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A new notion of part structure for natural language

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Abstract

In this paper a new notion of part structure for the semantics of natural language is presented: a notion of part structure that is relative to a situation and unlike extensional mereological notions, crucially involves conditions of integrity. The notion is motivated by a variety of different constructions of natural language.

Keywords: Part; Part structure; Groups; Quantities; Individuals; Integrated whole; Situation

1. Introduction

Traditionally, the notion of a part structure of an entity has been conceived of as an ontological notion: an entity has exactly one part structure, and the part structure of an entity is essential for its identity.[1] Moreover, in the more recent tradition in philosophy and especially in formal semantics, a particular formal notion of part structure has been assumed, a notion according to which the part structure of an entity consists only in a set of parts and an ordering among the parts. In this paper, I will present a different notion of part structure, namely a notion of a *situated part structure*, a part structure which an entity has only relative to a situation and in which conditions of integrity play a fundamental role. Situated part structures, as I have argued at length in [8], play a fundamental role in a broad range of natural language constructions and expressions, in particular the mass–count distinction, quantifiers ranging over the parts of an entity, expressions that act as 'part-structure modifiers' such as *whole*, *as a whole*, *together*, *individual*, and *alone*, and certain semantic selectional requirements imposed by predicates or readings of predicates. In this paper, I will focus on the conceptual aspects of situated part structures, keeping the discussion of their linguistic motivations at a minimum.

The notion of situated part structure allows one and the same entity to have different part structures in different situations, where situations are conceived of, simply, as partial specifications of entities

[1] There are other traditions, though, which explicitly take the 'structure' of an entity to be variable. For example, a body as a chemical object would have a different structure than a body as a biological object.

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with properties. There is a two-fold reasons why the part structure of an entity can vary in this way, and hence why a part structure need not be essential for an entity: (1) because of the way part structures are conceived and (2) because of the kind of information that may be contained in a situation. Part structures in the new sense consist not only in a set of parts and an ordering among the parts, but include specifications of entities or their parts as *integrated wholes*. An entity may be an integrated whole, for example, by having a particular form or by being a maximal entity whose parts are connected in a certain way. What is crucial is that an entity may be an integrated whole only relative to a situation, and there are two ways in which this can happen. First, as an entity may have different accidental properties in different situations, it may be an *accidental integrated whole* in one situation, but not in another; or it may be an (accidental) integrated whole in one way in one situation and in some other way in some other situation. Second, it may be that an entity lacks integrity in a situation simply because the situation disregards the properties that would specify the entity as an integrated whole. Thus, it may be the *partiality* of situations that is responsible for why an entity has different part structures in different situations.

Due to the role of integrity, the new notion of part structure differs from the notion of part structure most often used in linguistic semantics, namely the *extensional mereological notion*. According to that notion, a part structure is simply a set of entities and an ordering relation among those entities. The notion of integrated whole not only adds complexity to part structures; it also is responsible for why certain extensional mereological properties hold only conditionally for part structures in the new sense, in particular, extensionality, transitivity, and closure under sum formation. But this means that information about integrity also influences what counts as a part of an entity in a situation. As a consequence, an entity may not only have or lack integrity (of different sorts) in different situations; it may also be divided differently into parts in different situations.

The notion of situated part structure also requires a new conception of the semantic value of referential noun phrases and of arguments of predicates. Certain predicates and readings of predicates are sensitive to the part structure of an argument in a situation. Hence the relevant predicates must now take not simply *objects* as arguments, but rather *pairs* consisting of an object and a situation (a *'reference situation'*). In fact, the strongest claim can be established that not only some, but all, predicates take object–situation pairs as arguments. Correspondingly, referential NPs now have to be construed so as not to refer simply to objects, but rather to pairs consisting of an object and a reference situation.

I will start with presenting some of the main linguistic motivations for situated part structures and then proceed by developing the notion of situated part structure against the background of the extensional mereological notion. Situated part structures will at first be characterized in a rather informal, intuitive way so that the formal definitions and conditions can be given together at the end of the paper.

2. Linguistic preliminaries

2.1. Some basic assumptions

Let me first make explicit some widely shared assumptions about the semantics of singular count, plural, and mass NPs on which the present account of situated part structures is based.

One assumption is that the semantics of plural, mass, and singular count NPs is analogous. That is,

mass NPs refer to or quantify over quantities, and plural NPs refer to or quantify over groups in, essentially, the same way as singular count NPs refer to or quantify over individuals. Thus, *the water* refers to a quantity of water and *some water* quantifies over quantities of water; *the boxes* refers to a group of boxes and *some boxes* quantifies over groups of boxes. That mass NPs refer to or quantify over quantities and plural NPs refer to or quantify over groups can be traced to the extension of mass nouns consisting of quantities and the extension of plural nouns consisting of groups. Thus, the extension of *water* is simply the set of all the water quantities. Plural nouns obtain their extension by an operation of sum formation from the corresponding singular noun. Thus, the extension of *boxes* will be as in (1), where *sum* is an appropriate operation of sum formation, mapping a set of entities to the 'sum' or 'group' consisting of those entities:

(1) $[boxes] = \{x | \exists X(X \neq \varnothing \ \& \ X \subseteq [box] \ \& \ x = sum\ X)\}$

There is one difference between definite singular count NPs such as *the man* and definite mass and plural NPs such as *the water* and *the boxes*, though. Given the Russelian account, a definite singular count NP refers to the unique entity satisfying the content of the N′ in the relevant context. But the uniqueness condition is generally not met by a definite mass NP such as *the water* or a definite plural NP such as *the boxes*. Rather, *the water* refers to the maximal quantity of water in the relevant context—or the sum of the set of the relevant water quantities—, and *the boxes* refers to the maximal group of boxes in the relevant context—or the sum of the set of the relevant groups of boxes (cf. [11]; see also [6] and [7]). The denotations of *the water* and *the boxes* will then be as in (2), where $[water]^s$ is the extension of *water* in the situation s and $<$ is the relevant 'part of'-relation:

(2) a. $[the\ water]^s = \text{sum}_<([water]^s)$

b. $[the\ boxes]^s = \text{sum}_<([boxes]^s)$

The analogy between the semantics of singular count, plural, and mass NPs extends to quantification. English exhibits quantification over the parts of whatever entities singular count, mass, or plural NPs refer to. In fact, the same quantifiers *all*, *some*, and *part* are used in the partitive constructions in (3) to quantify over the parts of individuals, quantities and groups:

(3) a. all of / some of / part of the book

b. all of / some of / part of the water

c. all of / some of / part of the boxes

The quantifiers in (3a) range over the parts of the book, the quantifiers in (3b) over the parts of the water, and the quantifiers in (3c) over the parts of the group of boxes.

