Mass/Count Variation, a Mereological, Two-Dimensional Semantics

Abstract: We argue that two types of context are central to grounding the semantics for the mass/count distinction. We combine and develop the accounts of Rothstein (2010) and Landman (2011), which emphasize (non-)overlap at a context. We also adopt some parts of Chierchia’s (2010) account which uses precisifying contexts. We unite these strands in a two-dimensional semantics that covers a wide range of the puzzling variation data in mass/count lexicalization. Most importantly, it predicts where we should expect to find such variation for some classes of nouns but not for others, and also explains why.

1 INTRODUCTION

In this paper, we identify two context indices that underpin the semantics of the mass/count distinction. One index is a counting context (Rothstein 2010), that either ensures the set of entities that count as ‘one’ in a noun’s denotation is disjoint and suitable for counting, or, allows overlap leading to mass encoding (inspired by Landman (2011)). The other index is a precisification index (inspired by Chierchia (2010)). At some precisifications, the set of entities that count as ‘one’ can be excluded from a noun’s denotation leading to mass encoding. We combine these indices into a two dimensional semantics that not only models the semantics of a number of classes of nouns, but can also explain and predict the puzzling phenomenon of mass/count variation. Specifically, our account can explain why mass/count distribution patterns are uniform for some noun classes, but highly varied cross- and intralinguistically.

In section 2, we introduce the theories of Rothstein (2010), Chierchia (2010), and Landman (2011) and analyze the role of context in each of them. We detail how Chierchia’s account uses contexts as precisifications of vague expressions. We then present a way in which Rothstein’s and Landman’s accounts can be combined into a single account, based on (non-)overlap at a context, which offers greater coverage of the data.

In Section 3, we present the puzzle of mass/count variation. We identify five classes of nouns: Prototypical objects such as boy, chair; Substances, liquids, and gasses, such as mud, blood; Superordinate artifacts such as furniture, huonekalu (‘item of’ furniture’, Finnish); Homogenous objects such as fence, fencing; and Granulars, such as rice, lentils. The first two of these contain nouns with strong tendencies for either
count or mass lexicalization. The last three display large amounts of cross- and intralinguistic variation. We argue that neither a vagueness based account, nor a synthesized Rothstein-Landman (non-)overlap based account can sufficiently account for all of the data.

In Section 4, we argue that a dual-source account that employs indices for contexts that govern both overlap/non-overlap and precisifications has greater data coverage. In Section 5, we lay out our formal model for the dual source account, a two-dimensional semantics.

In Section 6, we show how our model can account for the distribution of count and mass nouns cross- and intralinguistically, and provide the lexical entries for paradigmatic nouns representing each noun class.

In Section 7, we discuss the shortcomings of this formalism, namely that it takes the notion of counting as ‘one’ as pretheoretical. We argue for the use of a much richer representational language such as that proposed in Sutton and Filip (2016b). We summarize these results in Section 8.

## 2 VAGUENESS, OVERLAP AND CONTEXT

### 2.1 Context Sensitivity and Vagueness: Chierchia (2010)

Chierchia (2010) claims that mass nouns are vague in a way in which count nouns are not. Count nouns have “stable atoms” in their denotation, that is, they have entities in their denotation that are atoms in every context. Mass noun denotations lack stable atoms. If a noun lacks stable atoms, there is no entity that is an atom in the denotation of the predicate at all contexts. In this sense then, mass nouns have only unstable individuals in their denotation. But counting is counting of stable atoms only. This motivates why mass nouns cannot be counted, i.e., straightforwardly occur with numericals, as in ?three muds (unless they undergo a shift into a count interpretation).

Chierchia enriches mereological semantics with a form of supervaluationism wherein vague nouns interpreted at ground contexts have extension gaps (vagueness bands). Contexts then play the role of classical completions of a partial model in other supervaluationist formalisms such that at every (total) context, a nominal predicate is a total function on the domain.

Contexts stand in a partial order to one another such that if $c'$ precisifies $c$ ($c \preceq c'$), then the denotation of a predicate $P$ at $c$ and at a world $w$ is a (possibly not proper) subset of $P$ at $c'$ and $w$. That is to say that for an interpretation function $\mathcal{F}$:

$$\mathcal{F}(P)(c)(w) \subseteq \mathcal{F}(P)(c')(w)$$ (1)

Let us briefly illustrate Chierchia’s supervaluationist account with his paradigm example of a mass noun rice. It is vague in the following way. It is not the case that across all contexts, for example, a few grains, single grains, half grains, and rice flour...
dust always count as *rice*, fall under the denotation of the predicate *rice*. But this means that such various quantities of rice are all in the vagueness band of rice, they fall in and out of the denotation of *rice* depending on the context. There may be some total precisifications of the ground context \( c \), in which single grains are rice atoms. There may also be some \( c' \) such that \( c \propto c' \), where half grains are rice atoms. There may also be some \( c'' \) such that \( c' \propto c'' \) in which rice dust particles are rice atoms. Most importantly, there is, therefore, no entity that is a rice atom at every total precisification of *rice*. In this sense, the denotation of *rice* lacks stable atoms, is vague. Counting is counting stable atoms, on Chierchia’s account, but *rice* has no stable atoms in its denotation, what it denotes cannot be counted, which motivates its grammatical property.

2.2 Counting Context Sensitivity: Rothstein (2010)

Rothstein (2010) builds on Krifka (1989, 1995) in so far as she rejects Link’s (1983) two-domain (atomic and non-atomic) ontology from which nouns take their denotation. However, she rejects Krifka’s idea that the meanings of all (concrete) count nouns are to be analyzed in terms the NU (“natural unit”) extensive measure function. On Krifka’s account, the entry for *cow* is as in (2):

\[
\lambda n. \lambda x. [\text{COW}(x) \land \text{NU(COW)}(x) = n]
\]

In Krifka’s theory, singular count nominal predicate meanings are derived with extensive measure functions (like NU) from mass noun predicate denotations \( \text{COW}(x) \), and they are quantized: entities they denote have no proper parts falling under the same predicate. A proper part of what is a *cow*, say just a tail, is not describable by a *cow*. However, it was pointed out, at least since Zucchi and White (1996, 2001) (and also from some privately corresponded comments from Barbara Partee) that there are count nouns that are not quantized, they do not come in natural units: e.g., *line*, *twig*, *fence*, *wall*. For instance, *fence* fails to be quantized, because it denotes entities which may have proper parts that also fall under the same predicate *fence*. Rothstein (2010) calls such nouns “homogenous” and provides a unified semantics that accommodates both such puzzling count nouns as well as prototypical count nouns like *cow*, *apple*, *boy*, which come in natural units, i.e., they are “naturally atomic”, and therefore quantized, and hence are unproblematic for Krifka’s theory.

