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PART STRUCTURES, INTEGRITY, AND THE MASS-COUNT DISTINCTION

The notions of part and whole play an important role for ontology. They also play an important role in many areas of the semantics of natural language such as the mass-count distinction, certain semantic selectional requirements, and expressions whose lexical meaning is sensitive to the part structure of an object such as *whole, together,* and *individual*. In recent analyses both in philosophy and linguistic semantics, usually a particular notion of part structure has been used, that of extensional mereology. According to this notion, a part structure consists simply of a set of objects and an ordering among them, and objects are identical just in case they have the same parts. This paper argues that such a notion is insufficient for ontology and, especially, for the semantic analysis of the relevant constructions of natural language. What is needed for the notion of part structure, in addition to an ordering among parts, is the notion of integrated whole.

Integrity plays a role for the identity of objects in that two objects that have the same parts may fail to be identical because one has integrity and the other does not, an example being a heap and the sand of which the heap consists. But integrity need not be essential for an object: an object may be only an accidental integrated whole, an example being the sand when taking the shape of a heap. Moreover, an entity may be only a conceived integrated whole, for example, the sand by being looked at as an 'amount' of sand. It is such a more general notion of integrity, comprising essential, accidental and conceived integrity, that, as I will argue, is important for the analysis of the relevant constructions of natural language. Given the possibility of accidental and conceived integrity, the same object may have integrity of different sorts in different 'situations of reference' or 'contexts' or be an integrated whole in one context and fail to be one in another context. Given that conditions of integrity are constitutive of part structures, this also means that an object may have different part structures in different contexts.

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

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particular, transitivity and closure under sum formation. This means that integrity conditions also influence what counts as the parts of an entity in those contexts. Thus, an entity may not only have or lack integrity (of different sorts) in different contexts; it may also be divided differently into parts in different contexts.

The general notion of integrity (relativized to a situation of reference) is, I will argue, at the heart of the mass-count distinction and should lead to a replacement of traditional characterizations that make use only of extensional mereological part relations. Moreover, it is required for an appropriate semantic analysis of part-structure modifiers and certain semantic selectional requirements of predicates.

After laying out some general assumptions about the semantics of noun phrases, the paper first presents and critically discusses the extensional mereological theories of part structure. It then introduces the notion of integrated whole and argues that this notion is required for ontological part structures and also underlies the mass-count distinction. The importance of the notion of integrity is further shown with linguistic data involving semantic selectional requirements and part-structure modifiers. At the end, the paper presents some further and inconclusive considerations concerning, among other things, the notion of reference situation that has extensively been made use of.

This paper keeps the discussion of empirical data at a minimum and focuses on formal and conceptual issues concerning the role of integrity for part structures and the mass-count distinction. For more empirical discussions the reader is referred to Moltmann (1997).

1. PART STRUCTURES

1.1. *Basic Assumptions*

The following discussion presupposes certain widely shared assumptions about the semantics of singular count, plural, and mass NPs, which first need to be made explicit.

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 such as *the apple*, *every apple*, and *some apple* refer to or quantify over individuals. Thus, *the water* refers to a quantity of water, *all water* and *some water* (universally and existentially) quantify over quantities of water, *the boxes* refers to a group of boxes, and *all boxes* and *some boxes* (universally and existentially) quantify 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* consists of all the water quantities and the extension of *boxes* of all the groups of boxes. Plural nouns obtain their extension by an operation of sum formation from the corresponding singular noun, as in (1), where *sum* is an appropriate sum operation, mapping a set of entities to the 'sum' or 'group' consisting of those entities:

(1) $[\textit{boxes}] = \{x | \exists X (X = \emptyset \,\&\, x = \textit{sum}(X) \,\&\, X \subseteq [\textit{boxes}])\}$

Quantified singular count, plural, and mass NPs can then be uniformly conceived as quantifiers ranging over their respective domain consisting of individuals, groups, or quantities (cf. Moltmann 1997).

There is one difference, though, between definite singular count NPs such as *the man* and definite mass and plural NPs such as *the water* and *the boxes*. Given the Russellian 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 satisfied with 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. Sharvy (1980); see also Link (1983) and Ojeda (1993)). The denotations of *the water* and *the boxes* will then be as in (2). Here [*water*] is the extension of *water* (in the relevant context) and *sum* the relevant sum-operation:

(2) a. [*the water*] = *sum*([*water*])
b. [*the boxes*] = *sum*([*boxes*])

The analogy among 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. Link 1983; Simons 1983). This is because using one and the same part relation for all three kinds of entities leads to problems when extensional mereological axioms are adopted, as we will see. The alternative, which I will argue for, is a unified part relation which is weaker than the extensional mereological ones and which involves the notion of integrated whole. The analogy among the semantics of singular count, plural, and mass NPs would then be accounted for on the basis of a single part relation, rather three different, though analogous relations. The reasons for adopting the alternative are a number of serious problems and inadequacies of the extensional mereological view of part structures. But let me first make explicit the assumptions of that view.

1.2. *The Extensional View of Part Structures*

A part structure on the extensional mereological view is a pair $(X, <)$, where X is a set of entities and $<$ the part relation that is specific to the type of entities in X, depending on whether the entities in X are individuals (or their parts), groups, or quantities. The view is called 'extensional' because it also assumes a particular condition on part structures, namely extensionality, the identity of objects that have the same parts.

There are various extensional mereological accounts of part structures.[1] But they all share certain fundamental assumptions; in particular, all extensional mereological theories assume transitivity, antisymmetry, reflexivity, and, usually, unrestricted sum formation:

(4) a. $x < y \,\&\, y < z \rightarrow x < z$ (transitivity)
b. $x < y \,\&\, y < x \rightarrow x = y$ (antisymmetry)
c. $x < x$ (reflexivity)
d. For any nonempty set X', $X' \subseteq X$, $sum_<(X')$ exists. (unrestricted sum formation)

Formally, the operation sum is usually defined as the least upper bound (cf. Link 1983), as in (5):

(5) $sum_<(X) = \iota x[\forall y(y \in X \rightarrow y < x) \,\&\, \forall x'(x' \in X \,\&\, (\forall y(y \in X \rightarrow y < x')) \rightarrow x < x'))]$

There is a better way of defining sums, though, namely by using the overlap relation, as in (6) (cf. Simons 1987):

(6) *Definition*
For a nonempty set X,
$sum_<(X) = \iota x[(\forall y)(y O_< x \leftrightarrow (\exists z)(z \in X \,\&\, y O_< z))]$

This definition is more adequate for the present purpose than the definition of least upper bound, since, unlike by (5), by (6) two sets $\{x, y\}$ and $\{y, z\}$, where $x \neq y \neq z$, cannot have the same sum. Thus, there cannot be a model in which *John and Mary* and *Bill and Mary* denote the same object, the group consisting of John, Bill, and Mary.[2]

Generally, extensional mereological theories also posit extensionality, that is, the identity of objects that have the same proper parts (cf. Simons 1987):

(7) $(\forall x'(x' < x \;\&\; x' \neq x \leftrightarrow x' < y x' \neq y)) \rightarrow x = y$
(extensionality)

As will be discussed below, because of transitivity and extensionality, extensional mereological theories require a distinction between different part relations for the domain of individuals, groups, and quantities (cf. Link 1983; Simons 1987). Thus, on an extensional mereological account of the part relation, three different part structures will be assumed for entities in the universe: one for individuals $(I, <_i)$, with I as the set of individuals and $<_i$ the individual-specific part relation; one for quantities $(M, <_m)$, with M as the set of quantities and $<_m$ the mass-specific part relation, and one for groups $(G, <_{pl})$, with $<_{pl}$ as the plural-specific part relation. I will come back to this issue in the next section.

1.3. *Extensional Mereological Accounts of the Mass-Count Distinction*

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 usually is characterized in terms of domain-specific part relations, using the notion of atom:

(8) *Definition*
x is an *atom* in a part structure $(X, <)$ iff $\neg\exists y \in X\ (x \neq y \;\&\; y < x)$.