Generally, semantic accounts of plural and mass NPs assume different part relations for groups and quantities (and also, as far as they are considered, individuals) (cf. [6,13,7]). However, the fact that in (3), the same part quantifiers are used for all three domains of entities motivates a view according to which one and the same part relation applies to all domains. In fact, such a view is required to account for examples like (4), where the same occurrence of a part quantifier ranges over parts of an individual and parts of a quantity (more precisely, it ranges over the parts of the sum of the bread and the wine, which may be of either kind):

(4) some of the bread and the wine

Within an extensional mereological approach, using one and the same part relation for all three kinds of entities leads to problems, in particular regarding the extensional mereological axioms of extensionality and transitivity. The choice of a single part relation for all kinds of entities, therefore, must go along with an adoption of a nonextensional account of part structures. Extensional mereological axioms (in particular transitivity) will then obtain only in a conditionalized form.

2.2. Motivations for situated part structures

There are two important characteristics of situated part structures. First, situated part structures include conditions that define entities or their parts as integrated wholes; second, they are relativized to a situation. Let me start with some motivations for including conditions of integrity in part structures and then come to the importance of relativizing part structures to situations.

One important area in which the notion of integrity plays a role is the mass–count distinction. In fact, the notion of integrated whole is at the heart of the mass–count distinction and can itself best be introduced by contrasting mass nouns with count nouns. Compare (5a), which involves a mass NP, with (5b), which involves a count NP:

(5) a. The salad contains apple.

b. The salad contains an apple.

(5b) strongly suggests that the salad contains a whole apple, whereas (5a) preferably has the reading in which the salad contains only pieces of apple (that is 'apple' without its usual shape).[2] Thus, *apple* as a mass noun implies no properties of form, whereas *apple* as a count noun suggests the absence of form. Such a gain or loss of a presupposition of integrity systematically occurs when mass nouns are converted into count nouns and conversely. Thus, the distinction between mass and count nouns consists in that mass nouns characterize an entity as not being an integrated whole, whereas count nouns do characterize an entity as an integrated whole.

There are two different ways, though, in which an entity may be an integrated whole: it may be an integrated whole essentially or accidentally. In the first case, the entity ceases to be when it loses the relevant sort of integrity; in the second case, the entity simply undergoes a change. A statue, for example is an essential integrated whole (with respect to its form), since if it loses its properties of form, it ceases to exist. By contrast, the material of the statue, though it is an integrated whole during some period of time, is not an essential integrated whole (with respect to form), since if it loses its properties of form, it does not cease to exist, but remains the same material (though with a different shape). An entity may also be described or referred to as an integrated whole without it being an integrated whole essentially. For example, the papers on my desk may be referred to as *the (loose)*

[2]The contrast between (5a) and (5b) disappears when *an apple* is replaced by a singular count NP with numeral determiner, e.g. *one apple*:

(1) The salad contains one apple.

(1) can easily be understood as the salad containing a quantity amounting to one apple, whatever shape this quantity may be in. *One apple* here seems to function like a measure phrase, involving the mass concept 'apple', as in *some amount of apple*.

collection of papers on my desk without it being such a collection essentially. The papers, by forming a collection on my desk, then constitute only an accidental integrated whole.[3]

If count nouns such as *collection* may attribute only accidental integrity to an entity, this means that the distinction between mass and count nouns should not be based on the attribution of integrity or the lack of it to entities *per se*, but rather on the attribution of integrity or the lack of it to an entity in a particular situation, whereby such a situation may carry information both about accidental and about essential properties of entities.

Count nouns then should be characterized as defining an entity as an (essential or accidental) integrated whole with respect to any situation. But should mass nouns be characterized in the opposite way, as defining an entity as not being an integrated whole with respect to any situation? Certainly, this couldn't be right. For if the material of the statue is referred to as *the material* (using a mass NP), this does not mean that the material is not an integrated whole in any situation. It is one, for example, in a situation in which it constitutes the statue. For this reason, the characterization of mass nouns requires the use of *minimal situations* containing only the information given by the noun itself. Clearly, in a minimal situation which contains only the information provided by the mass noun *material*, the material referred to by *the material* won't have any properties defining it as an integrated whole. Thus, the appropriate characterization of the mass–count distinction must be that mass nouns imply that any element in their extension is not an integrated whole in a minimal situation containing only the information provided by the noun; whereas singular count nouns imply that any element in their extension is an integrated whole in any situation.[4]

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[3]That nouns such as *collection* express accidental integrity conditions is not merely a matter of intuition. A simple linguistic criterion whether nouns express accidental or essential integrity conditions is the application of predicates of existence. Predicates of existence do not seem to hold of NPs with nouns like *collection* as head noun under any other conditions than of the corresponding plural NPs. Thus, (1a) has only one reading, on which it is equivalent to (1b):

(1) a. The (loose) collection of papers on my desk does not exist anymore.
b. The papers on my desk does not exist anymore (because I removed everything from my desk).

(1a) does not have another reading on which the papers ceased to form a loose collection on my desk, simply because I removed everything from my desk.

[4]Given this characterization, every count noun requires the elements in its extension to be integrated wholes. In certain cases, though, the count noun leaves open what sort of integrity conditions should obtain. This is the case with the noun *thing*. *Thing* implies that an entity it applies to is an integrated whole and, moreover, an essential integrated whole, though it does not say exactly in which way. The implication of integrity can be seen from the contrast between (1a) and (1b):

(1) a. This thing is an apple. (pointing at an apple)
b. #This thing is apple. (pointing at an apple or a piece of apple)
c. This stuff/The content of the bowl is apple. (pointing at small pieces of apples)

This thing as a subject allows only for count predicates such as *an apple*, as in (1a), not mass predicates such as *apple*, as in (1b). The reason is that the mass predicate implies the lack of integrity conditions, which is in conflict with the condition imposed by the count noun *thing*. (1c) illustrates that a mass noun such as *apple* may indeed function as a predicate if the subject is a mass NP. Indeterminacy of a count noun with respect to integrity conditions is found also with *collective nouns*, that is, singular count nouns that apply to groups (i.e. entities which consist of integrated wholes). Examples are the nouns *group* or *collection*. In the case of *the group of rocks*, the rocks may form a (presumably accidental) integrated whole with respect to space only, whereas in the case of *the group of scientists*, the scientists may form a (presumably accidental) integrated whole with respect to work cooperation only. The fact that count nouns impose integrity conditions even if they have an almost empty or only a poor lexical content can be seen also from the expression *part* in English. *Part* has both a mass and a count form ('this is part of the chair' vs. 'this is a part of the chair', see also [13]). As a count noun, *part* implies that the part it applies to is an integrated whole, whereas as a mass noun, it has no such implication. Thus, in predicative position, *part* as a mass noun requires a mass subject and as a count noun a count subject, as seen in (2a) and (2b):

(2) a. This wood is part/#a part of the chair. (pointing at a piece or at pieces of wood)
b. The leg is a part of the chair.

Thus, whereas *is part of* only means something like 'included in', *is a part of* roughly means 'included in' as well as 'is an integrated whole'.

Having seen the importance of the notion of (essential or accidental) integrity with the mass–count distinction, let us now turn to the linguistic motivations for the more complex notion of a situated part structure.

