Countability: Individuation and Context

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Abstract. We agree with recent countability research that a satisfactory account of *individuation* in terms of what counts as 'one' unit for counting is highly relevant for characterizing a semantics of the mass/count distinction. However, we argue that an account that rests on *individuation* alone does not suffice to cover all the relevant mass/count data, in particular the puzzling mass/count variation data. We assume that an account of individuation can and should be given, and then the main question we pose is 'What minimal extensions to classical mereology are required to account for mass/count variation data?' We do this in order to clear the decks of some of the complications involved in the semantics of the mass/count distinction. We conclude that, minimally, two dimensions of context sensitivity need to be incorporated into a mereological semantics. The first is to formally remove overlap from an overlapping set of individuated entities, the second is to model how a set of individuated entities can sometimes be taken as a counting base despite not being minimal with respect to the whole noun's denotation.

Keywords: Mass/count distinction, mereology, individuation, overlap, context sensitivity

1 Introduction: From Atomicity to Counting as 'One'

Early analyses of the mass/count distinction going back at least to Quine (1960) attempted to distinguish mass and count noun denotations via higher-order predicates such as *Atomic*, *Divisive*, *Cumulative*.[1] These were not formally characterized in classical formal mereology until Link (1983) and Krifka (1989):

$$AT(P) \leftrightarrow \forall x[P(x) \rightarrow \exists y \forall z[P(y) \wedge (P(z) \rightarrow \neg(z \sqsubset y))]] \quad (1)$$

$$CUM(P) \leftrightarrow \forall x \forall y[(P(x) \wedge P(y)) \rightarrow P(x \sqcup y)] \quad (2)$$

$$DIV(P) \leftrightarrow \forall x[P(x) \rightarrow \exists y[P(y) \wedge y \sqsubset x]] \quad (3)$$

$$(4)$$

Link (1983) proposes a sortal distinction between count and mass nouns, based on the atomic/non-atomic ontological distinction which is modeled by means of atomic and non-atomic semilattice structures. On Link's account, count nouns are atomic, and mass nouns pattern with plurals in being cumulative. Mass nouns and plurals also pattern alike in being divisive (down to a certain

[1] Also see Pelletier (1979) and references therein.

lower limit). However, none of these properties turned out to be either necessary or sufficient conditions for underpinning the mass/count distinction. For example, mass nouns such as *furniture* are atomic, count nouns such as *fence* are cumulative and also are as divisive as mass nouns such as *rice*.

Krifka (1989) rejects Link's sortal 'dual-domain' approach on which count and mass nouns are interpreted in two different domains. Instead, his strategy is to combine the notion of lattice structure with that of an extensive measure function. Extensive measure functions are defined over a single domain of objects structured by a general partial order (a single complete join semi-lattice) and used to derive count semantic predicates, which are subsumed under his *quantized* predicates. Lexical count nouns are based on an extensive measure function, NU (for 'Natural Unit'): namely, their lexical semantic structure contains the extensive measure function NU which does the "individuating job" of determining the singular objects in their denotation. This strategy amounts to a typal distinction between count and mass nouns, such that count nouns were defined in terms of extensive measure functions yielding 'natural units', which entails that the denotations of singular count nouns are quantized.

Nonetheless, even introducing a notion such as 'natural unit' does not address all problems. As Zucchi and White (1996, 2001) show, there are count nouns like *twig, sequence, fence* which fail be quantized. Moreover, superordinate (aka 'fake') mass nouns like *furniture* are naturally atomic (come in as natural units as the denotations of any other count nouns denoting artifacts such as *chair*). Indeed such nouns pose problems even for more recent accounts. For example, Chierchia (2010) argues that the property of formal atomicity is underspecified (vague) for mass nouns, but must still appeal to an alternative explanation for why 'fake mass' nouns such as *furniture* are mass.

In some recent work (Rothstein 2010, Landman 2011, Grimm 2012, Sutton and Filip 2016), it has been argued that a formal representation of what counts as 'one' is needed, which is not 'natural' in any sense. For example, Rothstein (2010) argues that non-naturally atomic nouns like *fence, wall* can be countable since the set of entities in their denotation that count as 'one' are indexed to counting contexts, which can remove overlap preventing the counting operation from applying. Landman 2011 proposes that mass nouns have overlapping generator sets (sets of entities that count as 'one'), and count nouns have non-overlapping generator sets. Grimm, just like Rothstein and Landman assumes a mereological theory, but enriches it with topological assumptions. Countable entities have the mereotopological property of being *maximally strongly self connected*, and Sutton and Filip (2016) argue that both vagueness with respect to what counts as 'one' and non-overlap in the set of entities that count as 'one' interact in such a way as to either block or facilitate variation in mass/count encoding.