The simplest version of such an account of the mass-count distinction is as follows: the mass domain does not include any atoms (with respect to the mass-specific part relation) and the singular count domain consists of atoms (with respect to the plural-specific part relation) (cf. Ojeda 1993):

(9) a. If N is a mass noun, then $[N]$ contains no atoms (with respect to the mass-specific part relation).
b. If N is a singular count noun, then $[N]$ contains only atoms (with respect to the plural-specific part relation).

Given (9) and the semantics of plural nouns as in (1), the plural domain will consist only of atoms and their sums (with respect to the plural-specific part relation).

Obviously, (9) requires a distinction among different part relations, namely individual-, plural-, and mass-specific part relations. This is because objects in the extension of singular count nouns may have proper parts that are again in the same extension. They count as atoms only with respect to the plural-specific part relation, not with respect to the individual-specific or the mass-specific part relation. I will say more about this distinction and its problems below.

The characterization of the mass-count distinction in (9) implies that mass nouns denote indefinitely divisible quantities. This obviously raises the problem that quantities, almost all of them, are not generally indefinitely divisible (the 'minimal-parts problem').

There are two ways one might try to solve this problem. The first is to take the lack of atoms to be an only perceived property of mass noun extensions: mass nouns are treated as if they do not have atoms in their extension (cf. Ojeda 1993). It is hard, though, to make sense of this proposal. A merely formal property such as having proper parts with respect to the relevant part relation can hardly be viewed as a property the agent only imposes on an object.[3]

A second possible way of solving the problem is to adopt a weaker condition on mass nouns and construe the mass-count distinction simply in terms of plural and count nouns necessarily consisting of atoms and mass nouns not necessarily consisting of atoms:

(10) a. If N is a mass noun, then $[N]$ does not necessarily contain atoms.
b. If N is a singular count noun, then $[N]$ necessarily contains only atoms.

On this view, the actual extension of a mass and a count noun may be the same. But (10) does not solve the problem. For there are many mass nouns, for example *furniture*, whose extension necessarily contains atoms.

One might then propose an account of the mass-count distinction that does not make use of the notion of atom. Quine (1960), for example, proposes that mass nouns have a cumulative extension, whereas singular count nouns do not (or rather not necessarily):

(11) X is cumulative iff $\forall xy\ (x \in X\ \&\ y \in X \rightarrow \text{sum}(\{x, y\}) \in X)$ (cumulativity)

(12) a. If N is a mass noun, then $[N]$ is cumulative.
b. If N is a singular count noun, then $[N]$ is not necessarily cumulative.

The problem with this characterization, though, is that it does not provide a way of distinguishing mass nouns from plural nouns, whose extension is cumulative too.

Besides these difficulties, the most fundamental problem with the extensional mereological account of the mass-count distinction is that it requires a distinction between three different part relations for individuals, quantities, and groups. Consider nouns like *thing*, *entity*, or *sum*. Any part of a thing x is a thing, and so x could not be an atom with respect to the plural-specific part relation. Similarly, any part of a sum x is a sum, and so x could not be an atom. Moreover, any sum of things is again a thing, and any sum of sums is again a sum. Thus, elements in the extension of *thing*, *entity*, and *sum* are not atoms, and the extension of those nouns is cumulative. What is required to maintain the atomicity condition and the absence of cumulativity for such nouns is to take the elements in their extension to have parts and sums in two different senses: in the sense of the individual-specific part relation and in the sense of the group-specific part relation. Atomicity and cumulativity then pertain only to the group-specific part relation. Elements in the extension of *thing*, *entity*, and *sum* have only individual-specific and no group-specific parts, and they have only individual-specific and no group-specific sums.

The most important problem with the distinction between different part relations is the following. If two entities may stand in two different part relations to each other, then one needs to know on the basis of the properties the entities have which part relation obtains. However, there is nothing in the nature of the entities themselves that indicates that they stand in the individual-specific or in the group-specific part relation. The only way one could know is to look at what expressions have been used to refer to those things. But then we are in a circle. We wanted to find an independent semantic criterion distinguishing mass and count nouns and end up with a condition that requires looking at whether nouns of the categories mass or count have been used. If the mass-count distinction is drawn in terms of individual-, group-, and quantity-specific part relations, then the question whether any of the part relations holds between two entities cannot be decided by looking at the entities themselves, but rather must be decided by looking at whether the entities have been referred to by nouns of the categories mass, plural, or singular count. The problem arising on an extensional mereological account of the mass-count distinction thus is that it does not yield a language-independent criterion for the semantic mass-

count distinction, a criterion which tells whether an entity is an atom or a given set of entities is cumulative with respect to a given part relation.

Another, more empirical problem with the extensional mereological characterization of the mass-count distinction using the notion of atom is this. Atomic part structures may be imposed on entities independently of the use of count nouns. For example, the NP *the furniture as a whole* denotes an object which in every respect behaves like an atom in all circumstances of evaluation (cf. Section 2). Also, a count NP may denote a nonatom, namely when modified by *whole* as in *the whole picture*. The object denoted by *whole picture* behaves like a quantity in all relevant respects.

A third problem for the extensional mereological account of the mass-count distinction arises with constructions that are neutral as regards any particular part relation. One of them are part quantifiers such as *all of* or *part of* when they apply to categories lacking a singular count-plural-mass distinction such as free relatives:

(13) John ate part of/all of/some of what was on the table (the apple/the nuts/the bread)

Notice that for (13) to be acceptable, it may not even be known to the speaker what was on the table, and thus what kind of object the relative clause stands for. Hence it may not be possible to choose any one of the three part relations for the determination of the range of the part quantifier. The part quantifiers *part of*, *all of*, and *some of*, in other words, cannot be taken as ambiguous between three different part relations. The only alternative for (13) would be to require them to involve the union of the three part relations, as quantifiers of the form Qx: $x <_i y \vee x <_{pl} y \vee x <_m y$. But then they would be ambiguous between the general (disjunctive) and the specific part relations, and this cannot be. For example, (14) cannot mean that John failed to eat part of the apple relative to the plural-specific part relation (but perhaps that he ate part of it only relative to the general part relation):

(14) John did not eat part of what was on the table.

One would then have to assume that *part* always denotes the general, disjunctive part relation. Such a disjunctive meaning in itself is rather unnatural, though, in particular in view of the fact that all part quantifiers systematically behave the same way with respect to the range of objects they may apply to.

The distinction into three part relations poses a more serious problem when extensional mereology is applied to sums of mixed domains such as

the entities denoted by *the apples and the milk* or *the apple and the milk*. The question is, what sum operation is involved here and what part relation does the part quantifier *part* in (15) denote?

(15) a. part of the apples and the milk
b. part of the apple and the milk

Sum formation in (15a, b) applies to entities from different domains: the plural and the mass domain in (15a) and the individual and the mass domain in (15b). This requires the introduction of a new operation of sum formation sum_{gen} on mixed domains, mapping sets of entities from the individual, mass or plural domain, that is, subsets of $I \cup M \cup PL$ to their sum. On the basis of this new sum operation, a new, generalized part relation $<_{gen}$ has to be defined for sums formed from mixed domains, as in (16):

(16) $x <_{gen} y$ iff $\exists x' x'' y' y''$ $(x', x'', y', y'' \in I \cup M \cup PL$ & $x = sum_{gen}(\{x', x''\})$ & $y = sum_{gen}(\{y', y''\})$ & $x' <_{k} y'$ & $x'' <_{k'} y'')$ (for $k, k' \in \{i, m, pl\}$)

Then *and* in (15a, b) involves the operation sum_{gen} and *part of* expresses the relation $<_{gen}$.

Given that the sum of the singleton of an object a is a itself, the part relation $<_{gen}$ includes the individual-specific, mass-specific, and plural-specific part relation.

Notice that sum formation with $<_{gen}$ may be required also in cases in which the category of the denotations of the conjuncts is not known, such as free relatives:

(17) John ate part of what was on the table and what was in the fridge.