Situated part structures play a role in two empirical areas: [1] the semantics of *part-structure-sensitive predicates* such as *compare*, as in (6a), and [2] *quantification over parts*, as with the partitive construction in (6b):

(6) a. John compared the students.

b. All of the students made two mistakes.

Compare as in (6a) is sensitive to the part structure of its object argument in the relevant situation for the following reason. (6a) allows for various readings, for example one in which John compared any individual student to any other individual student or one in which John compared any relevant subgroup of students to any other relevant subgroup of students. These readings can be traced to the group of students being divided differently into parts (individual students or subgroups of students) in two different situations associated with the two readings. The predicate *compare* as a two-place predicate then takes into account such divisions of objects into parts in the following way: applied to an object x and an object y in a situation s, *compare* specifies that any part of y in s is being compared by x to any other part of y in s. The first reading above then results from the individual students being the situated parts and the second reading from the relevant subgroups of the students being the situated parts.

Similarly, (6b) allows for various reading, for example one reading in which each student made a mistake and one in which certain relevant subgroups of students made a mistake. Again, these readings can be traced to *all of* in (6b) ranging over whatever the relevant parts of the group of students are, that is, the parts into which the group of students is divided in the relevant situation.

What counts as a situated part of an entity in a situation is not arbitrary, but rather depends, at least in part, on information about integrity provided by the situation. First of all, if x is a part of y in a situation s and y is a part of x in s, then x is a part of z in s only if x is not an integrated whole in s (that is, transitivity may be blocked when the intermediate entity is an integrated whole). Thus, (6a) does not have a reading in which John does not just compare individual students, but also body parts of students, and similarly *all of* in (6b) does not have a reading in which it ranges over body parts of students (even with a more appropriate predicate). The formulation of the condition on transitivity above still raises some problems, though. But I will address them only in a later section.

Also, closure under sum formation (i.e. every set of entities has a sum) holds for situated part structures only if certain conditions involving integrity obtain. The relevant data indicate that sum formation should be restricted for sets whose elements are integrated wholes. Consider the reading of *compare* in (6a) and *all of* in (6b) that involves only individual students, not subgroups of students. Given that *compare* involves the relevant, situated parts of the group of students, this means that no proper subgroup of students should be a (situated) part of the group of students, only individual students should. However, the maximal group of students certainly exists in the situation. The relevant difference is that the maximal group is, in a sense to be made precise, an integrated whole, but a proper subgroup of that group is not. Thus, the sum of a set of integrated wholes should exist in the relevant situation just in case that sum itself is an integrated whole in that situation.

By contrast, the sum of a set of entities that are not integrated wholes in a situation should always

exist in that situation. This means, in particular, that a set of quantities in a situation should be closed under sum formation. The evidence for that comes from the contrast between (7a), which contains a predicate which could hold only of certain subquantities, and (7b), which contains a predicate which can hold of all subquantities:

(7) a. # All of the water contains two grams of salt.

b. All of the water contains salt.

The unacceptability of (7a) and the acceptability of (7b) show that the parts of the water in the relevant situation must include all subquantities of water. For then, (7a) can not be true, but (7b) can.

There are two other sorts of phenomena, related to part structure-sensitive predicates, that motivate the notion of situated part structure, and in particular the role of integrity in part structures: semantic selectional requirements involving part structures and part-structure modifiers. Let me start with part-structure-sensitive semantic selection.

Semantic selectional requirements are semantic conditions that have to be satisfied by an object in order for a predicate to be true or false of it. There are at least two semantic selectional requirements that impose conditions on the part structure of an argument, as is discussed in [8]. Let me restrict myself here to one such requirement, namely what I call the *'Accessibility Requirement'*. The Accessibility Requirement roughly says that predicates whose meaning involves the parts of an argument may be true of an entity x only if x has an accessible part structure, i.e. only if x is not an integrated whole. The requirement manifests itself in that part-structure-sensitive predicates generally take only plural or mass, but not singular count, NPs. This is illustrated in the examples in (8) and (9). The predicates in (8) make reference to the parts of the second argument and hence are subject to ACC; they contrast in this respect with the predicates in (9):

(8) a. John compared / distinguished / ranked the family members / # the family.

b. among the chairs / the rice / # the group of chairs / # the bowl of rice

(9) a. The family / The family members is (are) in the house.

b. The chairs / The group of chairs is (are) blue.

Compare, for example, when taking a group x as its second argument involves a comparison among the parts of x, and *among* when applying to a pair $<x, y>$ locates x somewhere in-between the parts of y.

The Accessibility Requirement is responsible not only for whether sentences are acceptable, but also for whether certain readings of predicates are possible. Compare (10a) to (10b):

(10) a. John counted / listed the family members.

b. John counted / listed the family.

Count and *list* take plural as well as singular count NPs, though their semantic effects are clearly different with the two kinds of NPs. If John counted or listed the family, then he counted one (if he counted right) or listed one thing, but not so if he counted or listed the family members (and there were more than one member).

The Accessibility Requirement also affects the distributive interpretation of a predicate. Distri-

butivity is available generally only when the argument is not a referent of a singular count NP. Thus, a distributive interpretation is possible in (11a), but impossible in (11b):

(11) a. John gave the students an A.

b. John gave the class an A.

(11a) has readings in which John gave each student or each relevant subgroup of students an A (the predicate distributes over the relevant, situated parts of the group of students); but (11b) must mean that John evaluated the class as a whole (the predicate does not distribute over the relevant parts of the class).

A common linguistic view of distributivity is that the distributive interpretation of a predicate is due to the presence of an implicit distributive quantifier ranging over the parts of the relevant argument (see, for instance, [6] and [10]); on another view, defended in [8], distributivity is represented by a quantifier ranging over parts in one disjunct of a disjunctive lexical meaning of particular (lexical or lexicalized) expressions. A detailed discussion of distributivity should not concern us. What is important in the present context is only that on either view, distributivity involves a quantifier ranging over the parts of an argument in the relevant situation, and hence is also subject to the Accessibility Requirement.

Like the distinction between mass and count nouns, the Accessibility Requirement does not so much care about whether entities are integrated wholes or not *per se* (that is, whether they are essential integrated wholes); rather it cares about whether entities are integrated wholes in a particular situation. This can be seen from the fact that count nouns that express accidental, rather than essential, integrity conditions, for example *collection*, *group*, and *line*; behave exactly the same way with respect to predicates imposing the Accessibility Requirement:

(12) a. John cannot distinguish the papers on my desk / # the loose collection of papers on my desk.

b. John compared the people / # the line of people / # the group of people.

Thus, the Accessibility Requirement, more appropriately, says that a part-structure-sensitive predicate can apply to an entity x in a situation s only if x is not an integrated whole in s.