Central to Rothstein’s account is the notion of a *counting context*. Formally, counting contexts are subsets of the domain that are intersected with the denotation of a noun, but for “default contextual interpretations” contexts operate to remove overlap and yield a set of entities that “count as one”. Rothstein introduces a typal distinction between count and mass nouns. Mass nouns are of type \( (e, t) \), (predicates of individuals). They may or may not be naturally atomic. Count nouns are indexed to counting contexts and are of type \( (e \times k, t) \) (predicates of indexed individuals), they are “semantically atomic”. I.e., they denote individuals indexed for the context \( k \) in which they count as one, they are disjoint in a given context, and hence countable.

This means that “homogenous” count nouns like *fence* can denote non-overlapping, and so countable, “semantic atoms” at each context, even if these semantic atoms vary from context to context. For example, Rothstein’s semantics captures that fencing
enclosing a square field could plausibly count as four fences in one context and one fence in another.

Suppose the denotation of fence is the upward closure of \( \{ f_1, f_2, f_3, f_4 \} \), and there are two contexts \( k_1 = \{ f_1, f_2, f_3, f_4 \} \) and \( k_2 = \{ f_1 \cup f_2 \cup f_3 \cup f_4 \} \). Applying these contexts to fence would yield the following sets of ordered pairs

\[
\begin{align*}
[fence]_{k_1} & = \{ (f_1, k_1), (f_2, k_1), (f_3, k_1), (f_4, k_1) \} \quad (3) \\
[fence]_{k_2} & = \{ (f_1 \cup f_2 \cup f_3 \cup f_4, k_2) \} \quad (4)
\end{align*}
\]

This means that there would be four fences in context \( k_1 \) and one fence in context \( k_2 \). Although all count nouns, as a matter of semantic type are indexed to counting contexts, not all count nouns are counting context sensitive (i.e. not all count nouns change their denotation from counting context to counting context). For example, a naturally atomic predicate such as cow would denote the same set (the set of individual cows) across all counting contexts.\(^1\)

2.3 Overlap in a Context: Landman (2011)

The notion of what counts as ‘one’ is formalized in Landman (2011) as the members of the generator set for a predicate. The set of generators, \( \text{gen}(X) \), of the regular set \( X \) is the set of semantic building blocks for the predicate, namely, those entities that generate the denotation of a number neutral predicate via complete closure under sum.

If the elements in the generator set are non-overlapping, as in the case of count nouns, then counting is sanctioned: Counting is counting of generators and there is only one way to count. However, if generators overlap, as in the case of mass nouns, counting goes wrong, because more than one simultaneous counting outcomes are possible. Landman provides a new delimitation of the two cases when this happens, and hence two subcategories of mass nouns: mess mass nouns like mud, and neat mass nouns like furniture. A mass noun is neat if its intension at every world specifies a regular set whose set of minimal elements is non-overlapping. The entities in the generator set of neat mass nouns are what we would wish to count as “one”, such as single items of furniture. However, entities that count as one item of furniture, such as a vanity (consisting of a dressing table, a mirror, and possibly also a stool) may be sums of entities that each individually, and also their various sums, also count as one item of furniture “simultaneously in the same context”. A noun is a mess mass noun if its intension at every world specifies a regular set whose set of minimal elements is overlapping. Landman suggests that what counts as minimal for mess mass nouns may vary with context (see his salt, water and meat examples).
2.4 Overlap or Disjointness at a Context: A Synthesis of Rothstein (2010) and Landman (2011)

In Rothstein’s (2010) analysis, count nouns, which are counting context sensitive (“semantically atomic”), denote, in default contexts, non-overlapping entities that count as “one”. In Landman’s (2011) analysis, neat mass nouns like kitchenware and furniture denote an overlapping set of entities that count as “one” (although their minimal generators do not overlap). Crucially, however, as (5a-d) show, neat mass nouns are precisely a class of nouns that have cross- and intralinguistic count counterparts. Subscripts [+C] and [-C] indicate count and mass, respectively:

(5)

a. furniture$_{[-C]}$: huonekalu$_{[-C,PL]}$ ('furniture', Finnish); meubel$_{[-C,PL]}$ ('furniture', Dutch); meubilair$_{[+C]}$ ('furniture', Dutch)
b. kitchenware$_{[-C]}$: keittiöväline$_{[-C,PL]}$ ('kitchenware', Finnish); Küchengerät$_{[-C,PL]}$ ('kitchenware', German)
c. footwear$_{[-C]}$: jalkine$_{[-C,PL]}$ ('footwear', Finnish); Schuhwerk$_{[-C]}$ ('footwear', German)
d. jewelry$_{[-C]}$: koru$_{[-C,PL]}$ ('jewelry', Finnish)

As (6a-d) illustrate, context-sensitive count nouns like fence in English are precisely a class of nouns that have cross- and intralinguistic mass counterparts.

(6)

a. fence$_{[+C]}$; fencing$_{[-C]}$

b. wall$_{[+C]}$: Mauer$_{[+C]}$ ('wall', German); walling$_{[-C]}$: Gemäuer$_{[-C]}$ ('walling/ masonry', German)
c. bush$_{[+C]}$: Busch$_{[+C]}$ ('bush', German); shrubbery$_{[-C]}$: Gebüschr$_{[-C]}$ ('shrubbery', German)

Let us consider an example of each kind: furniture$_{[-C]}$ versus huonekalu$_{[-C]}$ ('furniture’ Finnish) and fence$_{[-C]}$ versus fencing$_{[-C]}$. One might argue that if you have a neat mass noun (furniture$_{[-C]}$, kitchenware$_{[-C]}$) in Landman’s terms that has a count counterpart, then that count counterpart is analyzable as “semantically atomic”, or a counting context sensitive count noun, on Rothstein’s theory (huonekalu$_{[-C]}$). Vice versa, if a counting context sensitive count noun (fence$_{[+C]}$) in Rothstein’s terms has a mass counterpart (fencing$_{[-C]}$), then that mass counterpart will be analyzable as a neat mass noun on Landman’s theory. Indeed Landman has claimed that nouns such as fencing are neat mass nouns (Landman p.c.). This general argumentation strategy is shown in Figure 1.
**Figure 1. Connecting Rothstein (2010) and Landman (2011)**

*furniture* versus *huonekalu*: On Landman’s analysis, for *furniture* we get overlapping entities that count as “one” simultaneously in the same counting situation, i.e., we have many different possible partitions of the domain and different ways of counting. For example, a vanity, but also the table and mirror that compose it, may each count as one item of furniture. However, in Finnish, it is not the case that either the vanity counts as “one” or the mirror and table each count as “one”. What one counts for *huonekalut* is a context dependent matter. From the perspective of Rothstein’s analysis, the count counterparts of neat mass nouns are counting context sensitive, and hence analyzable as “semantically atomic”.

*fence* versus *fencing*: On Rothstein’s analysis, *fence* is counting context sensitive (Section 2.2). That means that if one takes all possible contexts, then there is overlap between the members of the set of entities that count as “one” in one context, and the members of the set of entities that count as “one” in another context. However, on the assumption that the denotation for *fencing* is the same as the denotation of *fence*, then two conditions must hold for *fencing* to be a neat mass noun in Landman’s (2011) terms: (i) some of the entities in the denotation of *fence/fencing* are minimal (i.e. minimal generators); (ii) the same entities are non-overlapping.