Part in (17), and in general, will have to have a disjunctive meaning with an additional disjunct for the part relation $<_{gen}$. This, however, leads to serious problems, namely it makes the part relation transitive across different domains. It would predict, for example, an unavailable reading of (18) on which *part* ranges over groups of parts of an individual painting, rather than, as on its natural reading, over entire paintings:

(18) John painted part of the paintings.

The unavailable reading arises because $<_{gen}$ holds between a group x of parts of one of the paintings z and the entire group of paintings y. For x

is the sum of parts $x_1, x_2, x_3, \ldots$ that are individual parts of the painting z which is a plural-specific part of y (that is, $x_1 <_i z$, $x_2 <_i z$, $x_3 <_i z$, ..., and $z <_{pl} y$).

Thus, the possibility of extensional mereological operations across different domains requires a unified general part relation which raises the same problems with transitivity that the distinction into different part relations was originally supposed to solve.

1.4. *An Account of the Mass-Count Distinction Based on Integrity*

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 possible to use a single part relation for all domains of entities. In the following, I want to show that on the basis of that notion, the mass-count distinction can be construed more adequately.

The notion of integrated whole has played an important role in ontological discussions in the history of philosophy, going back to Aristotle and later Husserl (see Simons 1987 for an overview of the history of the notion). But the concept has become less prominent in more recent philosophical and especially linguistic analyses.

The notion of integrated whole, I want to argue, is at the heart of the mass-count distinction, and it can itself best be introduced by contrasting mass nouns with count nouns. When count nouns are converted into mass nouns, generally an implication of integrity gets lost in the process. Thus, *apple* as a count noun implies a certain shape, whereas *apple* as a mass noun rather suggests the loss of shape (e.g., pieces of apple).[4] Similarly, *cake* as a count noun implies a certain shape, whereas *cake* as a mass noun does not imply any shape. Conversely, when mass nouns are converted into count nouns, some kind of integrity will be added. Thus, a gain and a loss of a presupposition of integrity systematically occur when mass nouns are turned into count nouns and conversely.

As a first approximation, then, the distinction between mass and count nouns as a semantic distinction among the content of nouns resides in the fact that mass nouns imply that any entity in their extension is not an integrated whole, whereas count nouns imply that any entity in their extension is an integrated whole. This characterization of the mass-count distinction still needs to be revised, though, in several ways.

But first we need to address the question, 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 cer-

tain conditions hold among its parts – for instance, that 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 Simons 1987 for a more extensive discussion of the notion of integrity.) The notion of integrated whole is a very difficult one: no single definition of integrated whole has been developed, and it is not clear that it can be developed at all (cf. Simons 1987).

The difficulties with the notion of integrated whole might put into question the general approach of drawing the mass-count distinction on the basis of it, and it may shed a more favorable light on the extensional mereological approach. But clearly, the fact that a notion has not yet been defined, is very hard to define, or cannot be defined in a unified way does not constitute an argument at all against the ultimate adequacy of an account that makes crucial use of that notion.

The various count nouns there are in English involve all sorts of integrity conditions. Let me here introduce only one, very simple notion of integrated whole, a notion which by no means accounts for the kinds of integrity conditions imposed by mass nouns in general. This notion, which is adopted in a simplified way from Simons (1987), is the notion of R-integrated whole. For an appropriate relation R, an entity x is an R-integrated whole just in case all the parts of x are connected under R and no part is connected to an entity that is not part of x (cf. Simons 1987). The appropriateness of R consists basically in that R is a nonlogical relation and not a purely formal one such as difference or identity.

Let R_{trans} be the transitive closure of R, then we have:

(19) *Definition*
For a nonlogical, symmetric relation R, x is an (R-)*integrated whole* ((R)-INT-WH(x)) iff for every y and z such that $y < x$ and $z < x$, $R_{\text{trans}}(y, z)$, and for every y such that $y < x$ and for no w such that $\neg w < x$, $R_{\text{trans}}(y, w)$.

A simple example of an R-integrated whole is John's parents. John's parents form a group 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.

Let me now turn to the necessary revisions of the initial characterization of the mass-count distinction that I have given. The first revision consists in that the integrity imposed by count nouns may be relative to a particular time and a particular world. The reason is that certain count nouns – at least sometimes – express accidental, rather than essential, integrity conditions. Examples are *line, collection, configuration,* and *group*, as in *the line of*

people, the (loose) collection of papers on my desk, the configuration of chairs, and *the group of people in the room*.

That these nouns express accidental integrity conditions is not just a matter of mere intuition. There are some more linguistic criteria for whether nouns express accidental or essential integrity.

One of them is the application of predicates of existence. Predicates of existence do not seem to hold of the NPs with head nouns expressing accidental integrity under any other conditions than when they hold of the corresponding plural NPs:

(20) The line of people/The (loose) collection of papers on my desk/The group of people in the room does not exist anymore.

(20) doesn't make sense if the people ceased to form a line, the papers ceased to form a loose collection on my desk (without ceasing to be papers), and the people ceased to be a group in the room.

Another criterion is the use of anaphora. In the construction singular count noun-*of*-plural NP, with the singular count noun expressing accidental integrity, anaphora can relate only to the plural, not the singular count noun. But with singular count nouns expressing essential integrity, anaphora can relate to the singular count noun (and relate less easily to the plural):

(21) a. John saw Mary's collection of paintings. He liked it/? them.
b. John looked at the (loose) collection of papers on my desk. He did not recognize them/?? it.

In order to account for accidental integrity, one might propose that mass and count nouns should be characterized by the absence of integrity relative to a world and a time, rather than absolutely. But this is not yet quite right. If mass and count nouns are distinguished by imposing essential or accidental integrity, a problem arises if the same entity, an accidental integrated whole, is referred to, for example, as *the stuff* and *the collection of stuff*.[5] In this case, the mass NP does not imply the absence of integrity (but the absence of essential integrity). To account for those cases, it is necessary to assume that the NP relates not to an entire world for its evaluation, but rather to a partial world, a situation. In a particular situation, an object may be an accidental integrated whole; but in a smaller subsituation, it may fail to have integrity. Thus, mass nouns should be characterized as not expressing integrity in the minimal situation or situation type the speaker has in mind when referring to an object with the utterance of an NP. Let me call this situation or situation type *reference situation*. I will come back to this notion later on.

There is another potential problem for the account in (9) and that is nouns like *thing* (in some, especially philosophers', uses). Such nouns do not obviously express any kind of (essential or accidental) integrity. However, they do seem to impose implicit integrity conditions: the count noun leaves open what sort of integrity conditions should obtain so that the kind of integrity generally depends on the nature of the relevant entity. For example *thing* implies that an entity it applies to is an integrated whole, though it does not say exactly in which way. The implication of integrity can be seen by applying the predication test:

(22) 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 (22a), not mass predicates such as *apple*, as in (22b). 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*. (22c) illustrates that the mass noun *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, entities which consist of integrated wholes). Examples are the nouns *group* and *collection*. In the case of *the group of rocks*, the rocks may form an integrated whole with respect to space only, whereas in the case of *the group of scientists*, the scientists may form an integrated whole with respect to work cooperation only.

Another noun imposing implicit integrity condition is 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') (cf. Sharvy 1983). As a count noun, it implies that the object 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 is compatible with a mass subject, whereas as a count noun it is compatible with a count subject, as seen in (23a) and (23b). Moreover, a plural subject such as *the leg and the back* in (23c) requires the plural *parts* as predicate, rather than the singular *a part*:

(23) 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.
c. The leg and the back are parts of /# a part of the chair.

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'.[6]

Another revision of (9) is required. What distinguishes the referents of *a quantity of water* from *water*, of *an amount of wood* from *wood*, *an (arbitrary) collection of furniture* from *furniture*, *patches of snow* from *snow*, or *shoes* from *footwear*? There may be no manifest, essential or accidental, integrity that distinguishes the referent (or its parts) of the first NP from the referent of the second. But still, it appears, by using a count noun, the entity is referred to as an integrated whole or as consisting of integrated wholes, but with the integrity being a merely conceived one. The integrity imposed by those count nouns is not one found in the entities themselves but only one projected onto them. An (arbitrary) collection of furniture, for example, differs from furniture only in that the speaker conceives of the pieces of the furniture as belonging together – otherwise the pieces of furniture need not share any manifest property or connection.