Another, even more compelling sort of evidence that the Accessibility Requirement involves the part structure of an entity not absolutely, but relative to a situation comes from NPs modified by what I call *'part-structure modifiers'*, namely expressions like *together*, *as a whole*, *as a group*, *as a collection*, and *alone* as in (13a), and *individual*, *whole*, and *entire* as in (13b):

(13) a. the boxes together / as a whole / as a group / as a collection / alone

b. the individual boxes, the whole class, the entire collection of boxes

Adnominal part-structure modifiers do not serve to identify the referent of an NP; rather they modify the reference situation of the NP with respect to the part structure of the NP-referent. Thus, in (13a), *together*, does not restrict possible referents to groups of boxes that are 'together' (as opposed to groups of boxes that are separate), and *alone* does not restrict possible referents to groups of boxes that are alone. Rather, *together* in (13a) maps the relevant reference situation to another situation in

which the boxes form an integrated whole and *alone* maps the reference situation to a situation in which the boxes do not form part of an integrated whole.[5]

An important function of part-structure modifiers is to influence the satisfaction of semantic selectional requirements, in particular the possibility of a distributive interpretation. For example, the sole semantic function of *together*, *as a group*, and *as a whole* in the following examples is to block a distributive interpretation of the predicate:

(14) a. John and Mary together / as a group weigh 100 pounds.

b. The stamps together / as a whole cost 100 dollars.

c. The boxes together are too heavy to heavy.

This follows from the fact that *together*, *as a whole*, and *as a group* map the reference situation to a situation in which the NP-referent is an integrated whole, that is, in which it has an inaccessible part structure.

The function of the adjectival part-structure modifier *whole* is the opposite to that of *together*, *as a whole*, and *as a group*: *whole* shifts the reference situation of the NP to another situation in which the NP-referent in not an integrated whole and moreover in which every actual part of it is present. Thus, *whole* has the opposite effect on distributivity and on predicates requiring accessible part structures. This is seen from the fact that when modified by *whole*, a collective NP allows for distributive interpretation, as in (15b), and for part-structure-sensitive predicates, as in (16a–c), which would otherwise be impossible:

(15) a. John gave the whole class an A.

b. The whole collection is too expensive.

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[5]There is an alternative view of part-structure modifiers that should be mentioned. On that view, which one may call the *ontological account*, *the boxes together* refers to a different object than *the boxes*. Namely, it refers to an object that, unlike the referent of *the boxes*, is essentially an integrated whole.

Such a view has been proposed in the literature for a class of related expressions, namely *as*-phrases such as *a teacher*, as in (1):

(1) John as a teacher is successful.

On the ontological account of *as*-phrases, *John as a teacher* refers to a different object than *John*.

On the ontological account, *as*-phrases and adnominal part-structure modifiers, in a sense, 'define new entities'. But what are these 'new entities'? One proposal concerning the objects that NPs modified by an *as*-phrase or part-structure modifier refer to has been made by Fine in [3], who gives a formal account of what he calls 'qua-objects'. Qua-objects, on Fine's account, are mereological aggregates of objects of the familiar sort and properties. For example, the object John qua teacher is the aggregate of John and the property of being a teacher. Qua-objects would be good candidates for the referents of NPs modified by *as*-phrases or part-structure modifiers (though Fine does not actually make the linguistic claim). On this view, *John as a teacher* would refer to the aggregate of John and the property of being a teacher, *the boxes together* would refer to the aggregate of the boxes and the property of being an integrated whole, and *the whole class* would refer to the aggregate of the class and the property of not being an integrated whole, and so on.

Another proposal concerning the semantics of *as*-phrases within the ontological approach has been made by Landman in [4], where individuals are construed as sets of properties and *as*-phrases are taken as restricting those properties in some ways (which are not made explicit, though).

For a critical discussion of these or any other proposals concerning the 'new objects' that NPs modified by *as*-phrases or part-structure modifiers please refer to [8].

(16) a. John compared / distinguished / listed / counted the whole family.

b. John compared / ranked the whole collection of art.

c. Among the whole collection of art, there was not a single masterpiece.

With *together, as a whole*, and *alone*, the new situation may differ from the original reference situation simply by containing more information, namely the additional information that the NP-referent be an integrated whole (*together, as a whole*) or not be part of an integrated whole (*alone*). By contrast *whole* as an adjectival modifier may revise the reference situation. For example in (15a), the singular count noun *class* has characterized the referent as an integrated whole in the original reference situation, but in the new situation, *whole* requires that the entity not be an integrated whole. Thus, some of the information given by the singular count noun may be discarded during the perspective shift: *whole* may change the state of information associated with the NP in question (the reference situation), by eliminating properties that would define the NP-referent as an integrated whole.

Interestingly, this must be possible even if those properties are essential—as in the case of *class* in (15a) and *family* in (15a). But this means that a situation in the sense required should not have to represent all the essential properties of entities that occur in it.

Notice that part-structure modifiers may even yield different situations for one and the same object occupying different argument positions of a single predicate, as in (17):

(17) John compared the individual students to the students as a whole.

The first object argument of *compare* in (17) involves the students in a situation in which they fail to form an integrated whole (thus triggering a distributive interpretation of *compare* with respect to that argument position); the second object argument involves the same students in a situation in which they form an integrated whole.

Part-structure modifiers generally may occur also in adverbial position. But in that position, they have rather different sorts of readings. For example *together* in adverbial position may express group action, as in (18a), or cooperated action, as in (18b):

(18) a. John and Mary danced together.

b. John and Mary sat together.

Adverbial part-structure modifiers generally exhibit readings that are in certain ways related to the content of the predicate. Those readings can be derived from the same meaning as were assigned to adnominal part-structure modifiers. The differences can be attributed simply to the fact that adverbial part-structure modifiers apply to a different kind of situation, a situation that carries only information related to the content of the predicate (cf. [8] and [9]). Adverbial part-structure modifiers should not concern us further in this paper. Only one thing should be pointed out, namely that adverbial part-structure modifiers clearly show that entities may have different part structures in different situations. This can simply be seen from different adverbial part-structure modifiers modifying different conjoined VPs, as in (19):

(19) John and Mary came together and left individually.

The first conjunct in (19) specifies that John and Mary form an integrated whole in the situation that is about their coming, whereas the second conjunct specifies that John and Mary do not form an integrated whole in the situation that is about their leaving.

The linguistic phenomena discussed sofar involved the notion of an entity being an integrated whole in a situation, not distinguishing between essential and accidental integrity. This may give the impression that natural language does not care at all whether part-structure-related properties such as conditions of integrity are ontologically relevant or not. However, there are certain types of natural language expressions that in fact make a distinction between essential and accidental integrity. One of them are cardinality attributes such as *ten* (and perhaps also *many*). *Ten* as an adjectival or predicative modifier never simply counts the situated parts of an entity; rather, it only counts the parts of an entity that are essential integrated wholes. That is, *ten* never counts proper subgroups (which could only be accidental integrated wholes), but must always count individual group members (which generally are essential integrated wholes). Thus, (20a) can never mean that ten groups of students came, and (20b) can never mean that the students were divided into ten subgroups:

(20) a. Ten students came.

b. The students were ten.

Another, related expression that cares about essential integrity is the predicate *count*:

(21) John counted the students.