Let us now assess conditions (i) and (ii). With respect to (i), on the face of it, it might seem that there are no clear minimal fence entities. If a 2m stretch of fence counts as *fence*, then surely 1cm can’t make a difference, so a 1.99m stretch also counts as *fence*, therefore *fence* is sorites susceptible and so, arguably, vague. However, if *fence* is vague, then there are no clear minimal *fence* entities. The vagueness of *fence/fencing*, at least, that there are differences between *fence/fencing* and *furniture*.

The question is whether vagueness, characterized as sorites sensitivity, is relevant to the question of whether *fence/fencing* have minimal entities in their denotation. The reason for thinking that vagueness, in this sorites susceptible sense, is not relevant, is that the denotation of *fence/fencing* is constrained by what *could* count as ‘one’ fence/item of fencing in some context. If we take the denotation of *fence/fencing* independently of counting context to be what is generated by the union of the sets of entities that count as ‘one’ at all possible counting contexts, then there will, as a matter of fact, be some fence-entities that are minimal with respect to this set. Therefore, condition (i) holds.
Let us now examine condition (ii). We have just argued that there is some set of minimal fence entities. The question now is, would these units be non-overlapping? Here we hit a problem. As Figure 2 shows, this condition on a minimal fence unit might at different counting contexts yield an overlapping set of entities. Suppose, as in Figure 2, that \( \{a, b\} \) are minimal at \( c_1 \), but \( \{a', b'\} \) are minimal at \( c_2 \). The trouble is that \( a \) overlaps with \( b' \) and \( a' \) with \( b \) with respect to the middle upright stake.

**FIGURE 2. OVERLAPPING MINIMAL FENCE ENTITIES**

However, notice that at each counting context (or “variant” in Landman’s sense), the number of semantic atoms (minimal generators) is the same: For the case in Figure 2, there are two fences in \( c_1 \) and two fences in \( c_2 \). This means that *fencing* is not, properly speaking a neat mass noun, since it does not have non-overlapping minimal generators. All is not lost, however. We now show that, using Rothstein’s notion of a counting context (or Landman’s notion of a variant), we can capture the spirit of Landman’s account albeit in slightly different terms.

Recall that, for Landman, what makes counting go wrong is that the number of entities at each variant of the generator set may differ. With no single answer to the question ‘How many?’, counting goes wrong. However, one way of understanding and redefining Landman’s notion of neat is to say that a mass noun is neat iff the set of minimal generators (non-overlapping minimal entities) returns the same cardinality at all variants. This would allow fencing to be “neat”, but would also allow both fencing and nouns like furniture to be uncountable, and hence mass, since, although the minimal generator set would return the same cardinality at all variants, the generator set would not. Put another way, the set of entities that count as ‘one’ varies across counting contexts, not only in membership, but also in cardinality.

In summary, given a slight adjustment of the definition of neat mass that is nonetheless in the spirit of Landman (2011), we have argued that count counterparts of neat mass nouns are counting context sensitive and that mass counterparts of counting context sensitive count nouns are neat mass nouns. Thus we have proposed a unified Rothstein-Landman account for the analysis of both neat mass nouns and count nouns that are counting context sensitive. The theme that unites the accounts of Landman and Rothstein is *non-overlap at a context*. Rothstein’s (default) counting contexts remove overlap and yield count nouns. Landman’s contexts (involving a multiplicity of variants (i.e. a multiplicity of counting contexts in Rothstein’s sense)) allow overlap and so yield mass nouns. In Section 5, we formally define these two notions of context in terms of each other.
3 THE CHALLENGE OF MASS/COUNT VARIATION

In Section 2.4, we provided some data that neat mass nouns have counting context sensitive count counterparts and that counting context sensitive count nouns have neat mass counterparts. Another group of nouns which have been observed to display mass/count variation are what we dub granulars. This group, in English, include oats, lentils, rice, beans. Examples of cross- and intralinguistic variation are given in (7a-c).

(7)


Other nouns display startling uniformity with respect to whether they are count or mass within and across languages, however. On the one hand, prototypical objects, examples of which in English are cat, chair, table, car, are highly probably lexicalized as count nouns, whereas substances, English examples of which are mud, blood, water, air, are highly probably lexicalized as mass nouns intra- and crosslinguistically. These prototypical cases are not problematic for any of the theories we have discussed. For example, entities like cats are not overlapping (Landman 2011), indexed to counting context (Rothstein 2010), and not vague with respect to their countable units (Chierchia 2010). Substances are overlapping (mess mass) (Landman 2011), not indexed to counting context (Rothstein 2010), and vague (Chierchia 2010).

We summarize the mass/count variation data in Table 1:

<table>
<thead>
<tr>
<th>Noun Class</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototypical Objects</td>
<td>chair[+C]; tuoli[+C] (‘chair’ Finnish); Stuhl[+C] (‘chair’ German)</td>
</tr>
<tr>
<td></td>
<td>dog[+C]; koira[+C] (‘dog’ Finnish); Hund[+C] (‘dog’ German)</td>
</tr>
<tr>
<td></td>
<td>boy[+C]; poika[+C] (‘boy’ Finnish); Junge[+C] (‘boy’ German)</td>
</tr>
<tr>
<td>Superordinate Artifacts</td>
<td>furniture[+C]; huonekalu-t[+C,PL] (‘furniture’, Finnish); meubel-s[+C,PL]</td>
</tr>
<tr>
<td></td>
<td>(‘furniture’, Dutch); meubilair-[C] (‘furniture’, Dutch)</td>
</tr>
<tr>
<td></td>
<td>footwear-[C]; jalkine-et[+C,PL] (‘footwear’, Finnish); Schuhwerk-[C] (‘footwear’, German)</td>
</tr>
</tbody>
</table>
We will now argue that variation in mass/count encoding poses a major challenge for a vagueness-based account such as Chierchia’s (2010), and for disjointness/overlap based accounts such as Rothstein (2010) and Landman (2011). Then in Section 4, we put forward a dual-source account which overcomes many of these difficulties.

3.1 Vagueness-based accounts and mass/count variation

It should be acknowledged that Chierchia (2010) states the need for more than one source for the mass/count distinction. The primary evidence for this is fake mass nouns which are not vague, but are nonetheless mass nouns. In fact, Chierchia (2010) offers a number of different explanations for the mass/count lexicalization of different nouns. We argue in Section 4 for a more parsimonious explanation than that given by Chierchia (2010).