However, as we shall argue, even with a formal representation of what counts as 'one', that is, a formal account of *individuation*, we do not have a satisfactory account of the grounding of the mass/count distinction. In this paper, we will point out some weaknesses of such an account, and seek to clarify what, in

formal terms is minimally required to model the mass/count distinction in a more adequate way. Our strategy is to proceed in the most parsimonious way and answer the following fundamental questions: If we have a full-fledged formal theory of individuation (what counts as 'one'), what data would still remain to be explained for a formal theory of the mass/count distinction? Would classical mereology be sufficient to cover such data? And, if not, what minimal extensions would be required to classical mereology to do so?

In section 2, we identify a number of classes of nouns that have been given a lot of attention in the countability literature and outline the sense in which these nouns individuate entities into what counts as 'one'. We then schematize these results in mereological terms and suggest that concrete nouns form at least four individuation patterns. The result, we argue, is that the mass/count distinction cuts across the individuated/non-individuated divide. In section 3, we relate key recent research into theories of individuation and the mass/count distinction to discuss which formal enrichments have been suggested as necessary for a theory of individuation. In section 4, we propose that classical mereology must be minimally extended with two separate conceptions of context in order to cover the data that are intractable within formal theories relying on the notion of individuation.

2 Classes of Nouns and Patterns in Lattices

Considering just concrete nouns, we may distinguish five classes of nouns depending on their main lexicalization patterns. They are summarized in Table 1, where the 'Noun Class' is a cover term for the descriptive labels below it.[2]

All accounts of the mass/count distinction at least aim to cover nouns that we describe as "prototypical objects" (*chair*, *boy*) and as "substances, liquids and gasses" (*mud*, *blood*, *air*). Indeed, an absolutely minimal requirement on any account of the mass/count distinction is that it can at least semantically distinguish between these two classes.

2.1 Prototypical Objects

Nouns in the *prototypical objects* category are what have been called "naturally atomic". With these nouns, the 'natural units', or the entities we would count as 'one' are just the minimal entities in their denotations for which nothing else in the denotation is a proper part, i.e., they are quantized in the sense of Krifka (1989). As Table 1 helps to show, nouns in these classes display a strong tendency to be lexicalized as count. We schematize the denotation of prototypical objects as in Figure 1 in which the whole lattice represents (part of) the denotation of

[2] A notable omission from Table 1 are so-called "dual life" nouns such as $stone_{[+C]}/stone_{[-C]}$. We leave these aside in this paper, given that it is unclear whether one should take either the mass or count sense to be primary, or, indeed, whether such nouns should be classified as being of some intermediary morphosyntactic category between count and mass.

Table 1. Classes of Nouns and Mass/Count Variation

Noun Class	Examples
proto-typical objects	*chair*$_{+C}$; *tuoli*$_{+C}$ ('chair' Finnish); *Stuhl*$_{+C}$ ('chair' German) *dog*$_{+C}$; *koira*$_{+C}$ ('dog' Finnish); *Hund*$_{+C}$ ('dog' German) *boy*$_{+C}$; *poika*$_{+C}$ ('boy' Finnish); *Junge*$_{+C}$ ('boy' German)
super-ordinate artifacts	*furniture*$_{-C}$; *huonekalu-t*$_{+C,PL}$ ('furniture' Finnish) *meubel-s*$_{+C,PL}$, *meubilair*$_{-C}$ ('furniture' Dutch) *kitchenware*$_{-C}$; *Küchengerät-e*$_{+C,PL}$ (German, lit. kitchen device-s) *footwear*$_{-C}$; *jalkinee-t*$_{+C,PL}$ ('footwear' Finnish)
homogenous objects	*fence*$_{+C}$, *fencing*$_{-C}$; *hedge*$_{+C}$, *hedging*$_{-C}$ *wall*$_{+C}$, *walling*$_{-C}$; *shrub*$_{+C}$, *shrubbery*$_{-C}$
granulars	*lentil-s*$_{+C,PL}$; *linse-n*$_{+C,PL}$ ('lentils' German) *lešta*$_{-C}$ ('lentil' Bulgarian); *čočka*$_{-C}$ ('lentil' Czech) *oat-s*$_{+C,PL}$; *oatmeal*$_{-C}$; *kaura*$_{-C}$ ('oat' Finnish); *kaurahiutale-et*$_{+C,PL}$ (Finnish, lit. oat.flake-s)
substances, liquids, gases	*mud*$_{-C}$; *muta*$_{-C}$ ('mud' Finnish); *Schlamm*$_{-C}$ ('mud' German) *blood*$_{-C}$; *veri*$_{-C}$ ('blood' Finnish); *Blut*$_{-C}$ ('blood' German) *air*$_{-C}$; *lenta*$_{-C}$ ('air' Finnish); *Luft*$_{-C}$ ('air' German)

a noun in this class. The shaded area highlights the set of entities that count as 'one'.