(21) can never mean that John counted the subgroups of students into which the group of students might have been divided. It can only mean that John counted the individual students.

Thus, the lexical meaning of *'numerical expressions'*, that is expressions like *ten* and *count*, involves the notion of essential integrity and not just integrity in a situation.

Having seen some crucial motivations for situated part structures, we can now proceed to lay out formally the notion of situated part structure. However, for that purpose it is best to first present the alternative, more familiar view of part structures, the extensional mereological account. It will be rather obvious that the extensional mereological notion is inadequate to account for the data thus far presented.

3. The extensional view of part structures

On the extensional mereological view, a part structure is a pair $(X, <)$, where X is a set of entities and $<$ the part relation that is specific to the type of the entities in X (i.e. depending on whether those entities are parts of individuals, groups, or quantities). There are various extensional mereological accounts of part structures.[6] But they all share certain fundamental assumptions; in particular, all

[6]For a discussion of extensional mereological theories of the part relation and their problems see [13].

extensional mereological theories assume transitivity, extensionality, reflexivity, and, usually, unrestricted sum formation:

(22) a. $x < y \ \& \ y < z \rightarrow x < z$ (transitivity)

b. $\forall x'(x' < x \leftrightarrow x' < y)\ x = y$ (extensionality)

c. $x < x$ (reflexivity)

d. for any nonempty set X', $X' \subseteq X$, $\text{sum}_<(X')$ exists (unrestricted sum formation)

Because of transitivity and extensionality, extensional mereological theories have to make a distinction between different part relations for the domain of individuals, groups, and quantities. Thus, on an extensional mereological account of part structures, three different part relations will be assumed for entities in the universe: one for individuals, one for quantities, and one for groups. This is an issue, however, that I would like to discuss in more detail only in the next section.

An extensional mereological account of part structures generally goes along with a particular way of construing the mass–count distinction as a semantic distinction among the content of nouns. The mass–count distinction in extensional mereological approaches is generally accounted for in terms of domain-specific part relations, using the notions of atomic and nonatomic part structure: the mass domain is a nonatomic or not necessarily atomic domain (with respect to the mass-specific part relation), whereas the plural domain is a (necessarily) atomic domain (with respect to the plural-specific part relation) (see [7] for a recent discussion).

One general conceptual problem with such an extensional mereological account, however, is that it rests on the notion of atom. The problem with that notion is that there is no language-independent way of telling whether an entity is an atom with respect to a given part structure or not. Atomicity is defined solely in terms of the ordering relation associated with the extension of the relevant nouns.

The extensional mereological account of part structures and of the mass–count distinction contrasts with a nonextensional view which uses not just an ordering among parts, but in addition the notion of integrated whole. With the notion of integrated whole, it is also possible to use a single part relation for all domains of entities. Moreover, with the notion of integrated whole, the mass–count distinction can be construed in a more appropriate way, as in Section 2, namely as a distinction in the information content of nouns.

4. The role of situations in meaning

The traditional view of part structures goes along with a particular traditional view of meaning. Both have to be given up if situated part structures and their role in a sentence meaning are properly taken into account. (23) gives the traditional assumption about the part structure of an entity and (24) the traditional assumption about the semantic values of referential NPs and the arguments of predicates in natural language:

(23) An entity has exactly one part structure.

(24) a. Referential NPs refer (only) to objects.

b. Predicates take (only) objects as arguments.

The notion of situated part structure allows one and the same entity to have different part structures in different situations. Moreover, given the role of this notion in natural language, a different conception of the semantic values of referential NPs and of predicates is required. If predicates and readings of predicates and selectional requirements of predicates can be sensitive to the part structure of an entity in a situation, then referential NPs cannot just refer to objects, but rather must refer to objects relative to a situation, that is, formally, pairs consisting of an object and a situation. The situation will then tell what the relevant part structure of the object is and what constitutes the domain of the part quantifier in question. Predicates, in turn, now cannot just take objects as arguments, but rather must take as their arguments objects together with a situation, that is, pairs consisting of an object and a situation.

What exactly is the notion of situation that is needed here? There are two properties that are crucial for the required notion of situation:

(25) (i) situations carry partial information about entities

(ii) situations may contain only some of the entities in the universe

(25)(i) should be understood in such a way that situations may specify entities partially both with accidental and essential properties. Thus, an entity may be an accidental integrated whole in one situation, but not in another situation; or, alternatively, it may be an accidental integrated whole in some other way in another situation. Furthermore, an entity may fail to be an essential integrated whole in a situation even if it is an essential integrated whole in the world as a whole (i.e. the state of full true information). (25)(ii) implies that a situation may contain only some, and need not contain all, of the actual parts of an entity.

Formally, situations can be conceived as *primitives*, acting as indices with respect to which an n-place predicate and an n-tuple of entities is assigned one of the truth values 1 (True), 0 (False), and # (Undefined). Moreover, any situation s will be associated with a *domain* $D(s)$, which contains the entities in s.

What is the status of situations in a sentence meaning? First of all, situations are needed as part of the evaluation of a referential NP, as *'reference situations'*. Every referential NP in a sentence may be evaluated with respect to a possibly different reference situation. In the meaning of the entire sentence, reference situations then play the role of indexical parameters (like, for instance, time and spatial locations). But, since predicates may be sensitive to accidental properties an argument has in the reference situation, reference situations also have to form a component of the denotation of a referential NP. In such a case, the NP will have to denote not an object, but a pair consisting of an object and the reference situation. Thus, relative to a reference situation s', *the collection of papers* would be evaluated as the pair consisting of the only entity in s' that is a collection and a group of papers in s' and s' itself. That is, $[\textit{the collection of papers}]^{s'} = <x[[\textit{papers}]^{s'}(x) = 1$ and $[\textit{collection}]^{s'}(x) = 1]$, $s'>$.

But what are reference situations as regards their content? How big or small may they be? Reference situations are not quite as variable as they might seem. Rather they are quite restricted in content. From the above, it is clear that reference situations must in any case contain the descriptive information provided by the NP. This is the minimal information a reference situation should contain; but it is basically also the maximal information. This can be seen simply from the fact that a speaker can barely, by uttering the first sentence of (12a), i.e. *John cannot distinguish the papers on my desk*, have a reference situation in mind in which the papers, in addition to just being the papers, form a

collection. For then they would constitute an integrated whole and violate the Accessibility Requirement imposed by *distinguish*. It is hardly possible to imagine a use of the sentence in which it comes out unacceptable for that reason. Thus, reference situations seem to be subject to a rather strict minimality condition: they should contain the descriptive information provided by the relevant NP, and not much, if anything, else (see [8] for more discussion).