We call neat mass nouns such as furniture and count counterparts such as huonekalu (‘(item of) furniture’, Finnish) superordinate artifacts. As Chierchia suggests, superordinate artifacts are problematic for a vagueness-based account of the mass/count distinction. This is because they are not vague in the sense of having unstable individuals, since, for example, items of furniture such as chairs are in the denotation of furniture at all precisifications. Chierchia’s explanation for why superordinate artifacts can be mass is that:

<table>
<thead>
<tr>
<th>Homogenous Objects</th>
<th>fence[+C] vs. fencing[−C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>wall[+C]; Mauer[+C] (‘wall’, German); walling[−C]; Gemäuer[+C] (‘walling/masonry’, German)</td>
<td></td>
</tr>
<tr>
<td>bush[+C]; Busch[+C] (‘bush’, German); shrubbery[−C]; Gebüschen[−C] (‘shrubbery’, German)</td>
<td></td>
</tr>
</tbody>
</table>

|-----------|--------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Substances, Liquids &amp; Gasses</th>
<th>mud[−C]; muta[−C] (‘mud’ Finnish); Schlamm[−C] (‘mud’ German)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>blood[−C]; veri[−C] (‘blood’ Finnish); Blut[−C] (‘blood’ German)</td>
</tr>
<tr>
<td></td>
<td>air[−C]; lenz[−C] (‘air’ Finnish); Luft[−C] (‘air’ German)</td>
</tr>
</tbody>
</table>

jewelry_{[+C]}; koru-t[+C,PL] (‘jewelry’, Finnish)
“fake mass nouns arise as a ‘copy cat’ effect from the way in which number marking languages react to unstably atomic nouns. Since listing a potentially count noun as a singleton property is essentially a matter of lexical choice, we expect there to be variation, even across closely related languages or language families on this score, which has, in fact, been often observed in connection with fake mass nouns.” (Chierchia 2010, p. 139)

However, even if were to accept this mode of explanation, and were to accept that we should expect variation, even across closely related languages or language families, this does not necessarily explain why we should find variation within a single language as with the Dutch *meubel*-<sub>C</sub> and *meubilair*-<sub>C</sub> (‘furniture’). We may ask, why should not other, prototypical, count nouns be similarly *copy catted?* An explanation Chierchia gives is that copycatting may be driven by a “lack of interest in the atoms” (Chierchia 2010, p. 139 fn. 48) which “might account for the collective flavor of nouns like furniture, as for the fact they tend to be ‘superordinate’ category” (Chierchia 2010, p. 139 fn. 48). However, plural count nouns can be superordinate too (*vehicles, vegetables*), and it is not clear that they display less ‘lack of interest’ in their atoms. Finally, Chierchia’s copycat addendum predicts that the phenomena of fake mass nouns should not be found in classifier languages. However, as Sutton and Filip (2016c) argue, based on evidence from Cheng (2012), this does not appear to be borne out for *jiājù* (‘furniture’, Mandarin).

Furthermore, similar concerns arise for mass/count counterparts such as *fencing* and *fence*. Chierchia (2010, pp. 112-3) claims that count nouns such as *heap, mountain,* and *fence* are not vague in the relevant sense. Furthermore, nouns such as *fence*-<sub>S</sub> are not superordinates, so we should not expect mass counterparts to be generated by copy catting any more than for prototypical count nouns such as *cat*. Nonetheless, we do find mass terms such as *fencing, hedging,* but do not tend to find mass counterparts for nouns such as *cat.*

A more parsimonious account would be one in which, in addition to vagueness, a second semantic factor could explain mass/count variation both in superordinate artifacts such as *furniture* and in *fence*-like nouns. We give such an account in informally Section 4, and formalize it in Sections 5 and 6.

A second challenge to a vagueness-based account is that there are vague nouns that are not mass nouns. Examples of these are (7a-c). If *lentil* is not-vague and therefore count, then *leštka*-<sub>C</sub> (‘lentil’, Bulgarian) and *čočka*-<sub>C</sub> (‘lentil’, Czech) should be count too. Alternatively, if *leštka*-<sub>C</sub> (‘lentil’, Bulgarian) and *čočka*-<sub>C</sub> (‘lentil’, Czech) are vague and therefore mass, then *lentil* should be mass too. Chierchia’s response to this variation is:

“What this suggests is that standardized partitions for the relevant substances are more readily available in such languages/dialects. This type of variation is a consequence of the fact that vagueness comes in degrees: some nouns may well be less vague than others, in the sense that a usable notion of ‘smallest sample’ can more readily be devised. Clearly,
for example, defining smallest samples for (non commercially packaged) liquids is harder than for granular substances.” (Chierchia 2010, p. 140)

Whatever the merits of this tentative explanation turn out to be for crosslinguistic mass/count variation, it does not account for intralinguistic cases. Take the case of oat-st[C.PL], kaurat[C] (‘oat’, Finnish), oatmeal[C], kaurahiutale-eti[C.PL] (lit. ‘oat.flake’, Finnish). In British English, at least, oatmeal is commonly used to refer to the rolled oats used for making porridge, likewise with kaurahiutaleet in Finnish. As these data show, the mass/count encoding of the basic oat grain as opposed to the processed product (the meal/flakes) is switched between English and Finnish. This allows an argument against a vagueness-only view. Either the oats and the flakes/meal are, as a ‘smallest sample’, as available as each other, or one is more available than the other. If the former, then we should not expect mass/count variation in either English or Finnish. If the latter, we should expect mass/count variation in either English or Finnish, but not both. Whether the same or different, Chierchia’s vagueness-based approach plus story of crosslinguistic “smallest available sample” variation is insufficient to account for the data.

In conclusion, there are, cross- and intralinguistically, vague nouns that are sometimes lexicalized as either mass or count, and there are non-vague nouns that are sometimes lexicalized as either mass or count. Together, these data can be used to form compelling arguments that an account based on vagueness alone is insufficient to form a basis for the mass/count distinction.

3.2 Disjointness/Overlap-based accounts and mass/count variation

In 3.1 we argued that a vagueness-only based account of the mass/count distinction faces two challenges given mass/count variation data. First, homogenous objects and superordinate artifacts are not-vague but are mass as well as count. Second, granulars are vague nouns that are count as well as mass.

On the face of it, a hybrid Landman-Rothstein account based on (non-)overlap in context (Section 2.4) fairs better than vagueness-based approaches. Homogenous objects and superordinate artifacts can overlap in context (and be mass), or be disjoint in context (and be count).

In Section 2.4, we argued that the count counterparts of Landman’s neat mass nouns can be interpreted as counting context-sensitive nouns on Rothstein’s account, and that mass counterparts of counting context sensitive nouns can be interpreted on Landman’s account as neat mass. However, to establish that nouns like fencing are in the same broad class as nouns like furniture, we had to make a minor adjustment to Landman’s definition of neat mass, namely that set of minimal generators has the same cardinality at all variants.

For a semantic unification of these accounts, one must define Landman’s notion of context in which the set of entities that count as ‘one’ overlap simultaneously in the same context differently from Rothstein’s default counting contexts which return disjoint sets. Our proposal in Section 5 does this by defining Landman’s notion of context as the in terms Rothstein’s default contexts. (In brief, the interpretation of a
predicate at a Landman context will be the sum of the interpretation of that predicate over all Rothstein contexts.)