There is also linguistic evidence that shows that such nonmanifest, conceived integrity is involved. It comes from what can be called the *predication test*. We observe that when the subject is singular count, the predicate in general also needs to be singular count, rather than being mass or plural; and when the subject is mass, the predicate also needs to be mass, rather than being singular count:

(24) a. This patch of snow is a new patch of snow.
b. This patch of snow is new snow.

(25) a.?? This snow is new snow.
b.?? This snow is a new patch of snow.

These data can be explained semantically if it is assumed that all singular count nouns characterize an object as an integrated whole. If a subject is singular count, its referent is characterized as an integrated whole, and hence it requires a predicate allowing for integrity, rather than excluding it – as mass nouns do. Conversely, if a subject is mass, then its referent is characterized as not being an integrated whole; hence the predicate may not characterize the object as an integrated whole, but rather must imply the absence of integrity.[7]

The fact that a referent of an NP may be characterized as a merely conceived integrated whole imposes a further condition on how the situations for the evaluation of NPs, namely the reference situations, should be conceived. They should not only be able to represent objects with manifest properties, but also with properties the relevant agent only imposes on the object.

How should reference situations be construed formally so as to incorporate all three functions, representing accidental properties, partial information, and merely conceived properties? Later in Section 3, I will address in more detail the questions about the status of reference situations and their independent motivation. At this point, it should only be pointed out that reference situations should not include any particular domain of entities. The reason is the possibility of an attributive use of definite descriptions.

(26) The murderer of Smith is insane.

As Soames (1986) points out, (26) may be true in a circumstance of evaluation even if there the referent of *the murderer of Smith* is a different one than in the actual world. Thus, the truth of (26) should not depend on any particular domain of entities for the evaluation of *the murderer of Smith*.

Let me settle then the question about reference situations in the formally simplest possible way, namely by taking reference situations to be functions s from a domain D, a set of entities, to a function mapping an n-place property and an n-tuple of entities from D to one of the truth values 1 (True), 0 (False), and # (Undefined). We then have the condition in (27):

(27) For any reference situation s, domain of entities D, an n-place property P, and entities $x_1, \ldots, x_n$:
if $s(D)(P, \langle x_1, \ldots, x_n\rangle) \in \{1, 0\}$, then $x_1, \ldots, x_n \in D$.

Together with a domain D, a reference situation s constitutes a situation in the more traditional sense. Let me call such a situation a *domain-dependent situation*. A domain-dependent reference situation answers the question positively whether an n-tuple $\langle x_1, \ldots, x_n\rangle$ falls under a property P if it assigns the value 1, negatively if it assigns the value 0, and it leaves the question open if it assigns it the value #.

Part-structure-related predicates such as '$<$' and 'INT-WH' now should be relativized to a domain-dependent situation. They will then denote the *situated part relation* and the property of *situated integrated wholes* and define *situated part structures*. If x is part of y in a situation s with domain D, we will have $s(D)(<, \langle x, y\rangle) = 1$. If x is an integrated whole in a situation s with domain D, we will have $s(D)$(INT-WH, x) = 1. Often I will notationally simplify and use 's' instead of '$s(D)$', assuming the domain is fixed. I will then also use the simpler notation '$x <_s y$' and 'INT-WH(x, s)', instead of '$s(D)(<, \langle x, y\rangle) = 1$' and '$s(D)$(INT-WH, x) = 1'. I take the two-place notion of situated integrated whole 'INT-WH*' to be a more general notion than the one-place notion 'INT-WH' of essential integrated whole. Thus, if for an object x, INT-WH$^*(x)$, then also INT-WH(x, s) for any reference situation s.

There is another condition on reference situations, and that is that they should specify entities in their domain with all their essential properties:

(28) For a situation s and a domain D, if P is an essential property of x only involving x ($x \in D$), then $s(D)(P, x) = 1$.

The condition 'only involving x' should exclude properties such as having particular essential parts, since, as we will see in Section 2, not all essential parts of an entity need to be included in a situation.

For reasons to be explained later (Section 2), reference situations (without domain) should form an additional argument position of any noun, and as such they will also form an additional argument of any predicate. A general condition on a reference situation that is arguments of a noun then is that it should represent the referent of the noun phrase with the property expressed by the noun and its modifiers. Thus, if we take nouns to denote functions from worlds to extensions, we get the following condition on the semantics of common nouns, where $D(w)$ is the domain of the world w:

(29) If $[N']^w(x, s) = 1$, then $s(D(w))([N'], x) = 1$.

Given this, the mass-count distinction can now be characterized as follows, using the notion of situated integrated whole INT-WH*, the two-place relation between entities and (reference) situations:

(30) *Characterization of the mass-count distinction*

(i) For a singular count noun N and a domain-dependent situation s, if $[N](x, s) = 1$ or 0, then INT-WH(x, s).

(ii) For a mass noun N and a domain-dependent situation s, if for a minimal reference situation s such that $s([N], x) = 1$ or 0, then ¬ INT-WH(x, s).

Recall that the use of partiality is crucial for an appropriate characterization of mass nouns. Mass NPs often refer to integrated wholes, but, so the claim goes, in a minimal situation of reference such integrity can be disregarded. That is, in such a situation s for a mass referent x, we will have s(INT-WH, x) = #.

The use of reference situations for the evaluation of NPs and the appeal to minimal situations in the characterization of mass nouns raises the question of how big or small reference situations should be. The general principle is that reference situations tend to be small: they should contain the descriptive information provided by the NP – though to some extent they may also represent implicitly given integrity conditions, as we will see

later (Section 2). The requirement for reference situations to be small, most plausibly, is enforced by general conditions of communication. Reference situations should match as much as possible the explicit information that was given.

1.5. *Integrity and Part Structures*

What role does integrity play in part structures? Most importantly, integrity is (partly) responsible for the failure of extensionality and transitivity of the part relation. 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. Wiggins 1980). The sand constitutes the heap, but it is not identical to it. The reason is that the heap is an entity that essentially has a form and hence is an 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 – that is, the referent of *the orchestra members*. Thus, extensionality, the principle that two entities sharing the same proper parts are identical, may be blocked whenever one entity essentially is an integrated whole, but the other one is not.[8]

As concerns transitivity, it has been observed that 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 library's collection; but the page is intuitively not part of the library's collection. One way of explaining the failure of such inferences is to argue that the premises involve different part relations – in the first case, for example, the relation of being a part of an individual and the relation of group membership. Such an explanation is more difficult to give, though, for the second case.

With the notion of an integrated whole, a different account is possible using one and the same part relation: an inference from $x < y$ and $y < z$ to $x < z$ is allowed only if y is not an integrated whole. y not being an integrated whole should only be a necessary, not a sufficient condition, though, for the conclusion to obtain. 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.

The question then is: under what conditions exactly does transitivity go through? I will not try to provide a complete answer to this question, but only indicate the nature of the condition at stake. Consider the inference in (31):

(31) The page is part of the book.
The book is part of my written work.
The page is part of my written work.

Transitivity seems to go through in (31), even though the book is an integrated whole. The reason for this 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, the library's collection does require books as parts and thus integrated wholes. In other words, it is (more or less) essential for a library's collection 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 – that is, the inference from $x < y$ and $y < z$ to $x < z$ – is conditional upon the integrity of y not being essential for z.

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. In fact, the integrity of the left hand is also essential for the body. This suggests that it depends ultimately on the nature of the entity x itself – that is, on what part structure x has essentially – whether some subunit counts as its part or not. More precisely, the inference from $x < y$ and $y < z$ to $x < z$, is conditional upon one of two conditions being fulfilled: either y is not an integrated whole or the essential part structure of z implies the essential integrity of x as a part of z.