Besides reference situations, a sentence meaning, of course, involves another set of situations, the situations (or, if preferred, possible worlds) in which the sentence is true. Following Situation Semantics (cf. [1]), these situations can be called *'described situations'*. The meaning of a sentence with n referential NP can thus be construed as a function from n (possibly different) reference situations to a set of described situations. Thus, *John compared the papers* will have a meaning of the following sort, a function from two reference situations s' and s'' to a function from situations to truth values:

(26) $\lambda s' s'' \lambda s[[compare]^{s}(<j, s'>, <sum_{<s''}(\{x|[papers]^{s''}(x) = 1\}), s''>)]$

After these preliminaries concerning the role of situations in sentence meaning, let us now turn to the notion of situated part structure itself.

5. Situated part structures

5.1. The notion of integrated whole

Situated part structures crucially involve conditions of integrity. The notion of integrity itself, however, is not new, but has played a prominent role in earlier philosophical discussions of part structures (see the discussion in [13] and references therein). However, even though the notion of integrated whole has long been recognized as playing a crucial role in part structures, the recognition of its importance has largely gone lost in more recent traditions in philosophy and especially linguistic semantics.

What is an integrated whole? A prototypical way for an entity to be an integrated whole is by having a particular shape. More generally, an entity is an integrated whole if certain conditions hold of its parts, for instance if the parts stand in particular relations to each other and fail to stand in such relations to other things that are not parts of the entity. (See [13] for a more extensive discussion of the notion of integrity). For present purposes, it is sufficient to introduce only a very simple notion of integrated whole. This notion, which is adopted in a simplified way from [13], is the notion of R-integrated whole, which applies to an entity x just in case all the parts of x are connected under an appropriate relation R and no part is connected to an entity that is not part of x (cf. [13]). The appropriateness of R consists, for example, in that R should not be a purely formal relation such as difference or identity. Let R_{trans} be the transitive closure of R, then we have:

(27) *Definition*

For an appropriate, symmetric relation R, x is an (R-)*integrated whole* iff for every y, $z<x$, $x \neq y$, $x \neq z$, $R_{trans}(y, z)$ and for every $y<x$ and for no w $\neg w<x$, $R(y, w)$.

A simple example of an R-integrated whole is John's parents. John's parents form an entity whose parts (father and mother) are connected by the relation 'have John as a child with' and are not connected to any other entity by this relation. Another kind of R-integrated whole is a lake. Here R roughly is the relation λxy[water(x) & water(y) & is spatially adjacent to (x, y)].

A particular kind of R-integrated whole which is also linguistically relevant can be obtained from a one-place property F. Define a relation FF by $FF = \lambda xy[F(x)$ & $F(y)]$. Then an FF-integrated whole is a maximal entity all of whose parts are F. By this notion, the referent of a definite plural or mass NP, for example *the children* or *the water* will come out as an FF-integrated whole (for F being the property of being children or the property of being water).[7]

With the important definition of R-integrated whole, the role integrity plays in situated part structures can now be made precise.

5.2. Integrity and part structures

It has been noted by various authors that integrity plays a role in part structures in the more familiar, ontological sense, namely integrity is (partly) responsible for the failure of extensionality of the part relation (cf. [13]). An example for the failure of extensionality is a heap and the sand from which the heap is made. The heap and the sand arguably have the same parts, but intuitively they are distinct entities since they generally have different 'life histories' (cf. [14]). The reason for that involves the notion of an essential integrated whole: the heap is an entity that essentially has a form and hence is an essential integrated whole, whereas the sand is not an integrated whole essentially. Similarly, an orchestra is essentially an integrated whole, but not (the group of) the members of the orchestra (as a group, that is, as a referent of *the orchestra members*). Thus, extensionality may be blocked whenever one entity essentially is an integrated whole, but the other one is not.[8]

The issue of extensionality is not really important for situated part structures, though. Situated part structures don't care about whether entities are essential or accidental integrated wholes and they are not governed by conditions involving identity. Hence failure of extensionality is not a reason for including integrity conditions in situated part structures.

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[7] The question here arises, what kind of integrated whole should the entity be that is modified by *together*, *as a whole*, and *as a group* in adnominal position? Neither do the expressions themselves tell us what kind of integrity should obtain, nor does the relevant context in which they apply. For example, *together* in *the boxes together* does not seem to specify any particular connection R among the boxes which would define them as an R-integrated whole; there is no suggestion of, let's say, spatial closeness or similarity among the boxes. Rather, the function of *together* here seems to be like an unspecific instruction to the addressee 'conceive of the boxes as an integrated whole so that the integrity of the group of boxes will be a merely conceived one'. Other expressions in natural languages used that way are locutions like 'the collection of boxes' and 'the boxes taken together'.

[8] However, if two entities x and y differ in that x but not y is an integrated whole essentially, it is generally not sufficient that x has a particular property W which defines it as an integrated whole and y does not. Entities like orchestras and families differ from entities like the referent of the family members or the orchestra members not only in that they are integrated wholes, but also in that they allow for replacement, loss, or addition of parts over time or in counterfactual situations. That is, the two kinds of entities differ in temporal and modal properties. (See also [13] for discussion.)

As was already mentioned, however, the notion of integrated whole plays a role in situated part structures in that it is responsible (partly) for why the part relation may fail to be transitive. Thus, John's leg is part of John, John is part of the group of children; but John's leg is not part of the group of children. Or, the page is part of the book, the book part of the books on the desk; but the page is intuitively not part of the books on the desk.

One way of explaining the failure of such inferences may be that the premises involve different part relations, for example the relation of being a part of an individual and the relation of group membership, as in the first example. This is in fact the strategy that is generally taken within an extensional mereological account of part structures. An appeal to different part relations does not make sense, though, for the second example just mentioned.

With the notion of integrated whole, a different account is possible, using a single part relation: an inference from $x<y$ and $y<z$ to $x<z$ is possible only if y is not an integrated whole. Thus, we have the following condition on situated part structures, a principle of conditionalized transitivity, where INT-WH (being a situated integrated whole') is a two-place relation between entities and situations:

(28) *Conditionalized transitivity*

If $x <_s y$ and $y <_s z$ and $\neg$INT-WH(y, s), then $x <_s z$.

Recall that also sum formation applies only in a conditionalized form, based on conditions of integrity. The principle in question is this: if a set X consists only of entities that are integrated wholes in a situation s, then X does not have a sum in s, unless the sum itself would be an integrated whole in s. It is not an entirely trivial matter to formalize the last condition. One can't impose conditions on sums that perhaps don't exist. Instead one has to be able to talk about *all* sums of sets of integrated wholes in order to distinguish those that are themselves integrated wholes. For this purpose, let us make use of another part structure, which should be a component of situated part structures anyway, namely an *ontological part structure*. It need not concern us what axioms exactly govern ontological part structures, except that ontological part structures are closed under sum formation:

(29) A structure (X, $<$) is an *ontological part structure* only if

for every $X' \subseteq X$, $X' \neq \emptyset$, sum(X') exists

For given a situation s, a situated part structure then will be composed of two sub-part structures: an ontological part structure and a part structure relative to s.