Assuming one has two notions of context (one in the Landman sense and one in the Rothstein sense), then, on a (non-)overlap based account, superordinate artifacts and homogenous objects may be classed as mass when interpreted relative to Landman contexts and as count when interpreted relative to Rothstein contexts. Thus a synthesized Rothstein-Landman account could accommodate the mass/count variation data for homogenous objects and superordinate artifacts from Table 1. This is a clear advantage over a vagueness-only based account for which nouns in these classes were problematic.

Nonetheless, nouns in the granulars class still pose a challenge for even a hybrid Rothstein-Landman account. The difficulty is that no matter how one looks at it, the set of entities that count as ‘one’ for granulars does not overlap. Overlap was present for homogenous objects, because if one has two (relevantly) similar homogenous objects that count as one (such as two portions of fence), then one can append one to the other and get a sum entity that also (in at least some contexts) counts as one fence too. Overlap was present for superordinate artifacts, because if one has two objects that count as ‘one’, such as a pestle and a mortar for kitchenware, such that these two objects have a joint function qua item of kitchenware (holding and grinding things), then the sum of these entities could well also count as ‘one’ with respect to kitchenware.

The same does not hold for granulars. For example, single lentils count as one with respect to the predicate lentils, however, there are no contexts in which sums of lentils count as ‘one’ lentil. Hence, there cannot be overlap going ‘upwards’ in the lattice from single lentils as we found with both homogenous objects and superordinate artifacts. However, nor can one locate overlap going either ‘downwards’ or ‘horizontally’ in the lattice. Parts of single lentils do not count as ‘one’ lentil, so downwards overlap is ruled out. Furthermore, single lentils do not themselves overlap, hence there cannot be ‘horizontal’ overlap either.

Granulars can be lexicalized as count (e.g. lentils [+C]) or as mass (e.g. čočka [-C] (‘lentil’, Czech)), but, as we have seen, the set of entities that count as ‘one’ for such nouns is non-overlapping at all contexts. Non-overlap within and between contexts means that granulars should all be count nouns. However, we often find mass nouns in this class, therefore (non-)overlap at a context cannot be the whole story when it comes to the mass/count distinction.

In summary, neither a vagueness-only account nor an account only based on (non-)overlap at a context can accommodate the full range of cross- and intralinguistic data, therefore, either an entirely new source for the distinction may be at play, or something more complex than (non-)overlap or vagueness alone may be at work. We opt not to throw the baby out with the bathwater and so, choose the latter. In the next Section we argue that these data can be accommodated with a dual-source account (vagueness and (non-) overlap at a context).
4 A DUAL SOURCE ACCOUNT

In this section, we argue that two different indices of evaluation affect mass/count encoding and so should feature in a semantics for concrete nouns. One index is the set of counting contexts in the sense of Rothstein (2010), the other is the set of permissible precisifications in the sense of Chierchia (2010). We will show how all of the above cross- and intralinguistic mass/count variation data can be accommodated by an account that uses both of these indices. We formally present these ideas in Section 5.

Given that, in Section 2, we argued that homogenous objects (fence) and superordinate artifacts (furniture) can be subsumed under the same broad class of nouns, we now have four main classes to analyze: (i) prototypical objects; (ii) homogenous objects & superordinate artifacts; (iii) granulars; (iv) substances, liquids and gasses. In the following Sections (4.1-4.4) we discuss the concept of counting as ‘one’ for each of these classes. We assess each class in terms of sensitivity or insensitivity to counting context, and to precisification context.

We show that when a set of entities that count as ‘one’ for a predicate is insensitive to both indices, the predicate noun is stably count. When there is no clear set of entities that count as ‘one’, it is not determinate whether the predicate is sensitive or insensitive to counting context. This leads to predicates being stably mass. We further show that when a set of entities that count as ‘one’ for a predicate is insensitive to one, but not both indices, then we should expect mass/count variation.

4.1 Prototypical Objects

Nouns in this class tend to be ‘naturally atomic’ in the sense of Rothstein (2010), or come in ‘natural units’ in the sense of Krifka (1989). The set of entities that count as one are these natural units: single chairs, boys, cats for chair, boy, cat, respectively. Nouns in this class are not sensitive to counting contexts (a single cat counts as ‘one’ cat at all counting contexts). These informal characterizations will be formally derived in Section 6.

The set of entities that count as ‘one’ also does not greatly vary depending on the precise interpretation of, for example cat. That is to say that, for some set of entities (such as the clear cases of cats), these individuals will be in the set of things that count as one cat at every index of interpretation for cat.

Notice that this way of thinking differs from Chierchia’s (2010). In Chierchia (2010), there is no concept of what counts as ‘one’ independently of the set of entities that are atoms in a predicate’s denotation across all permissible precisifications (the stable atoms). We go a slightly different route. We take what counts as ‘one’ as a more pre-theoretical notion, and then assess whether or not different precisifications include or exclude individuals that count as ‘one’ from the noun’s denotation.

For prototypical objects, there is a set of countable entities on any and across all precisifications. This characteristic of a predicate is what we define as insensitivity to
precisification contexts with respect to the entities in the predicate’s denotation that count as ‘one’.

Prototypical objects are insensitive to counting contexts too. Relative to some precisification, there is no change in the number of countable entities as the counting context varies. So, even on an account the integrates both variation in interpretation (precisifications) and variation in the way one individuates (counting contexts), nouns in this class are countable insofar as at any (or all) precisifications and at any (or all) counting contexts, there is a non-empty set of non-overlapping, and thereby countable set of entities available.

4.2 Superordinate Artifacts and Homogenous Objects

Here we adopt the viewpoint of the synthesized Rothstein-Landman framework we outlined in Section 2. The set of entities that counts as one in this class is sensitive to counting context. For example, depending on the counting context, a square of fencing may count as one fence, or as, say, four fences (Rothstein 2010). Also, depending on the counting context, what counts as one meubel (‘(item of) furniture’, Dutch) or what counts as one item of furniture will vary from context to context. For example, a vanity may count as one in some contexts, but as two (a table and a mirror) in others.

Just like prototypical objects, the set of entities that count as ‘one’ for nouns in this class are not sensitive to precisification contexts in the sense that there are some entities (fences, pieces of furniture) that count as one no matter how one varies the precisification of fence/furniture (the set of entities that count as ‘one’ is not empty).

Also like prototypical objects, the lack of vagueness for nouns in this class means that at any or across all precisifications, there is a set of entities that form a putative counting base. However, the sensitivity of these nouns to counting contexts means that whether or not one is left with a non-overlapping countable set is determined by whether one interprets the nouns relative to a Rothstein-type non-overlapping context or a Landman-type overlapping context. Therefore, we should expect possible variation in the mass/count encoding of these nouns. If they are indexed to counting contexts à la Rothstein, nouns in this class will be lexicalized as count. If indexed to contexts à la Landman, nouns will be lexicalized as mass.