A view of part structure then emerges that deviates even more radically from the extensional mereological view than the account of situated part structures that I will give later (which simply conditionalizes extensional mereological axioms and uses a non-relational, nonmodal notion of integrated whole). As soon as essential integrity is involved, what the parts of an entity are cannot be determined by looking merely at whether subunits of the entity are integrated wholes and at what part-whole relations hold among them. Rather the parts are determined on the basis of the type of essential part structure the object has as a whole, simply by what kinds of parts the object must have.

This more complex condition holds, of course, only for ontological part structures, since only they involve essential integrity. In the domain of pluralities and masses, essential integrity is irrelevant. In the domain of plurals, only atoms – elements also in the extension of the corresponding singular count noun – can be essential integrated wholes, not groups of

atoms, which qualify only for accidental integrity. Similarly, quantities cannot be essential integrated wholes.

Thus, it may not be possible to impose any significant conditions on ontological part structures independently of the type of essential part structure of an object – in the presence of essential integrity, certainly transitivity and closure under sum formation do not hold. What counts as a natural part simply depends on the part structure the object has essentially or normally – that is, on which potential parts are essential or normal and which are not. But in the absence of essential integrity, general conditions such as transitivity and sum formation certainly obtain. We can thus say:

(32) A pair $(X, <)$, where X is a set of non-integrated wholes, is an *ontological part structure* iff

(i) $x < y \,\&\, y < z \rightarrow x = z$
(ii) $x < y \,\&\, y < x \rightarrow x = y$
(iii) $x < x$
(iv) For any nonempty set X', $X' \subseteq X$, $sum_{<}(X')$ exists.

Integrity plays a role in the domain of pluralities and masses only insofar as it is relative to a particular reference situation – depending on the essential or accidental properties entities have in that situation, on the domain of the situation, and on the amount of partial information the situation contains. Thus, transitivity can be blocked when subgroups or subquantities are situated integrated wholes, as on the group-group comparison readings of (33a) and (34a) and the only readings of (33b) and (34b):

(33) a. The girls and the boys are incomparable.
b. The water and the wine are incomparable.

(34) a. The hot stones and the cold ones cannot be compared.
b. The hot and the cold sand cannot be compared.

Define the relation FF on the basis of a one-place property F as: FF(x, y) iff $F(x)$ and $F(y)$. Then, in the reference situation with a particular domain in (33a), the group of the girls and the group of the boys happen to be the maximal groups of girls and of boys and thus form FF-integrated wholes for F = the property of being a girl and the property of being a boy respectively. Similarly, in (33b), the water and the wine happen to form FF-integrated wholes for F = the property of being water and of being wine respectively. We then get the relevant nontransitive part-structure-readings on which John compared the group of the girls to the

group of the boys in (33a) (rather than individual girls and boys) and on which he compared the water to the wine in (33b). In (34a) and (34b), we can get nontransitive part structures on the basis of accidental properties.

Thus, the following condition holds for situated part structures:

(35) $x <_s y \,\&\, y <_s z \,\&\, \neg$ INT-WH*$(y, s) \rightarrow x <_s z$

(35) does not say anything about what happens when y is an integrated whole. Here both options are left open: that x is a part of z and that x is not a part of z. The first option must be admitted because (33a), for example, also allows for the 'fusion'-reading on which individual girls and boys are said to be incomparable.

When transitivity is given up, the notion of sum has to be redefined. It must now be defined relative to the transitive closure of the situated part relation, as in (36b):

(36) a. x *trans*$(<_s)$ y iff $\exists z_1, \ldots, z_n\ (x <_s z_1 \,\&\, \ldots \,\&\, z_n <_s y)$

b. $sum_{trans(<_s)}(X) = \iota x[(\forall y)(y O_{trans(<_s)} x \leftrightarrow (\exists z)(z \in X \,\&\, y O_{trans(<_s)} z))]$

Closure under sum formation should not hold unconditionally for the situated part relation. Certain types of examples in natural language require that it be restricted for sets whose elements are integrated wholes. In other words, the domain of a situation should contain a group as an entity (that is, a sum of integrated wholes) only under certain conditions. Consider the following examples with a part-structure-sensitive predicate and quantification over parts:

(37) a. John compared the students.

b. All of the students made two mistakes.

On one reading, *compare* in (37a) involves an evaluation among individual students, not subgroups of students, and *all* in (37b) ranges only over individual students, not subgroups of students. Given that *compare* involves the situated part relation, this means that no proper subgroup of students should be a (situated) part of the group of students, only individual students should. Thus, no group of students should be in the domain of the situation except for the maximal group of students. How can one derive the fact that subgroups should not and the maximal group should be included in the domain of a situation? The difference between the two sorts of groups is that the maximal group is an FF-integrated whole for F being the property of being a student, but the subgroups are not. Thus, the domain of a situation

should contain the sum of a set of integrated wholes just in case that sum itself is an integrated whole in the situation.

Contrast this case now with the part structure of a quantity. Such a part structure generally must include all subquantities, as can be seen from the contrast between (38a) (which contains a predicate which could hold only of certain subquantities, and (38b)) which contains a predicate which can hold of all subquantities:

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

The unacceptability of (38a) and the acceptability of (38b) can be explained if the parts of the water in the relevant situation must include all subquantities of water.

So the principle we need is as follows: if for a situation s, a set X consists only of entities that are integrated wholes in s, then X does not have a sum in s, unless the sum itself would be an integrated whole in s. This principle can be formulated as the following condition on the domain of a situation, where $<$ is the ontological part relation (which is closed under sum formation):

(39) *Restriction on Situated Sum Formation*
If for a situation s and a nonempty set X: for every $x \in X$, INT-WH(x, s), then $sum_{<_s}(X)$ exists iff INT-WH($sum_{<}(X)$, s).

We have seen that the notion of integrated whole is a crucial parameter for the mass-count distinction and for many conditions on part structures. The general picture that emerges then is that extensional mereological properties hold only under certain conditions, depending on whether entities or their parts are integrated wholes.

Let us turn to the notion of situated part structure. Given that an entity may have a part structure only relative to a particular situation, we get a new, more complex notion of part structure. For a given situation s, such a part structure will be composed of two sub-part structures: the ontological part structure and the part structure relative to 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 reference situation to be a component. This is because integrity conditions can be 'retrieved' from the information content of the situation. To make this precise, I will restrict myself to R-integrated

wholes, since this is the only defined notion of integrated whole that I am using. We then have:

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

It is important that the integrity-defining relations R are relativized to the situation: whether an entity counts as an integrated whole in a situation depends solely on what relations hold among its parts in that situation, not on what relations hold among them in the actual world. We have seen reasons for that earlier with examples such as (34a, b), where only the properties of being hot and being cold matter, not, let's say, color.

Situated part structures can now be defined as follows:

(41) For a (domain-dependent) 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 $y <_s x$, then $x = y$.
(v) If $x <_s y$ and $y <_s z$ and $\neg$ INT-WH*(y, s), then $x <_s z$.
(vi) If for a set $X \subseteq D(s)$, $X \neq \emptyset$, for every $x \in X$ INT-WH*(x, s), then $sum_{<_s}(X)$ exists iff INT-WH*($sum_{<}(X)$, s).

Given (41ii) and (41iii), a situated part structure is always a restriction of an ontological part structure. (41iii), the condition that the situated part relation be a restriction of the ontological part relation, actually can be derived from the condition (41ii), the condition that the domain of the situation be a subset of the ontological domain (given the general conditions on reference situations). The situated part relation is a subrelation of the ontological part relation because, as I have so far assumed, essential integrity is preserved in a situation. It may be a proper subrelation because of the accidental and conceived integrity that the situation may carry (which may specify fewer situated parts of a given entity) and because the domain of the situation may be more restricted than the universe. A situated part structure will take into account at least as much integrity as an ontological part structure, and this is what makes the situated part relation a possibly coarser relation than the ontological part relation.[9]

2. FURTHER LINGUISTIC DATA INVOLVING ESSENTIAL, ACCIDENTAL, AND CONCEIVED INTEGRITY

The semantics of mass nouns and plurals is the main area that has traditionally been recognized as involving part-whole relations. However, there are a number of other types of phenomena in natural language that involve part structures, and usually they also involve the notion of integrity. In fact, we find phenomena for each of the three kinds of integrity: essential, accidental, and conceived integrity.