With ontological part structures as components of situated part structures, it is now possible to formulate the principle of conditionalized sum formation. Below it is formulated as a condition on the domain of a situation:

(30) *Conditionalized Situated Sum Formation*

If for a situation s and a nonempty set X: for every $x \in X$, INT-WH(x, s),

then $sum_<(X) \in D(s)$ iff INT-WH($sum_<(X)$, s)

For defining situated part structures, it is not necessary to take integrity conditions to form an *explicit* component of a part structure. It suffices to simply take the relevant situation to be a component. This is because integrity conditions can be 'retrieved' from the information content of a situation. To make this precise, let the notion of situated integrated whole INT-WH be restricted to R-integrated wholes, since this is the only notion of integrated whole that has been defined. We then have:

(31) For an entity x and a situation s,

x is a *situated integrated whole* in s (INT-WH(x, s)) iff there is an appropriate symmetric relation R such that: for all x', x'', $x' <_s x$, $x'' <_s x$, $x' \neq x'' \neq x$: $R_{\text{trans}^s}(x', x'') = 1$; and for all x', $x' <_s x$, $x' \neq x$, for no y, $y <_s x$, $y \neq x$: $R_{\text{trans}^s}(x', y)$.

How about reflexivity as a property of the situated part relation? There is reason to take the situated part relation $<_s$ to be reflexive. For example, *part of the children came* does not exclude that all of the children came. Also it is reasonable to assume that the ontological part relation is reflexive.

Situated part structures are then defined as follows:

(32) For a situation s, *a situated part structure* in s is a triple $(s, (D(s), <_s), (Y, <))$

such that the following conditions hold:

(i) $(Y, <)$ is an ontological part structure

(ii) $D(s) \subseteq Y$

(iii) $<_s \subseteq <$

(iv) If $x <_s y$ and $y <_s z$ and $\neg$INT-WH(y, s), then $x <_s z$.

(v) If for a set $X' \subseteq D(s)$, $X' \neq \emptyset$, for every $x \in X'$, INT-WH(x), then

$sum_<(X') \in D(s)$ iff INT-WH($sum_<(X')$, s).

This definition of situated part structure is not without potential problems, though. In the next section, let me point out some of them, in particular regarding Conditionalized Transitivity.

5.3. *Some further issues*

According to Conditionalized Transitivity, the intermediate entity y not being an integrated whole should only be a sufficient, not a necessary, condition for the conclusion to obtain. This is adequate. For consider my left hand which is part of my left arm. My left arm certainly is part of my body; but the left hand still naturally counts as part of the body. So the question is: under what conditions exactly does transitivity go through? I will not try to answer this question, but only hint at the nature of the condition at stake. Compare the valid inference in (33a) to the invalid one in (33b):

(33) a. The page is part of the book.

The book is part of my written work.

The page is part of my written work.

b. The page is part of the book.

The book is part of my library.

The page is part of my library.

Transitivity seems to go through in (33a), even though the book is an integrated whole. The reason appears to be that the larger entity, my written work, does not, by its own nature, require that it have any parts that are integrated wholes (such as books). My written work might just consist in loose pages. By contrast, a library in the invalid inference (33b) does require books as parts and thus integrated wholes. That is, it is essential for a library that it have books (i.e. integrated wholes) as parts, but it is not essential for my written work to have such parts. This suggests that transitivity, the inference from $x<y$ and $y<z$ to $x<z$, is conditional upon the integrity of y not being essential for z if y is an integrated whole.

But even this cannot be right. Consider again my left hand and my left arm. My left arm certainly is an integrated whole and a part of the body, and its integrity is (more or less) essential for the body; moreover, the left hand is an integrated whole and part of the body. But the left hand also is a natural part of the body. Given the integrity of the left hand is also essential for the body perhaps it depends ultimately on the nature of the entity itself whether some subunit, a part of a part, counts itself as a part or not. But this means that there may not be any general principles governing the part structure of an entity independently of the nature of the entity itself. A view of part structures then emerges that deviates even more radically from the extensional mereological view than the present account which simply conditionalizes extensional mereological axioms and uses a non-relational, nonmodal notion of integrated whole.

Let me at this point also add some remarks about the failure of extensionality and transitivity and different kinds of entities. Failure of extensionality and transitivity occur not only with entities from different domains (quantities vs. individuals or individuals vs. groups), but also with entities from one and the same domain. This even holds for groups, that is, entities in the domain of plurals. Suppose that the judges are exactly the same persons as the teachers, then extensionality fails in (33a) (with a distributive predicate) and in (33b) (with a collective predicate):

(33) a. The judges earn different incomes (cf. [5]).

b. The judges (together) earn more money than the teachers (together).

Moreover, there is failure of transitivity in (34), in a situation in which John compared the group of girls to the group of boys (rather than comparing individual girls and boys):

(34) John compared the girls and the boys.

Thus, it appears that the same conditions on part structures are active in all domains of entities.[9]

Now that we have the notion of situated part structure and know from Section 2 what role it plays in natural language, the task of the next section is to make explicit the linguistically relevant definitions and conditions that involve the notion of situated part structure.

6. Formal definitions of linguistically relevant notions using situated part structures

Let us start with a formal characterization of the mass–count distinction. Here the notion of situated integrated whole will be involved together with the notion of a minimal situation:

(35) *Characterization of the mass–count distinction*

(i) For a singular count noun N for any minimal situation s such that $[N]^s(x) = 1$ or 0, then

INT-WH(x, s).

(ii) For a mass noun N, for any minimal situation s such that $[N]^s(x) = 1$ or 0,

$\neg$INT-WH(x, s).

The Accessibility Requirement also involves situations; it involves both reference situations for the relevant argument position and described situations with respect to which the predicate is evaluated. It will roughly take the following form (which, for the sake of simplicity, is restricted to one-place predicates):

(36) *The Accessibility Requirement (revision)*

For a (one-place) predicate P whose meaning involves the parts of an argument:

if for an entity x and situations s and s', $[P]^{s'}(x, s') = 1$ or 0, then $\neg$INT-WH(x, s').

When P is undefined for a pair $<x, s'>$ with respect to a situation s, the reason may be precisely that x is not an integrated whole in s' (unless some other presupposition associated with P fails to be satisfied).

The formulation in (36) is not yet quite correct empirically, but in respects irrelevant for current purposes (see [8] for more discussion).

How can the difference be accounted for between part-structure-sensitive predicates such as *compare* which simply involve situated parts, and numerical predicates like *count* and *two*, which

[9] With plurals, we also get examples of parts being replaceable:

(1) The students of this university have become much better over the years.

Here, *the students of this university* denotes an entity whose parts change over time (the individual students leaving or entering the university).

involve essential parts? A simple way is to impose the meaning postulate in (37) on one-place numerical predicates, where 'INT-WH' as a one-place predicate expresses essential, rather than situated, integrity:

(37) *Meaning Postulate on Numerical Predicates*

For a one-place numerical predicate,

If for any x, s, $P(<x, s>)=1$ implies, for some relation R, $R'(y, y')=1$

for some $y <_s x$, $y' <_s x$, $y \neq y' \neq x$, then INT-WH(y) and INT-WH(y').