4.3 Granular

Nouns in this class denote stuff made up of grains, granules, flakes and the like. Normally, that their denotations are so constituted, is clearly perceptible and well known for those who have grasped the sense of these nouns. Furthermore, for count nouns in this class, the single grains, granules, flakes etc., are what are denoted and explicitly available for counting. We take this as a strong reason to identify the individual grains, granules, flakes etc. as the entities that count as one for nouns in this class. For example, for both lentils[+C,PL] and čočka[-C] (‘lentil’, Czech), what counts as ‘one’ are single lentils.
As we argued in Section 3.2, nouns in this class are not counting context sensitive. That is to say that, single lentils, rice grains etc. in the denotation of rice, lentils, respectively, count as ‘one’ at every counting context.

However, nouns in this class are vague; their denotation changes depending on the precisification. Crucially, the context in which these predicates are precisified can sometimes exclude the single grains, granules or flakes etc. from their denotations. For example, on less precise interpretations of rice, and lentils, single rice grains/lentils will be of too small a quantity to be in the denotation of rice, lentils, respectively. In more precise contexts, they will be in the denotation. That means that the set of entities that intuitively count as one can be excluded from the denotations one some precisifications. This is represented graphically in Figure 3, where four possible precisifications of rice are displayed ($\pi_0, \pi_1, \pi_2, \pi_3$).

![Figure 3: Precisifications of rice do not all include the entities that count as ‘one’](image)

Just like prototypical objects, nouns in this class are not counting context sensitive. This means that whether they are interpreted relative to any counting context, including a Landman-type context (which allows a multiplicity of simultaneous variants), there will be a non-empty set of non-overlapping countable entities, provided these entities are in the denotation of the noun at all.

Whether these entities are in the denotation of the noun at all is where precisification context sensitivity comes in. For example, there are precisifications on which rice contains single grains in its denotation ($\pi_2$ and $\pi_3$ in Figure 3) and precisifications that exclude the single grains ($\pi_0$ and $\pi_1$ in Figure 3). A similar thing could be said of lentils (pace Chierchia (2010)). When predicates such as rice and lentils are interpreted relative to the intersection of interpretations across all contexts ($\pi_0$), the set of entities that count as ‘one’ is empty, because the single grains, lentils etc. are excluded from the denotations of these predicates at this (least precisified) context. Recall that when the set of entities that count as ‘one’ is empty when evaluated on all precisifying contexts, the predicate is precisification context sensitive.

This means that, depending on how strictly the noun is interpreted by default, countability is affected. If interpreted on all admissible precisifications (at $\pi_0$), the individual grains, flakes etc. will be excluded. This results in nouns being lexicalized as mass. If, by default, a noun is interpreted in a more precise manner, then the
individual grains, flakes etc., may be included, and the noun can be lexicalized as count.

4.4 Substances, liquids and gasses

Nouns in this class do not, intuitively, have any entities that count as ‘one’. There is nothing that we can identify either on perceptual or functional grounds that forms individuals in their denotations. If we take this basic intuition seriously, then when we come to represent the semantics of these nouns we will assign only the empty set to the set of entities that count as ‘one’ for e.g., mud, blood, and air. This is a departure from Landman (2011) who argues that mess mass nouns have contextually provided minimal entities. In a sense, this is forced upon Landman since he works with generator sets. The upward closure under sum of a generator set should provide the standard denotation for the noun in question and so, for Landman, the generator set of a substance, liquid or gas noun cannot be empty for non-empty standard denotations.

For us, given the assumption that substances, liquids and gasses have no entities that count as ‘one’, the question of whether the set of entities that count as one is overlapping does not sensibly arise (does nothing overlap?). For this reason, we leave it as indeterminate whether nouns in this class are counting context sensitive.

Like granulars, substances liquids and gasses are vague in that the extensions of substances, liquids and gasses vary across precisifications. If the set of entities that count as ‘one’ is always empty, then there will nonetheless be no entities that count as ‘one’ on any precisifications. In some sense, then, these nouns are insensitive to precisifications with respect to the set of entities that count as ‘one’. However, given that we have defined precisification context sensitivity as there being no entities that count as ‘one’ when evaluated on all precisifications, technically, nouns in this class are precisification context sensitive, albeit in a slightly arbitrary way.

Hence, at any context, on any single precisification, or across all precisifications, nouns in this class provide nothing to count, hence we should expect uniformity in lexicalization as mass nouns.

In the Section 5, we develop our two-dimensional formal framework and in Section 6, we formally represent the above classes and their sensitivity/insensitivity to precisification contexts and counting contexts in order to account for patterns that have been observed in mass/count variation.

5 FORMAL MODEL: A TWO-DIMENSIONAL SEMANTICS

In this section we detail our formal representation for the above informal observations. That is to say, we give a model that can represent both Rothstein’s counting contexts that enforce disjointness, Landman’s contexts that allow overlap, and a range of precisifications.
The model is two-dimensional, since expressions are evaluated along two indices: counting contexts (including both Rothstein’s and Landman’s contexts) and precisification contexts.

5.1 Model

Our model will allow evaluations across two dimensions of contexts, counting contexts and contexts that determine precisifications. Models are tuples \( (\mathcal{D}, I, \mathcal{W}, \mathcal{C}, \Pi) \). \( \mathcal{D} \) is the domain (entities and truth values). \( \mathcal{D}(\mathcal{E}) \) the domain of entities is structured as a Boolean semilattice closed under sum. \( I \) is the interpretation function (we will mostly use \( [ . ] \)). \( \mathcal{W} \) is the set of worlds, however, for simplicity we will suppress intensions here, and describe the semantics of expressions in purely extensional terms. \( \mathcal{C} \) is the set of counting contexts (details below). \( \Pi \) is the set of precisifying contexts (details below).

The standard definition of a disjoint set is:

\[
DISJ(X) \iff \forall x, y \in X[x \neq y \rightarrow x \cap y = \emptyset]
\]

However, this entails that the empty set is (trivially) disjoint. We wish to remain agnostic over the disjointness of nothingness, so we replace this definition with that of non-trivial disjointness:

If: \( \exists x \in X \)
Then: \( DISJ(X) \iff \forall x, y \in X[x \neq y \rightarrow x \cap y = \emptyset] \)
Else: Undefined

Which allows us to make a similar move for Overlap:

If: \( \exists x \in X \)
Then: \( OVERLAP(X) \iff \exists x, y \in X[x \neq y \wedge x \cap y \neq \emptyset] \)
Else: Undefined

Counting contexts \( (c_i \in \mathcal{C}) \) map sets onto maximally disjoint subsets. For a set \( X \), there is a constraint on counting contexts:

\[
X_{c_i} = \{ Y : Y \subseteq X, DISJ(Y), \forall x \in X \exists y \in Y [x \cap y \neq \emptyset] \}
\]

This means that, when applied to disjoint sets, counting contexts are the identity function. When applied to non-disjoint sets, each counting context will yield a maximally disjoint subset of that set.