2.2 Substances, Liquids and Gasses

In contrast, *substances, liquids and gasses* seem to lack any clear individuable entities/units at all. That is to say that outside of cases of coercion in which a package or container is supplied in context, nothing counts as 'one' of these substances. For example, nothing counts as *one blood*, *one mud*, or *one air*, and something counts as *one water*, only to the extent that we can coerce the meaning of this expression to, for example, ONE BOTTLE OF WATER or ONE GLASS OF WATER. Nouns in this category display a strong tendency to be lexicalized as mass. However, the three categories in between are far more complex to account for and all display cross and intralinguistic count/mass variation. We schematize the denotation ofsubstances, liquids and gasses as in Figure 2 in which the whole lattice represents (part of) the denotation of a noun in this class. Unlike Figure 1, there is no shaded area for entities that count as 'one'. This represents that such nouns are not individuated.

2.3 Superordinate Artifacts

Nouns in this class have been variously labelled "fake mass nouns", "superordinate aggregates", "object mass nouns", "neat mass nouns", however arguably superordinate count nouns such as *vehicle* should also fall in the same grouping. A well known puzzle with such nouns is why so many languages lexicalize them as mass nouns at all. The denotations of these nouns have clearly individuable

entities at the 'bottom' of them which should *prima facie* be good candidates for counting, and superordinacy in itself is no bar to countability (as evidenced by count nouns such as *vehicles*, *fruits* (US English), *vegetables*).

Nonetheless, one may find both mass and count nouns in this category with both cross- and intralinguistic variation. What counts as 'one' for nouns in this category is not, however, restricted to entities at the bottom of the lattice (as is the case with prototypical objects). As observed by Landman (2011), sums of minimal entities may also count as 'one'. For example, for *kitchenware*, a teacup and a saucer count as 'one' item of kitchenware, but in many contexts, so might a teacup and saucer together, and, for *furniture*, tables/desks, stools/chairs and mirrors all count as single items of furniture, but so does a vanity formed of one of all three. This pattern is schematized in in Figure 3. The 'minimal' entities that count as 'one' are shaded in darker gray. The rest of the lattice is also shaded, but the lighter color indicates that some, but not necessarily all sums of minimal entities count as 'one'.

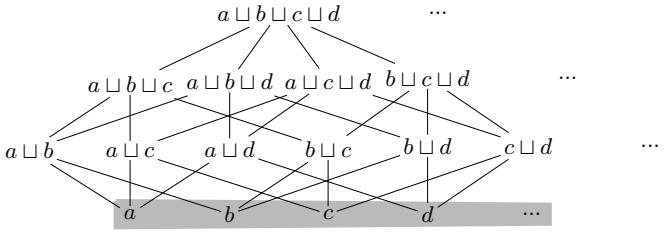

Fig. 1. Prototypical Objects: Individuals are disjoint bottom elements

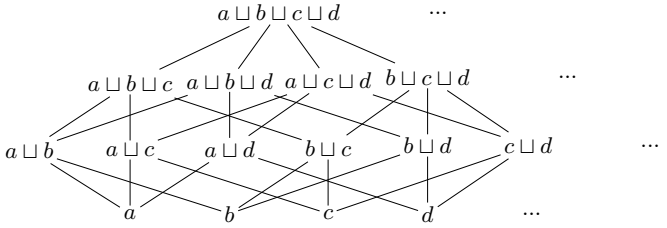

Fig. 2. Substances: No individuals

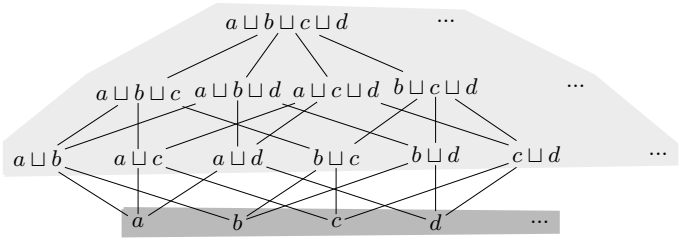

Fig. 3. Superordinate Artifacts and Homogenous objects: Individuals are disjoint bottom elements plus at least some sums thereof

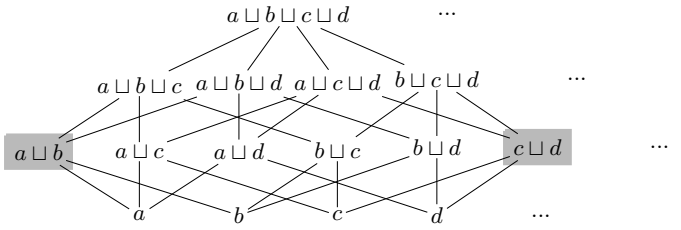

Fig. 4. Granulars: Individuals are non-bottom, disjoint individuals

2.4 Homogenous Objects

This class includes nouns such as *fence* and *fencing*. We use 'homogenous' here in the sense of Rothstein (2010). For example, for some entities that count as fences, proper parts of these entities themselves count as fences. Note that such nouns denote divisive predicates in the sense of (3) above (down to a certain lower limit). These nouns are cumulative, even with respect to what counts as 'one'. For example, if two fences are attached together, then there will be contexts in which their sum counts as a single fence.