That is, any numerical predicate may imply a binary relation among parts of any element in its extension only if those parts are essential integrated wholes. For instance, *ten* involves a binary relation of distinctness among the parts of any group of which *ten* is true. Hence, these parts must be essential integrated wholes.

On the account sketched in Section 2, part-structure-modifiers induce a *perspective* on an entity, more specifically, they map the reference situation associated with an NP to a possibly different reference situation by adding or eliminating information. Adnominal *together*, *as whole*, *whole*, and *individual* thus would express functions mapping a pair consisting of an object and a situation to a pair consisting of the same object and a possibly different situation. Formally, this is given in (38) for entities x and situations s:[10]

[10]This account of part-structure modifiers is still too simplified, though. Perspective shifters impose a an additional condition besides modifying the reference situation. One reason is that it has to be explained why *together* is unacceptable with obligatorily collective predicates, as in (1):

(1) # John and Mary together are asleep.

Nothing so far rules (1) out. *Are asleep*, being obligatorily distributive, does not require a special distributive disjunct in its lexical meaning and hence should not care about whether an argument is an integrated whole in the reference situation or not. (And that it indeed does not care can be seen from the acceptability of *the class is asleep*, with a singular count NP.) The additional condition that a perspective shifter imposes consists in restricting the evaluation of the predicate. This condition is even more important for *as*-phrases such *as a teacher* as is discussed in [8]. In the case of an adnominal part-structure modifier such as *together* in (1), the evaluation of the predicate must be 'based on' the argument being an integrated whole; and this is, in general, possible only if the predicate allows for a choice among a collective and a distributive interpretation. Hence the unacceptability of (1).

The relation 'based on' is an inherently vague relation which roughly holds between two propositions p and q if p holds only relative to the information given by q. Formally, this anticipation of the evaluation of the predicate can best be construed by using the generalized-quantifier treatment of NPs. On this account, the denotation of *John* will be the set of properties of John. The denotation of *John as a teacher*, in first approximation, will be the set of properties of John all of which hold of John based on John's being a teacher. Taking into account the role of reference situations and the situations the sentence as a whole describes, the denotation of *John as a teacher* will have to be construed as a function from properties to described situations of the following sort (cf. [8]), where s' is a reference situation and BASED ON takes two structured propositions as arguments (here pairs consisting of situated properties and objects):

(2) $[John\ as\ a\ teacher]^{s'} = \lambda P \lambda s[P^s(j, s'') = 1 \& \text{ BASED ON}(\langle [teacher]^{s''}, \text{John}\rangle, \langle P^s, \langle \text{John}, s''\rangle\rangle)]$, where s'' is the situation that differs minimally from s' in that $[teacher]^{s''}(\text{John}) = 1$.

(38) a. $[\textit{together}](x, s) = [\textit{as a whole}](x, s) = \langle x, s' \rangle$,

where s' minimally differs from s in that INT-WH(x, s').

b. $[\textit{alone}](x, s) = \langle x, s' \rangle$, where s' minimally differs from s in that $\neg\exists y$ INT-WH(y, s') and $x_{s'} y$.

c. $[\textit{whole}](x, s) = \langle x, s' \rangle$, where s' minimally differs from s in that $\neg$INT-WH(x, s')

and for all x', $x' < x$ and $x' \neq x$ then $x' \in D(s)$.

Correspondingly, the denotations of *the students as a whole* and *the whole class* relative to a reference situation s will be as in (39a) and (39b):

(39) a. $[\textit{the students as a whole}]^s = < x, s' >$, where $x = \iota y[y = \text{sum}_{<_s}([\textit{students}]^s)]$

and s' differs minimally from s in that INT-WH(x, s').

b. $[\textit{the whole class}]^s = \langle x, s' \rangle$, where $x = \iota y[[\textit{class}]^s(y) = 1]$ and s' differs minimally from s in that $\neg$INT-WH(x, s'), and for all x', $x' < x$ and $x' \neq x$, then $x' \in D(s)$.

A predicate will then apply to a pair $<x, s'>$ consisting of the NP-referent x and the new, modified situation s'. A part structure-sensitive or distributively interpreted predicate in particular will then be evaluated relative to the part structure x has in s', taking into account whatever integrity conditions hold of x or its parts in s.

7. Concluding remarks about situated part structures and reference situations

In this paper, I have presented some of the main motivations for situated part structures as part structures relevant for natural language. Both situated part structures and ontological part structures involve the notion of integrated whole. But they differ in the kind of integrity conditions they may take into account. Unlike ontological part structures, situated part structures may involve accidental integrity conditions, and they need not take into account all the essential integrity conditions that hold of an entity or its parts.

Because of the restricted transitivity and closure principles, integrity conditions also influence what counts as the parts of an entity. Integrity conditions themselves, as we have seen, can be retrieved from the information content of a situation. Hence, together with the ontological part structure, it is the information content of a situation that determines situated part structure of an entity. But this means that the reason why one and the same entity may have different situated part structures in different situations is simply because situations differ in information content.

Formal mereological accounts of part structures—not only extensional mereological ones—have generally assumed that an entity could have only one part structure. But this is because, if those accounts acknowledged integrity at all as a component of part structures, they acknowledged only essential integrity. However, by admitting accidental integrity conditions and (unrestricted) partiality regarding the properties an object may have in a situation, the notion of a variable part structure of an object establishes itself rather naturally.

Along with the notion of situated part structure went the assumption that referential NPs refer not to objects, but rather pairs consisting of objects and situations. Because of distributivity (which is

possible for all argument positions of all predicates in English), this assumption had to be made in full generality; that is, all referential NPs refer to object–situation pairs and all arguments of predicates are object–situation pairs.

This use of reference situations raises many further questions. Foremost among them is: are reference situations needed for any other purposes than part structure sensitive predicates and part quantification? At first sight, reference situations seem to coincide with *resource situations* which are invoked in situation semantics in order to account for incomplete, referentially used definite descriptions, such as *the man* in (40) (cf. [1]):

(40) The man left.

However, reference situations are needed even for attributively used definite NPs and quantified NPs when they are complements of part-structure-sensitive predicates, as in (41):

(41) a. John counted the people in the room, whoever they were.

b. John counted some apples.

With attributively used definite NPs, as in (42), a speaker does not refer to a specific situation containing the referent.

(42) John's murderer is insane.

For the speaker may not know who the referent is, and even if he or she knew, (42) would be true even if someone else than the person in the situation the speaker is referring to is insane.

In order to account for such cases, one would either have to replace a single reference situation by a set of situations, the set of all (possibly counterfactual) situations that correspond to a particular situation type, or else by an abstract situation containing not the actual referent, but rather something like a parameter which can be anchored to the actual referent.

To sum up, part-structure related phenomena pose challenges in a number of ways. First, they lead to a radically different notion of part structure. Second, they lead to a new parameter in sentence meaning, namely reference situations. Reference situations certainly require further exploration, and hopefully obtain independent motivation.

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