Certain predicates, let's call them *part-structure-sensitive predicates*, take the part structure of an argument into account, in particular a group or a mass argument. For example, *compare* and *count* when applying to a group argument x say something about the parts of x:

(42) a. John compared the students.
b. John counted the students.

Part-structure-sensitive predicates may differ, though, as to whether they care about the situated or the essential part structure of an argument. *Compare*, as in (42a), is an example of a part-structure-sensitive predicate that cares about situated (essential or accidental) part structures, whereas *count*, as in (42b) is a predicate that cares only about essential part structures.

(42a) can have a reading on which John compared only certain subgroups of students – for example, the MIT students and the Harvard students. Here, implicit information provided by the reference situation specifies two subgroups of students as accidental FF-integrated wholes (for F being the property of being a student at MIT and the property of being a student at Harvard respectively). This integrity allows the two subgroups to be formed in the first place and moreover prevents the individual students from being parts in the reference situations (as they are not being compared). In this case, the group of students will have only two accidental parts in the reference situation and no essential parts.

(42b), by contrast, can only have the reading on which John counted the individual students – that is, on which he counted the essential parts of the group of students.

An important phenomenon supporting situated part structures is *semantic selectional requirements*. 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. One such requirement is what I call the 'Accessibility Requirement' (cf. Moltmann 1997). Part-structure-sensitive semantic selectional requirements, again, show that part structures for the purpose of semantic analysis must include conditions of integrity.

The Accessibility Requirement manifests itself in that certain predicates appear to take only plural or mass but not singular count NPs, as in (43), or if they take count NPs, they have a clearly different reading, as in (44). In (45), we have predicates not subject to the requirement:

(43) a. John compared/distinguished/ranked the family members/# the family.
b. Among the chairs/the rice/# the group of chairs/# the bowl of rice.

(44) a. John counted/listed the family members.
b. John counted/listed the family.

(45) a. The family is/The family members are in the house.
b. The chairs are/The group of chairs is blue.

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 the family, then, if he counted right, he counted one, but not so if he counted the family members (and there was more than one member); similarly for *list*. Clearly, the condition that prevents *count* and *list* from involving family members when taking *the family* as its object is the same as that which prevents *compare*, *distinguish*, and *rank* to be applicable to *the family* at all.

What distinguishes the predicates in (43) and (44) from those in (45) is that the former, but not the latter, make reference to the parts of an argument. For example, *compare* when applying to a group x involves a comparison among the parts of x, and *among* when applying to a pair $\langle x, y\rangle$ locates x somewhere in between the parts of y. The requirement in question, thus, consists roughly in that predicates making reference to the parts of an argument can apply to an entity x only if x is not an integrated whole.

The requirement not only affects predicates, but also, for example, the distributive interpretation of a predicate. Distributivity is available generally only when the argument is not a referent of a singular count NP. Thus, it is possible in (46a) and (47a), but impossible in (46b) and (47b):

(46) a. The chairs are light.
b. The group of chairs is light.

(47) a. John gave the students an A.
b. John gave the class an A.

(46a) has a reading in which each one of the chairs is light; but such a reading is unavailable in (46b). Similarly, (47a) has a reading in which

John gave each student an *A*; but (47b) must mean that John evaluated the class as a whole.

There are different views of how the distributive interpretation of a potentially collective predicate should be conceived. A discussion of these views should not concern us here (cf. Moltmann 1997). What is important is only that distributivity can be subsumed under the condition above on part-structure-sensitive predicates on any view on which distributively interpreted predicates involve a quantifier ranging over the parts of the argument, as either an implicit distributivity operator or as part of the lexical meaning of the verb (see Link 1983, Roberts 1987, Moltmann 1997 for discussion). The requirement then says that a predicate or reading of a predicate making reference to the parts of an argument can apply to an entity only if the entity is not an integrated whole.

This formulation is not yet quite correct, though, because it must be relativized to reference situations. The crucial empirical observation is that count nouns which may express accidental, rather than essential integrity conditions behave exactly the same with respect to the relevant predicates:

(48) a. John compared the people/# the line of people.
b. John cannot distinguish the papers on my desk/# the loose collection of papers on my desk.
c. John counted the people in the room/# the group of people in the room.

Thus, the Accessibility Requirement cares about whether a potential argument of a part-structure-sensitive predicate is an integrated whole in the reference situation, rather than being one essentially:

(49) *Accessibility Requirement*
A predicate or reading of a predicate that makes reference to the parts of an argument can apply to an object x in a reference situation s only if x is not an integrated whole in s.

The fact that the Accessibility Requirement involves situated part structures has an unusual and not uncontroversial consequence. As a general fact, every predicate in English allows for a distributive interpretation for every argument position, and distributive interpretation is subject to the Accessibility Requirement. But this means that now every argument position of any predicate must be made sensitive to reference situations, and hence every argument position must take pairs consisting of entities and reference situations. Correspondingly, every referential NP must denote not simply an object, but rather a pair consisting of an object and a reference situation. Thus, harmless as situated part structures may seem, the

role that they play in natural language implies rather radical changes in the familiar semantic structure of a sentence: the simple picture that referential terms refer to objects and predicates take those objects as arguments now has to give way for the view that reference situations always form a component of the denotation of a referential term and of any argument of any predicate. The reference situation specifies what the part structure of the entity is so that the evaluation of the predicate can take that part structure into account. Reference situations then play a very different role than indexical parameters in the traditional sense such as time and location. Unlike those parameters, reference situations do not just help to identify an object, rather they influence also the evaluation of the predicate and thus must form part of the argument the predicate takes. I will come back to this point in Section 3.

There is even stronger evidence that the Accessibility Requirement involves not the essential part structure of an entity, but rather the part structure it has in a reference situation. It comes from what I call *part-structure modifiers*. Part-structure modifiers include postnominal modifiers such as *together, as a whole, as a group, as a collection*, and *alone* as in (50a), as well as adjectival modifiers such as *individual, whole,* and *entire,* as in (50b):

(50) a. the boxes together/as a whole/as a group/as a collection/alone
b. the individual boxes, the whole class, the entire collection

Part-structure-modifiers generally also occur in adverbial position.

The meaning of part-structure modifiers generally involves the notion of integrated whole. Thus, *together* in adverbial position as in (51a) means that John and Mary form an integrated whole by cooperating in their work, and *together* in (51b) that they form an integrated whole by being spatially close:

(51) a. John and Mary work together.
b. John and Mary sat together.

Suppose then that the meaning of *together* is to specify integrity in some way or other. Then what is its meaning in adnominal position, as in (52)?

(52) a. John and Mary together weigh 100 pounds.
b. The stamps together cost 100 dollar.
c. The boxes together are too heavy.

To answer this question, let us first consider what the function of adnominal part-structure modifiers is. Adnominal part-structure modifiers have a

semantic function that does not consist in a contribution to the descriptive content of the sentence. Rather they make more abstract semantic contributions. One of them 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* in (52) is to block a distributive interpretation of the predicate. This fact can be taken together with the observation that the presence of *together* in (53) renders a part-structure-sensitive predicate unacceptable:

(53) # John compared/classified/enumerated/rated/ranked the paintings together.

These two facts follow if *together* also in adnominal position specifies that the entity it applies to is an integrated whole – that is, has an inaccessible part structure.

But what kind of integrated whole should the entity be to which adnominal *together* applies? Neither do the expressions themselves tell us what kind of integrity should obtain, nor does the relevant context in which *together* applies. For example, *together* in (52c) 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* in (52c) appears like an unspecific instruction to the addressee 'conceive of the boxes as an integrated whole'. That is, the boxes are said to form a merely conceived integrated whole in the reference situation, namely, an *R*-integrated whole with *R* being the relation of being conceived as belonging together.

With adnominal *together* then we have a second case besides certain count nouns where an expression specifies merely conceived integrity.