One difference between homogenous objects and superordinate artifacts is that, at least for some nouns in this class, there seem to be fewer restrictions on what can be put together to count as 'one'. This derives from the homogeneity of these objects, as opposed to the more functionally defined homogenous artifacts. A whisk and a teaspoon cannot, at least in ordinary contexts, count as a single item of kitchenware since the two together do not *function* as a single item. A pestle and mortar can count as a single item of kitchenware, since these two do have a joint function with respect to being a kitchenware tool. For fences and bushes, however, provided that two or more portions of fencing/hedge are relevantly similar, one can be appended to the other to make what could count as a single fence/hedge. Nonetheless, it is not the case that, for example, any two entities in the denotation of *fence* could be put together to form one fence. It

is hard to imagine how a 50cm high picket fence and a 4m high chainlink fence could count as 'one'. For this reason, we schematically represent homogenous objects in the same way as superordinate artifacts in Figure 3.

For at least some languages with count/mass counterparts in this category such as English and German, the morphologically simple item tends to be count (*hedge*, *Busch* ('bush'/'shrub', German)) and a morphologically more complex item formed from this root tends to be mass (*hedging*, *Gebüsch* ('shrubbery' German)).

2.5 Granulars

Granulars align roughly with what Grimm (2012) labels "collective aggregates". These tend to be formed of collections of similar items with food items as common examples (*rice, lentils, beans*). Their denotation most obviously, from a perceptual perspective, consists of non-overlapping grains, flakes, granules and the like. Furthermore, whenever one finds a count noun in this class, it is precisely the single flakes, grains or granules that are denoted by the singular form.

However, parts of these grains, flakes or granules are also in the number neutral denotations of these nouns. For example, rice flour counts as rice, and red lentils, after cooking down into a kind of pulp, still count as *lentils*. This pattern of the relationship between the regular denotation and what counts as 'one' is schematized in Figure 4. To reflect that these nouns are granular, the individuated entities are disjoint (non-overlapping), but are not at the bottom of the lattice. A pile of broken up rice grains or lentils still count as *rice* or *lentils*, respectively. This category also displays a large amount of count/mass variation as Table 1 helps to show.

2.6 Individuation does not determine mass/count encoding

With these four individuation patterns outlined,[3] it should be clear that being individuated in the sense of having entities that count as 'one' or not is insufficient for determining whether nouns are count or mass. We grant that the only completely non-individuated class tends strongly towards containing only mass nouns, but superordinate artifacts, homogenous objects, and granulars all contain many examples of both mass and count nouns.

Notice too, that being individuated is not the same as coming in natural units. Sums of fence units can still count as *one fence*, and collections of items of kitchenware such as pestles and mortars can still count as *one item of kitchenware* or as *ein Küchengerät* ('one (item of) kitchenware', German).

3 Enrichments Needed for a Theory of Individuation

In this section we highlight some of the shortcomings of a theory of mereology with respect to defining the individuation patterns for the noun classes described

[3] We do not rule out there being more than these four.

above. I.e., such a theory is based on a theory of individuation, on explaining what is 'one' in the denotation of count nouns denotations. We will show how, for example, concepts from mereotopology and concepts such as vagueness and/or underspecification are required to justify the intuitive categorizations of what counts as 'one' for the different noun classes outline.

It is certainly a theoretically coherent position to assume that a theory of the mass/count distinction is really a theory of individuation (of what is 'one'). The decision whether such a theory is to be adopted is not the main point at issue. Rather, we aim to lay the ground for what a theory of the mass/count distinction would look like that did take a theory of individuation as basic so that, in Section 4 we will be able to determine, for such a theory, if classical mereology is sufficient to characterize the mass/count distinction in an adequate way. The reason for pursuing this line is that the mass/count distinction cuts across the individuated/non-individuated divide, as the schemas in Figures 1-4 show. For example, even though homogenous objects, superordinate artifacts and granulars are all individuated, some of these nouns are count, and others are mass.

