. Thus, *whole* cannot be distributive for either of the sources.

To deal with the distributivity of *whole*, Moltmann (2005) relies on pragmatics. If distributivity is not assumed, *whole* is an empty expression. To avoid redundant use of *whole*, a pragmatic condition of distributivity is triggered. Moltmann argues that the pragmatic nature of distributivity is supported by the collective reading of *whole* with certain predicates. I have argued against Moltmann because the distributive and collective readings of *whole* are determined by the properties of predicates rather than the contexts.

Unlike Moltmann, I have considered the semantics of *whole* in the mereological structure proposed by Link (1983), which employs the group formation and member specification functions. I have proposed that *whole* is the member specification function, mapping a group to its members. Since the members of a group are plural, the D operator is introduced for a sentence with *whole*. This triggers distributivity. To derive members for a singular count term, I have extended the concept of the member specification function for discrete and dense structures. I have also shown that a collective reading of *whole* involves internal distributivity, following Landman (1989) and Brisson (2003). Thus, the semantics of *whole* can be defined by the member specification function, regardless of its argument category or predicate properties.

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