The adjectival modifier *whole* has the opposite effect on predicates requiring accessible part structures and on distributivity. When modified by *whole*, a collective NP allows for distributive interpretation, as in (54a, b), and part-structure-sensitive predicates, as in (55a–c), which would otherwise be impossible:

(54) a. John gave the whole class an A.
b. The whole collection is too expensive.

(55) 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.

Both (54a) and (54b) allow for distributive readings, and the examples in (55) are perfectly acceptable (with the relevant readings of the predicates).

This effect of *whole* can be explained if *whole* as an adjectival modifier characterizes the part structure of an entity as being accessible – that is, as not constituting an integrated whole – in the reference situation. Since the singular count noun, e.g., in (54a) *class*, has done precisely the opposite, namely characterize the entity as a very specific integrated whole, apparently *whole* changes the reference situation, namely by eliminating properties that would define the entity as an integrated whole. Notice that this must be possible even if those properties are essential – as is the case with *class* in (54a) and *family* in (55a).

The modifier *individual* also interacts with distributivity. *Individual*, when modifying a plural NP, enforces a distributive reading of the predicate, and it enforces a particular distributive reading:

(56) a. John gave the individual students an A.
b. John likes the individual students.

(56a) and (56b) only have distributive readings, and they have only readings on which the predicate distributes over the group members. (56a) could not possibly describe a situation in which John gave certain subgroups of students an A, and (56b) could not possibly describe a situation in which John likes certain groups of students (as groups).

Moreover, with predicates sensitive to the part structure of an argument, *individual* enforces a particular part-structure-related reading, as in (57a), as opposed to (57b):

(57) a. John compared the individual students.
b. John compared the students.

(57b) may be true in a situation in which John compared some group of students to another group, for example the Harvard students to the MIT students. But such an interpretation is excluded in (57a), which can only be true if John compared any one student to any other student.

Again, this can be attributed to a particular part-structure property which *individual* expresses. *Individual* can be analysed as expressing the property of having only parts in the reference situation that are essential integrated wholes. (Recall that only group members, not subgroups are essential parts of a group.) It then follows that the situated part structure of a group specified by individual consists only of the group members, and no subgroups.

The meanings of adnominal *together, as a whole*, *whole*, and *individual* can thus be conceived as relations between objects and reference situations as in (58):

(58) a. [*together*] = [*as a whole*] = $\lambda x s$[for all domains D: INT-WH*(x, $s(D)$)]
b. [*whole*] = $\lambda x s$[for all domains D: ¬ INT-WH*(x, $s(D)$)]
c. [*individual*] = $\lambda x s$[for all domains D: ¬ INT-WH*(x, $s(D)$) & $\forall x'(x' <_{s(D)} x \rightarrow$ INT-WH*(x'))]

The sentence (57a) will then be analysed as in (59):

(59) [*compare*](John, $\langle sum_{<_s}$([*students*]), $s\rangle$),
for a reference situation s such that for every domain D, $s(D)$([*students*], $sum_{<_{s(D)}}$[*students*]) = 1 and $s(D)$([*individual*], $sum_{<_{s(D)}}$[*students*]) = 1

It may not be obvious that part-structure modifiers need to be analysed in this situation-related way. There is at least one alternative account of part-structure modifiers, the *ontological account*, which needs to be briefly discussed. On the ontological account, *as*-phrases and adnominal part-structure modifiers, in a sense, 'define new entities'; that is, an NP modified by an *as*-phrase or part-structure modifier refers to a different object than an NP not modified by an *as*-phrase or part-structure modifier. Let us call such an object a 'qua object', following Fine (1982). Thus, *the boxes together, the whole class*, and *the individual students* would refer to different objects than *the boxes*, *the class*, and *the students*. Setting aside the issue of what exactly such qua objects are, let us consider only the general adequacy of the ontological account of adnominal part-structure modifiers.

For evaluating the ontological account, there is, of course, a consideration of ontological economy, that it is implausible that there should be so many new objects for NPs modified by *as*-phrases or part-structure modifiers. But there are also more linguistic criteria that show that natural language does not treat the referents of NPs with modifier of the relevant sort and NPs without such a modifier as different objects.

One criterion is anaphora. Anaphora can refer to the object itself, rather than necessarily referring to the qua object, as seen in (60a). Moreover, the absence of a distributive reading of the second sentence of (60b) shows that they must refer to the object itself and cannot refer to the qua-object:

(60) a. John praised the individual students. He did not praise them as a group.
b. John gave the whole class an A. Last year he gave it a B.

Another criterion is predicates of existence. Predicates of existence are not applicable to NPs modified by an *as*-phrase or a part-structure modifier while, for example, specifying the time of the existence of a potential qua object:

(61) a. The five pieces do not exist any more.
b. # The five pieces together do not exist any more.

(61b) could not possibly make a claim about the time of existence of the five pieces as an integrated whole.

A third criterion is identity statements. Thus, (62a,b), though not completely felicitous, are certainly true:

(62) a. The individual students are the students.
b. The picture as a whole is the whole picture.

One other argument against the ontological account is that it would not be applicable to all adnominal part-structure modifiers, in particular not to *alone*:

(63) The box alone weighs 100 pounds.

Alone does not express an inherent property of an entity, rather it specifies isolation of an entity from other relevant entities. It expresses the property of not being part of an integrated whole (in the relevant context).

So it appears that natural language treats objects referred to by NPs with part-structure modifiers as not in principle distinct from objects referred to by NPs without such modifiers. Rather NPs with part-structure modifiers refer to objects relative to particular situations of reference.

3. FURTHER CONSIDERATIONS ABOUT CONCEIVED PROPERTIES AND REFERENCE

The analysis of the linguistic data given in this paper has a number of unusual features which require some further discussion and, in particular, raise the question whether they have any independent motivation. What follows are some open-ended remarks addressing these concerns.

First, we have seen that part-structure-sensitive predicates may take into account accidental properties of their arguments (accidental integrity). Is this a general possibility for predicates or is it limited to part-structure-sensitive ones? There is at least one class of predicates that is sensitive to

accidental properties of arguments, namely spatial adjectives and prepositions. For example *high* in (64a) requires that the stick be in vertical position, and *behind* in (64b) that the box be in a certain spatial, and thus accidental, relation to the speaker:

(64) a. The stick is ten inches high
b. The box is behind the tree.

The second concern is the use of merely conceived properties. The mass-count distinction and also part-structure modifiers seem to involve merely conceived properties and they seem to stand alone in that regard. Is appeal to merely conceived properties needed anywhere else in semantic analysis? It is hard to come up with comparable cases. In a somewhat different area, agent-dependent, nonmanifest properties do play a role, namely the individuation of certain objects, e.g. functional objects. A table is a table not merely because of the configuration of its parts, but because it is intended to be used as a table. Also part structures themselves are often highly functional. Thus, whether a potential part is an actual part of an object often depends on whether it has a particular function within the whole. However, the conceived part-structure properties we have discussed are different from such functional properties in that they do not serve to individuate objects, but only to induce a perspective on them.

Another point to be discussed is the use of reference situations, whose nature has been specified only minimally in this paper. Are reference situations needed anywhere else besides part-structure-sensitive expressions?

At first sight, reference situations seem to be close to the notion of *resource situation* in Situation Semantics (cf. Barwise and Perry 1983). Resource situations serve to identify the referent of a referentially used incomplete definite description (as in *the man left*). One might propose that the relevant count nouns and part-structure modifiers specify the part structure of an object in a resource situation and that predicates may take properties of resource situations into account. However, there are problems with this proposal.

For one thing, it would not allow for a treatment of attributively used definite descriptions, where the referent cannot be dependent on a particular situation referred to (cf. Soames 1986). Attributively used NPs also allow for part-structure modifiers:

(65) The whole solution whatever it may be should be found in this book.

It is for this reason that part-structure modifiers should be evaluated with respect to a domain-independent (situation) rather than an actual situation.