3.1 Mereotopology

The schema in Figure 1 for prototypical objects is a standard representation of the denotation for a count noun, however, given a single domain assumption on which all nouns are interpreted relative to the same domain, it actually hides a wealth of assumptions. If we assume a single general domain, with respect to which the denotations of predicates are defined, then most common concrete count nouns will not have, as atoms at the 'bottom' of their denotations, entities which are atoms with respect to the whole domain. This is a point one can find in the background of Rothstein (2010) where formal atoms of the domain need not be specified to give an account of the semantic atoms (things that count as 'one') for a predicate, and it is explicit in recent work from Landman (Landman 2015). However, this means that, for example, the $a, b, c, d, ...$ in Figure 1 are atoms relative to a predicate, but not necessarily formal atoms in the whole domain. For example, if the domain contains chair backs, chair seats, and chair legs, the the denotation of *chair* will contain, as individuated entities, entities that are, formally, sums of chair parts. Now, if one accepts this characterization, then certain arguments, such as those employed in Grimm (2012), gain some traction.

Grimm (2012) argues that classical mereology is not sufficient for characterizing individuals. This is because, in classical mereology, all sums are equal. That is to say that the sum of any two entities is considered to be a mereological entity in its own right. However, many sums are not good candidates to be individuals. For example, the sum of Donald Trump and a Blancmange sitting a thousand miles away does not make for a good candidate to be an individual. Less bizarrely, even if we were to pile an assortment of chair legs, a chair back and a chair seat together, we do not have a chair individual, or if we took a sum of twenty starlings, they would not make a flock unless reasonably proximate.

Taking these considerations seriously suggests that a formal theory of individuation must involve not only mereological relations, but also topological ones (mereotopology). The need for mereotopology can also be seen in Figure 4. For granular nouns, we have assumed in that what counts as 'one' are the (whole) grains or granules. For example, single lentils count as 'one' with respect to the predicate *lentil*. However, if the number neutral property for *lentil* also denotes parts of lentils and lentil flour, then only a privileged selection of sums will be whole lentils (hence the highlighting of $a \sqcup b$ and $c \sqcup d$, but not e.g. $a \sqcup d$ in Figure 4). Similarly, the things we would count as 'one' for homogenous objects can be affected by mereotopological factors too. If two box bushes are placed in close enough proximity, they may count as a single hedge/bush, but not if they are too far apart.

3.2 Vagueness and Underspecification or Overspecification

For substances, liquids and gasses, we suggested that there are no entities that intuitively count as 'one'. This loosely reflects a general consensus in the semantics of countability literature, but the details differ. For example, Chierchia (1998,2010), and Rothstein (2010) appeal to vagueness or underspecification with respect to what the atoms of prototypical mass nouns are. In other words, for example, there are no entities that count as 'one' *mud*, because the meaning of mud does not determine or specify such a set.

An alternative position, defended by Landman (2011) is overdetermination. On this view, it is not quite right to say that there are no entities that count as 'one' for substances, liquids and gasses, but rather that there is no single set of entities that count as 'one'. There are, on this view, many ways one could cut the cake and so no single way to count. With more than one way to count where the answer to the question 'how many' depends on the way one does count, then counting goes wrong.

We do not wish to argue in favour of over- or underdetermination here. What matters is that these enrichments to one's model are needed already to form an account of individuation. It remains to be seen, however, whether under/overdetermination will still be needed for a theory of countability if a theory of individuation is taken as basic.

3.3 Context Sensitivity

The need for context sensitivity in a theory of individuation comes from two sources. First, there are data from Yudja, a language in which, it is argued, all nouns can be directly attached to numerals and then counted (Lima 2014). In the examples cited by Lima (2014), counting with substances, liquids and gasses, for example *apeta* ('blood', Yudja), was assessed in relation to a context. Informants were shown pictures as contexts. The portions of blood, sand etc., are clearly separated, albeit not always the same size or quantity and were reliably described these situations using direct numeral attachment to nouns in this class. It is less clear that an out of the blue use of *Txabïu apeta* ('three

blood', Yudja) would get a specific interpretation, however Lima argues that such constructions are not interpreted only as coercions into conventional units. It is not so contentious, therefore, to assume some form of context dependency between nouns in the substances, liquids and gasses category in Yudja and what counts as 'one' for these nouns. That is to say that Yudja speakers do seem to individuate substances, liquids and gasses albeit in a context dependent way.

Second, vague, but nonetheless countable nouns such as *heap*, *fence*, and *mountain* provide some evidence for context-sensitivity in what counts as 'one'. Chierchia (2010), in the context of arguing that it is vague what the countable entities in the denotations of mass nouns are, claims that nouns such as *fence* are not vague in the same way. Although it might be vague what the smallest fence unit is, just as it is famously vague at how many grains a heap becomes a non-heap, this vagueness is different from the underspecification of what the atoms for a noun such as *mud* are. The point, simply put, is that there are clear cases of mountains, fences and heaps, and so, provided that one sets what Chierchia calls a 'ground context', one can be assured of, for example, a set of non-overlapping minimal fence units at every ground context. This claim strongly resembles one made by Rothstein (2010) who argues that "counting context" dependency should be encoded into the semantics of count nouns so as to capture the countability of nouns such as *fence* and *twig*. In other words, there is a element of context that determines what counts, minimally, as fences or twigs. It is important to note that the same applies for mass nouns such as *fencing*. What counts minimally, as an item of fencing may vary with context.