This means that contexts \( c_i \in \mathcal{C} \) will behave like Rothstein’s “default contexts”. Interestingly, we can then define Landman’s contexts (that allow overlap) in terms of a sub-valuation on the set of contexts. Subvaluations are applied here to capture Landman’s (2011) idea that furniture-like nouns overspecify the set of entities that count as one. Subvaluating is a means of overspecifying. Formally speaking, subvaluations can be defined in terms of unions:
This approximates Landman’s (2011) notion of context, since it will include the union of all maximally disjoint subsets of $X$. For a set $X$, $X_{c_0}$ will not be disjoint unless $X$ was already disjoint. This means that the null counting context, $c_0$, will be the identity function on sets of entities that count as ‘one’. Disjoint sets map to the same disjoint set. Overlapping sets map to the same overlapping set.

Precisifying contexts ($\pi_i \in \Pi$) map sets that do not completely partition the domain (has an extension gap) into sets that do completely partition the domain. Like Chierchia (2010) and other supervaluationists, precisifying contexts form a partial order. $\pi \prec_X \pi'$ ($\pi'$ precisifies $\pi$), relative to a set $X$:

$$\pi \prec_X \pi' \iff X_\pi \subseteq X_{\pi'}$$

This means that precisifying does not ‘shrink’ the membership of a set, but may expand it. We follow a characterization of vagueness-based accounts made by Landman (2011), namely as involving underspecification as opposed to overspecification. Indeed, this is what supervaluations provide. Supervaluations capture the idea that nouns like rice underspecify their denotations insofar as there are amounts of rice, such as a single grain, that do not count as rice in every precisifying context. Formally speaking, supervaluations can be defined in terms of intersections:

$$X_{\pi_0} = \bigcap_{\pi_i \in \Pi} X_{\pi_i}$$

Predicates will then be interpreted relative to counting contexts and precisifications. However, in some cases (to be outlined below) the counting and precisifying contexts will be the null counting context $c_0$ or the null precisification context $\pi_0$.

5.2 The IND predicate.

Crucial to our account is the notion of what counts as ‘one’. We treat this as a pretheoretical notion, and represent it as a second order predicate that maps sets of entities to the sets of entities that count as ‘one’ (we discuss the merits of this ‘pretheoreticality’ assumption in Section 7). We allow, like Landman (2011) that the set of entities that count as ‘one’ may be disjoint or overlapping. For example, $IND(CAT)$ will be the set of disjoint single cats. $IND(FURN)$ will be the set single items of furniture (that may overlap such as with a table, a mirror and their sum which forms a vanity). $IND(RICE)$ and $IND(LENTIL)$ will be the sets of disjoint single grains of rice and single lentils respectively. $IND(MUD)$ will be empty, which models the intuition that substances liquids and gasses lack identifiable individuals independently of the provision of an explicitly or contextually provided measure or package.

However, the IND predicate also introduces a requirement for a counting context. Predicates, $P$, we assume, are already typed with a precisification context argument,
so are of type $\langle \pi, \langle e, t \rangle \rangle$. Applying $IND$ (which is of type $\langle \langle \pi, \langle e, t \rangle \rangle, \langle c, \langle \pi, \langle e, t \rangle \rangle \rangle \rangle$) to $P$ yields an expression of type $\langle c, \langle \pi, \langle e, t \rangle \rangle \rangle$. The intuitive idea here is that $IND(P)$ yields a set of entities that count as one $P$. This set can then be interpreted relative to either a specific counting context ($c_i$) or the null counting context ($c_0$) and relative to a specific precisification ($\pi_i$) or the null precisification ($\pi_0$).

5.3 Precisifying context sensitivity (\(\Pi\)-Sensitivity)

A predicate $P$ is \(\Pi\)-sensitive relative to a counting context $c_i$ iff:

$$\Pi\text{-sensitive}(P)_{c_i} \iff \|IND(P)\|^c_i\pi_0 = \emptyset \quad (8)$$

If a predicate is such that, over precisification contexts, the set of entities that count as ‘one’ are excluded, then there will be no entities that count as ‘one’ on all precisifications (at $\pi_0$). For example, if single grains are in the denotation of $RICE$ at some, but not all $\pi_i \in \Pi$, then single rice grains will not be in the denotation of $RICE$ at $\pi_0$. Nouns in the substances, liquids and gasses class such as $mud$ are vacuously \(\Pi\)-sensitive. They do not have any entities that count as ‘one’, so $IND(MUD)$ is empty at all precisifying contexts, so is also empty at $\pi_0$.

It follows that if a predicate is not \(\Pi\)-sensitive, then the reverse is true:

$$\text{Not: } \Pi\text{-sensitive}(P)_{c_i} \iff \|IND(P)\|^c_i\pi_0 \neq \emptyset \quad (9)$$

There are entities that are in the denotation of, for example, $cat$, and $furniture$ at all precisifications, therefore these nouns are not \(\Pi\)-sensitive.

5.4 Counting context sensitivity ($C$-sensitivity)

We can define $C$-insensitivity as the denotation of a predicate being disjoint with respect to the entities that count as ‘one’, relative to a precisification $\pi_i$, by using counting contexts $c_i \in \mathcal{C}$, and specifically using the subvaluated index $c_0$:

$$C\text{-insensitive}(P)_{\pi_i} \iff DISJ(\|IND(P)\|^c_0\pi_i) \quad (10)$$

Recall that $c_0$ takes the union of the interpretations of the formula across all counting contexts. $C$-insensitivity entails that there are entities that count as ‘one’ and the interpretation of $IND(P)$ is disjoint at $c_0$.

This will capture the idea that nouns in the prototypical objects class such as $cat$ will be disjoint at $c_0$, since $IND(CAT)$ is anyway disjoint.

$C$-sensitivity, defined in terms of overlap, entails that there are entities that count as ‘one’ and the interpretation of $IND(P)$ is not disjoint at $c_0$.

$$C\text{-sensitive}(P)_{\pi_i} \iff OVERLAP(\|IND(P)\|^c_0\pi_i) \quad (11)$$
Nouns in the *substances, liquids and gasses* class are not defined for disjointness with respect to what counts as one and so it is undefined whether or not they are counting context sensitive (*C*-sensitive).

Nouns in the granulars class such as *rice, lentils* come out as disjoint when assessed at precisifications that include the entities that count as ‘one’, since the set of single grains of rice/single lentils is anyway disjoint, so does not change across counting contexts. However, in precisifying contexts where the entities that count as ‘one’ are excluded from the denotations of granulars, then, at those precisifying contexts, it is undefined whether or not they are disjoint. We discuss the surprisingly positive ramifications of this in Section 6.