Another problem is that resource situations are hard to reconcile with the fact that adnominal part-structure modifiers express merely conceived integrity. Situations as in Situation Semantics are supposed to be parts of the world and thus not the carrier of agent-imposed properties. Finally, resource situations only serve to identify the referent of an NP and, since they do not form a component of the argument of a predicate, could not possibly influence the way the predicate is understood. Resource situations thus appear inadequate as the basis for the semantics of part-structure modifiers.

There is another notion in the semantic literature which bears resemblance to the required notion of reference situation and this is the notion of *mode of presentation*. Modes of presentation seem close to the notion of reference situation in several respects: they do not hinge on the referential use of NPs; they, on a common view, consist of properties of objects; and, on one view, form a component of an object/mode of presentation-pair referred to by an NP. Modes of presentation as originally conceived by Frege serve to identify the referent of a noun phrase, represent the cognitive significance an object has for an agent, and act as the semantic values of NPs in intensional contexts. The first function, it is generally agreed, should be given up, following Kripke's and others' observations about direct reference. It then remains the view that modes of presentation serve as the semantic value of noun phrases in intensional contexts, representing the cognitive significance of their referents.

On a plausible recent view, combining direct reference and modes of presentation, NPs in intensional contexts refer to pairs consisting of an object and a mode of presentation (cf. Recanati 1993). Thus, using a structured-propositions account, the logical form of (66a) will be as in (66b):

(66) a. Mary believes that John is ill.
b. believe(Mary, $\langle\langle$John, $m_1\rangle$, $\langle$ill, $m_2\rangle\rangle$)

The denotation of *John* thus is a pair consisting of an object and a mode of presentation – though in the case of attitude reports the mode of presentation will not influence the way the predicate is understood. If we accept this account of propositions, we automatically get an appropriate object for the evaluation of count nouns and part-structure modifiers. The descriptive content of the NP and its modifiers would spell out (partly) the mode of presentation, which in turn will influence the way the predicate is understood. If modes of presentation represent the cognitive role of an object for an agent, then they also provide a natural way of treating expressions imposing merely conceived integrity.

There is some apparent evidence for the assimilation of modes of presentation to reference situations. It comes from psychological predicates

such as *like*, which are intensional in a weak sense. The way John likes the exhibition is spelled out in (67a) by the part-structure modifier *as a whole*, but is left implicit and thus possibly represented by an implicit mode of presentation in (67b):

(67) a. John likes the exhibition as a whole.
b. John likes the exhibition. (as a whole but not the individual exhibits)

There may be other constructions that, one might argue, systematically spell out modes of presentation or specify reference situations, for example *as*-phrases as in (68) and the nouns in attributive constructions as in (69):

(68) John likes Shakespeare as a dramatist, but not as a poet.

(69) a. John likes the dramatist Shakespeare, but not the poet Shakespeare.
b. John likes Shakespeare, the dramatist, but not Shakespeare, the poet.

The problem with using modes of presentation, though, is that it is not clear that they are the appropriate objects for the relevant modifiers to spell out. If modes of presentation are properties or sets of properties, they could serve that function well; but conceiving of them that way is not without problems (cf. Schiffer 1978, 1987).

There are some further differences between modes of presentation for the purpose of attitude reports and for the purpose of the analysis of the relevant nouns and modifiers. In attitude contexts, modifiers that spell out a mode of presentation seem to have a very different effect than modes of presentation that remain implicit. Suppose in both (70a) and (70b), that John is acquainted with the picture only globally, not with its details:

(70) a.?? John believes that the picture as a whole is on sale.
b. John believes that the picture is on sale.

(70a) is odd because modifiers in attitude contexts do not just spell out the relevant mode of presentation, rather they still must also influence the way the predicate is understood and they seem to imply that whatever property they express constitutes one of several possible perspectives which the agent intentionally takes. Thus, the identification of reference situations with modes of presentation is rather problematic, and thus independent motivations for reference situations are not obviously at hand.

4. SUMMARY

In this paper, I have argued for the importance of the notion of integrated whole in both ontology and natural language semantics. Whereas ontology only cares about essential integrity, notions of accidental and conceived integrity play a role in the semantics of natural language as well – in particular, for the mass-count distinction, semantic selection, and the semantics of part-structure modifiers.

Because of the restricted transitivity and closure principles, integrity conditions also influence what counts as the parts of an entity. Integrity itself, as we have seen, can be retrieved from the information content of a reference situation. Hence, together with the ontological part structure, it is the content of a reference situation that determines the 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 reference situations may 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 and conceived integrity and 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.[10]

NOTES

[1] For a discussion of extensional mereological theories of the part relation and their problems, see Simons (1987).

[2] See also Landman (1989), who proposes a different solution to the problem, replacing sums by sets, which always satisfy the condition in question.

[3] In this respect, the property of not having proper parts differs from properties such as having integrity, which can easily be taken to have a merely conceived status (cf. Section 2).

[4] The implication of integrity with count nouns seem to get loss with numerals. Contrast *an apple* in (1a) with *one apple* in (1b):

(1) a. The salad contains an apple.
b. The salad contains one apple.

(1) can easily be understood in such a way that the salad contains a quantity of one apple, whatever shape this quantity may be in. *One apple* then seems to function more like a measure phrase, involving the mass concept ‘apple’, as in *some amount of apple*.

[5] A reviewer points out that also the same whole apple may be in the extension of *apple* as a mass noun and *apple* as a singular count noun. It is arguable, though, that when the apple is in the extension of *apple* as a mass noun, it is an integrated whole only accidentally, whereas when it is in the extension of *apple* as a count noun it is an integrated whole essentially.

[6] There are other restrictions on the singular count use of 'part' which should be noted. Singular count *part* appears to apply only to 'functional parts'. For example, it cannot apply to the parts of a plural referent, as in (1) and (2), as opposed to the referent to a collective noun as in (3). (4) indicates that not any collective noun will do, but only those that describe functional or 'organized' wholes (like *collected works*):

(1) a. John is # a part/part of the children.
b. John and Mary are part/# parts of the children.

(2) a. This one is part/# a part of Mary's books.
b. These are part/# parts of Mary's books.

(3) a. This book is a part of Mary's collected works.
b. These books are parts/parts of Mary's collected works.

(4) a. This sheet is part/# a part of the loose collection of paper on my desk.
b. These sheets are part/# parts of the loose collection of paper on my desk.

Thus, a part must refer to a functional part, that is, a part that plays a particular role in an entity which has a particular organization.

There are other expressions denoting a part-of-relation which impose an even stronger condition than the count noun *part*. In particular, there is the verb *have*, as in (5):

(5) The door has a handle.

Have does not simply denote the converse of the relation 'is a part of'. It is subject to more restrictions, as seen from the following contrasts:

(6) a. The potato is (a) part of the dinner.
b. #?The dinner has a potato.

(7) a. A first course is part of the dinner.
b. The dinner has a first course.

Thus, *have* is restricted to essential or normal parts relative to the relevant type of entity. A potato is not a normal part of a dinner; but a handle is a normal part of a door. Often, though, what is a normal part may depend on the expectation concerning the object. Only a certain kind of dinner has a first course. Or one may have (8) (Ed Keenan, p.c.):

(8) The dissertation lacks imagination.

Only a certain kind of dissertation has imagination essentially.

The same 'is a normal part of'-relation is involved in the verb *lack*, which expresses the absence, rather than the presence, of a part:

(9)a. The car lacks a wheel.
b. The dinner lacks a first course.
c. #?The dinner lacks a potato.

It can also be noted that *have* confirms the nontransitivity of the part relation:

(10)a. #The door has a handle.
The house has a door.
The house has a handle.

[7] One might suggest that the predication test involves merely a syntactic condition: subject and predicate must agree in the categories singular count, mass, or plural. But this is not the case. In some cases, for reasons still to be found, subject and predicate may disagree in the relevant categories. For example, *part* as a mass predicate may be true both of singular count NPs and mass NPs:

(1) This leg is part/a part of the chair.

[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 Simons 1987 for discussion.)

[9] There may be one case, though, where essential integrity is not preserved in a situation, as will be discussed in the next section, namely the part-structure modifier *whole*. If this case is taken into consideration, then the generalization does not quite obtain.

[10] There are also other traditions 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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