3.4 Summary

It is likely that our list of mereotopology, underspecification/vagueness, overspecification, and context sensitivity are not exhaustive of the formal devices needed for a full account of individuation. For example, for artifacts such as *chair* as well as superordinate artifacts such as *furniture*, some form of lexical semantic representation of function will probably be needed. However, what we have aimed to do thus far is clear the decks of some of the complications involved in the semantics of the mass/count distinction. In the next section, we assume that some account of individuation can be given and so the schemas in Figures 1-4 can be taken for granted. This means that having entities that count as 'one' is not a sufficient condition for being a count noun, but it also enables us to ascertain how far we can proceed in specifying the mass/count distinction in purely mereological terms once a theory of individuation is taken as basic.

4 Applying Mereology to the Noun Classes

4.1 Formally Characterizing the Noun Classes in Mereological Terms

Since the domain is, as standardly assumed in mereological semantics, a Boolean algebra minus the empty set, we can say the following about the relationship

between the denotations of all classes of nouns and the set of entities that count as 'one'. If $IndP$, denotes the set entities that count as 'one' P, being a P-individual is a sufficient condition for being P:

$$\forall P \forall x[Ind(P(x)) \rightarrow P(x)] \tag{5}$$

(5) is trivially satisfied by substances, liquids and gasses, which have no entities that count as 'one', and is non-trivially satisfied for all other noun classes.

Another property that can be seen is with respect to the distributional properties of mass and count nouns amongst these classes. As noted in section 2, substances, liquids and gasses are in all but rare cases lexicalized as mass nouns. A notable exception is Yudja (Lima 2014), which appears to allow direct counting with all nouns. All other noun classes, which have non-empty *Ind* sets contain some nouns lexicalized as count. This suggests that individuation (being able to identify what counts as 'one') is a necessary, but not sufficient condition for countability, and lacking individuated entities is a sufficient condition for being uncountable.[4] In other words, if C is a second order property of predicates (being countable), such that $\Diamond C$ means possibly countable and $\Box\neg C$ means necessarily not countable:

$$\forall P[\Diamond C(P) \leftrightarrow \exists x[Ind(P(x))]] \tag{6}$$

$$\forall P[\Box\neg C(P) \leftrightarrow \neg\exists x[Ind(P(x))]] \tag{7}$$

The intuitive explanation for why (6) should make the lexicalization of a count noun possible is that individuation, finding at least some individuals in a noun's denotation, is the first minimal step towards being able to count. Otherwise, there would be nothing to count.

However, we may also describe a property held by the three classes of nouns which display variation. In other words, for a predicate P we can describe when mass/count variation is to be expected ($\Diamond C(P) \wedge \Diamond\neg C(P)$), and, by negation of both sides of the biconditional, when it is not permitted ($\Box C(P) \vee \Box\neg C(P)$).

$$\forall P[\Diamond C(P) \wedge \Diamond\neg C(P) \leftrightarrow \exists x \exists y[Ind(P(x)) \wedge P(y) \wedge y \sqsubset x]] \tag{8}$$

$$\forall P[\Box C(P) \vee \Box\neg C(P) \leftrightarrow \forall x \forall y[(Ind(P(x)) \wedge P(y)) \rightarrow \neg y \sqsubset x]] \tag{9}$$

In words, it turns out that mass/count variation is licensed when a particular kind of relationship exists between members of the set of Ps and members of the set of P individuals. For superordinate artifiacts, homogenous objects, and granulars, there are entities in the set of Ps that are proper parts of entities in the set of P individuals. Examples of this are summarized in Table 2. For prototypical objects this is not so, since, vagueness aside, parts of boys, cats and

[4] This would require taking the view that in Yudja, a more liberal view is taken on what counts as 'one' such that nouns denoting, for example, *mud* would have non-empty *Ind* sets. This may be relative to some specific context only, however. The examples for counting with nouns denoting substances and liquids in Lima (2014) tend to be in contexts where there are clearly perceptual portions involved such as drops of blood.

chairs are not chairs.[5] It is also not the case that substances, liquids and gasses have entities in their denotations that are parts of individuals, since they have empty *Ind* sets.

Table 2. Examples of Individuals and parts of individuals in the denotation of predicates

Noun Class	Examples	Individuals	Parts of Individuals
superordinate artifacts	*kitchenware*, *Küchengerät*-$e_{+C,PL}$ ('kitchenware', German)	pestle, mortar, pestle⊔mortar	pestle, mortar
homogenous objects	*fence* , *fencing*	fence_1, fence_2 $\text{fence}_1 \sqcup \text{fence}_2$	fence_1, fence_2
granulars	*rice*, *lentil-s*	grains of rice lentils	parts of grains, rice flour parts of lentils, lentil flour

The question is why should the property in (8) facilitate the possibility of either mass or count encoding and its negation in (9) prevent it? Furthermore, we may ask whether such an explanation needs to appeal to more than just mereological relations and properties. In the remains of this section, we show how far we consider one can get with mereology alone. In 4.2, we then argue that simple mereology is insufficient for providing a satisfactory analysis of countability.

Since, of recent accounts, Landman (2011) remains truest to a purely mereological account, we will adopt two further notions from Landman, namely *disjointness* (not overlapping) and *generator set*. One area of loose consensus in the semantics of countability, that was emphasized most notably in Landman (2011) is that one should not, usually, allow for overlap in the set of entities which one wishes to count. Landman's idea was that overlap leads to overdetermination of how many entities there are and that if this overlap cannot somehow be ignored, then counting goes wrong. The importance of non-overlap is also mentioned by Chierchia (2010), and via the notion of a 'default' counting context in Rothstein (2010). The standard mereological notions of disjointness are given in (10) and (11):

$$DISJ(x, y) \leftrightarrow x \neq y \rightarrow x \sqcap y = \varnothing \tag{10}$$

$$DISJ(P) \leftrightarrow \forall x \forall y[(P(x) \wedge P(y) \wedge x \neq y) \rightarrow x \sqcap y = \varnothing] \tag{11}$$

Generator sets in Landman (2011), informally, play the role of what we have referred to here as *Ind* sets, namely the sets of entities that count as 'one'. However, Landman (2011) formally characterizes them in the following way:

> A generating set for X is a set $\mathbf{gen}(X) \subseteq X - \{\varnothing\}$ such that:
> $\forall x \in X : \exists Y \subseteq \mathbf{gen}(X) : x = \sqcup Y$

[5] This is, again, not absolute. For example, *table* seems to behave closer to fence insofar as two tables pushed together can count as 'one' table.

In other words, the a generator set should, when closed under sum, yield the set it generates. These two notions can be put together to form two reasonable *countability norms* which are inspired by Landman's (2011) notions of *disjointness* and *generator sets*:

Disjointness Condition: *Ind* sets should be (non-trivially) disjoint.

Generator Condition: *Ind* sets should be generator sets.

Now, provably, the property in (8) entails that one or the other of these norms must be violated. This should be clear from Figures 3 and 4, but can also be demonstrated. The right hand side of (8) can only be satisfied if $x \neq y$, since $y \sqsubset x$. Either (i) $y \in Ind(P)$ or (ii) $y \in P$ and $y \notin Ind(P)$. If (i), then there are $x, y \in Ind(P)$ such that $y \sqsubset x$. Since $y \sqsubset x \leftrightarrow x \sqcap y \neq \varnothing$, it is not the case that $DISJ(Ind(P))$. If (ii), then there is a $y \in P$ and an $x \in Ind(P)$ such that $y \sqsubset x$ and $y \notin Ind(P)$. If $Ind(P)$ is disjoint, then there is also no $z \sqsubset y$ such that $z \in Ind(P)$. Hence, there can be no subset of $Ind(P)$, Y such that $\sqcup Y = y$, hence $Ind(P)$ is not a generating set for P.

Homogenous objects and superordinate artifacts have the potential of being countable, since they do have non-empty *Ind* sets. However, countability can be undermined unless the overlap in their *Ind* sets is somehow ignored.

Granulars have the potential of being countable, since they have non-empty *Ind* sets. However, countability can be undermined because their *Ind* sets do not generate the entirety of their denotation (i.e. do not generate anything 'below' the granular level).

4.2 Beyond Mereology

It is at this point that it seems that a purely mereological analysis gives out. Superordinate artifacts and homogenous objects breach the *disjointness condition*, but some nouns in these classes are count nouns. Granulars breach the *generator condition*, but some nouns in these classes are count nouns.

In cases where the *disjointness condition* is violated, a noun may still be lexicalized as count (as with *fence* and *huonekalu* ('furniture', Finnish)) if some mechanism exists by which one can ignore overlap in an *Ind* set in such a way as to ensure only one counting result in any given context. At the very least, this seems to require that count nouns in the homogenous objects and superordinate artifacts groups must be indexed in some way to either something akin to Rothstein's counting contexts (Rothstein 2010), or to a formal device such as Landman's "variants", where a variant of a generator set is a maximally disjoint subset (Landman 2011). Although a maximally disjoint subset (variant) can be specified in mereological terms, we nonetheless require a formal device which applies a single variant to an *Ind* set at a given occasion. For example, if a teacup and saucer count as two items of kitchenware on one occasion, then this formal device should make it possible that the cup and saucer sum count as a single item on another occasion.

In cases where the *generator condition* is violated, a noun may still be lexicalized as count (as with *lentil*) if one has a formal device that can explain why an *Ind* set can sometimes be taken as a counting base despite not generating the whole nouns denotation. We suspect, in agreement with Sutton and Filip (2016), that an explanation of this phenomena will need to be derived from a distinct form of context-sensitivity such as the one that underpins Chierchia's vagueness-based account of the mass/count distinction (Chierchia 2010). Chierchia points towards examples where the denotations of mass nouns appear to shift in context. For example, a single grain of rice is sufficient in quantity to count as *rice* in contexts where someone has an allergy, but insufficient to count as *rice* when one is making paella. While this evidence is not sufficient to fully justify supervaluationism as applied by Chierchia, it does suggest that the *Ind* set for granulars is on looser grounds that the *Ind* sets in other categories. For example, for prototypical objects, homogenous objects, and superordinate artifacts, if $x \in Ind(P)$ at a context c, then $x \in P$ at all contexts c', however, for nouns such as rice, there are at least some contexts in which, if $x \in Ind(P)$ at c, it is possible that $x \notin P$ at some context c'. However, this does not imply that the individuated units for granulars are underspecified or vague. Minimally, therefore, we require another index to another form of context, or else a richer story about how extensions of granular nouns can vary from use to use.

5 Conclusions

In this paper we have identified a number of complications that arise in trying to establish the right formal tools to model the mass/count distinction in concrete nouns. We have argued that, as important as a theory of individuation is, the development of a theory of individuation does not entail that one has a theory of the mass/count distinction. Furthermore, we have argued that, even if one assumes an independently motivated theory of individuation, classical mereology is still insufficient for capturing the puzzling mass/count variation data for superordinate artifacts, homogenous objects and granulars.

We have concluded that, minimally, two dimensions of context sensitivity need to be incorporated into a mereological semantics. The first to formally remove overlap from an overlapping *Ind* set, the second to track the way in which the truth conditions of, especially, granular nouns shift in such a way as to change the position of the *Ind* set in the lattice or even remove it from the noun's denotation entirely in some situations.

References

Chierchia, G.: Plurality of nouns and the notion of semantic parameter In: Rothstein, S. (ed.) Events and Grammar, pp. 53–103. Springer, Berlin Heidelberg (1998)

Chierchia, G.: Mass nouns, vagueness and semantic variation. Synthese. 174, 99–149 (2010)

Grimm, S.: Number and Individuation PhD Dissertation, Stanford. (2012)

Krifka, M.: Nominal Reference, Temporal Constitution and Quantification in Event Semantics In Bartsch, R, van Benthem, J. F. A. K. and van Emde Boas, P. (eds.), Semantics and Contextual Expression. pp. 75–115. Foris Publications (1989)

Landman, F.: Count nouns – mass nouns – neat nouns – mess nouns. The Baltic International Yearbook of Cognition 6, 1–67 (2011)

Landman, F.: Iceberg Semantics for Count Nouns and Mass Nouns: the evidence from portions. Handout, Presentation at Henirich Heine University Düsseldorf (2015)

Lima, S.: All notional mass nouns are count nouns in Yudja. Proceedings of SALT 24, 534–554 (2014)

Link, G.: The Logical Analysis of Plurals and Mass Terms: A Lattice-Theoretic Approach In: P. Portner and B. H. Partee (eds.) Formal Semantics - the Essential Readings, pp 127–147. Blackwell (1983)

Pelletier, Francis Jeffry: Mass Terms Some Philosophical Problems. Francis Jeffry Pelletier (ed.). Holland, Boston, D. Reidel Pub. Co (1979)

Quine, W.V.: Word and Object The MIT Press (1960)

Rothstein, S.: Counting and the mass/count distinction. Journal of Semantics. 27, 343–397 (2010)

Sutton, P. R., and Filip, H.: Vagueness, Overlap, and Countability. Forthcoming in: Proceedings of Sinn und Bedeutung 20 (2016)

Zucchi, Sandro and White, Michael: Twigs, Sequences and the Temporal Constitution of Predicates Proceedings of SALT 6. Teresa Galloway and Justin Spence (eds.). (1996)

Zucchi, Sandro and White, Michael: Twigs, sequences and the temporal constitution of predicates. Linguistics and Philosophy 24 (2):223–270. (2001)