Nouns in the superordinate artifacts and homogenous objects class will not be disjoint. Take for example, for *kitchenware*. In some counting contexts, a pestle and mortar will count as two items of kitchenware, but in other contexts it will count as one. This means that at *c₀*, the *IND* set of *kitchenware* will not be disjoint, since it will contain pestles, mortars and pestle and mortar sums.

### 6 Mass/Count Lexicalization Patterns, Lexical Entries and Further Predictions

6.1 Distribution of Mass/count lexicalization across and within languages

Having defined Π-sensitivity and *C*-sensitivity, we can derive predictions for the likely encoding of lexical items as count or mass cross- and intralinguistically. This is summarized in Table 2.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Example Class</th>
<th>Mass/Count Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Π-sens. No</td>
<td>No Prototypical Objects</td>
<td>Strong tendency as count</td>
</tr>
<tr>
<td>Yes</td>
<td>No Granulars</td>
<td>Variation</td>
</tr>
<tr>
<td>No</td>
<td>Yes Homog. Objects &amp; Superord. Artifacts</td>
<td>Variation</td>
</tr>
<tr>
<td>Yes</td>
<td>Undefined Substances, liquids, gasses</td>
<td>Strong Tendency as Mass</td>
</tr>
</tbody>
</table>

By using these two properties as two sources for the grounding of the mass/count distinction, we are able to predict where one should expect to find variation in mass/count lexicalization patterns. This is something that the other accounts we considered above do not manage to do. The reason why should be clear from Table 2. With just one single source (either Π-sensitivity or *C*-sensitivity) one would be forced to make a binary decision with respect to mass/count lexicalization leaving no room for variation. With two sources, there is room to motivate how displaying one source, but not the other, can give rise to a tension, the resolution of which leads to either count or mass encoding.
As a brief but important digression, let us observe that our four-way distinction displays parallels with Grimm’s (2012) work on the *Scale of Individuation*:

| substances | granular aggregates | collectives | individual entities |

Grimm (2012) did not address artifacts. However, *substances* align roughly with our class of *substances, liquids, gasses*, and Grimm’s *individual entities* aligns with our *prototypical objects*. It is less clear how the intermediate classes of Grimm relate to our *granulars*. Grimm tends to place what we call ‘granulars’ in either the ‘granular aggregates category (for more fined grained entities), and in the collectives category for more course grained entities (Grimm p.c.).

From the ordering in Grimm’s (2012) scale of individuation, one can predict patterns in mass/count encoding for specific languages. For example, for a language such as English which arguably has two countability classes, count and mass, it should be ruled out, for example, that substances are lexicalized as count, but collectives as mass. It should also be ruled out that individual entities should be lexicalized as mass, but granular aggregates as count.

With respect to our classes, we doubt there is an ordering relation between homogenous objects and superordinate artifacts on the one hand and granulars on the other. That is to say that the count or mass encoding of, say, superordinate artifacts in a language does not predict the mass/count encoding of granulars.

It is interesting, given that Grimm derives his scale from morphological and syntactic factors that are independent to our own, that we have arrived at approximately converging conclusions.

### 6.2 Mass and Count in our two-dimensional semantics

As Table 2 shows, mass encoding can come either from $\Pi$-sensitivity or $\sigma$-sensitivity. However, when only one form of sensitivity is present, it is possible to find count encoding too. Our explanation for this is that there is a lexical choice in whether counting bases are indexed to the contexts of utterance ($c_i, \pi_i$), or the null contexts ($c_0, \pi_0$). We will show how, prototypical objects, and for substances liquids and gasses, this choice makes no difference. Crucially, for the classes of granulars, homogenous objects, and superordinate artifacts, we show how this choice translates into count nouns when applying $c_i, \pi_i$, and mass nouns when applying $c_0, \pi_0$.

We adopt Landman’s (2015, this volume) distinction between body and base, and of representing the lexical entries of nouns as a pair *(BODY, BASE)*. We define the body as the denotation of the number neutral predicate, and the base as the putative set of entities for counting. Unlike Landman (2011), we do not require the base to generate
the body. Below is the schema for a noun lexical entry and the schemas which show how these entries differ for count and mass nouns:

Noun schema:  
\[ \text{[noun]}_{\pi_i} = \langle \text{BODY, BASE} \rangle \]

Count schema:  
\[ \text{[p]}_{c_i \pi_i} = \langle P_{\pi_i}, \text{IND}(P)_{c_i \pi_i} \rangle \]

Mass schema:  
\[ \text{[p]}_{c_0 \pi_0} = \langle P_{\pi_0}, \text{IND}(P)_{c_0 \pi_0} \rangle \]

With respect to the body, both count and mass nouns are indexed to the precisification context of utterance (\(\pi_i\)). This reflects that the standards of precision (precisifying context) may vary for count and mass nouns. For example, the interpretation of *lentils* is sensitive to precisifying context in the same way that the interpretation of *rice* is.

With respect to the base, not only is there an index to a precisifying context (\(\pi_i\) for count nouns and \(\pi_0\) for mass nouns), but also to a counting context (\(c_i\) for count nouns and \(c_0\) for mass nouns). Recall that the inclusion of the counting context as an argument is introduced as part of the semantics of \(\text{IND}\).

Our proposal is that when the counting base is disjoint and non-empty, we expect a count noun. When the counting base is empty or not disjoint we expect a mass noun. Variation in mass/count lexicalization will be expected when the disjointness and/or emptiness of the base turns on whether the indices are \(c_0\) and \(\pi_0\) or \(c_i\) and \(\pi_i\).

6.3 Examples of lexical entries and further predictions

We now go through some example of each of the classes of nouns described in Table 1 and show how the sensitivity of counting bases to either precisification contexts or counting contexts makes correct predictions about the behaviors of the nouns in each case.

6.3.1 Prototypical objects: *cat*

The lexical entry for *cat* will be as in (12). The body is the number neutral predicate \(\text{CAT}\). The base is a maximally disjoint subset of the set of individual cats, which is just the set of individual cats. This set is non-empty and disjoint, therefore *cat* is grammatically countable.

\[ \text{[cat]}^{c_i \pi_i} = \langle \text{CAT}_{c_i \pi_i}, \text{IND}(\text{CAT})_{c_i \pi_i} \rangle \]  

(12)

However, suppose, just for fun, we were to try to give *cat* a lexical entry in the mold of a mass noun as in (13). Critically, the result should still be a count noun. The base set is non-empty and disjoint, therefore even *cat’* should be grammatically countable.

\[ \text{[cat’]}^{c_0 \pi_0} = \langle \text{CAT}_{c_0 \pi_0}, \text{IND}(\text{CAT})_{c_0 \pi_0} \rangle \]  

(13)
6.3.2 Superordinate artifacts: *furniture* versus *huonekalu*

The lexical entry for *furniture* will be as in (14). The body is the number neutral predicate \( FURN \). The base is the set of items of furniture that count as ‘one’. The base set is non-empty, but it is not disjoint, since it is indexed to \( c_0 \). For the same reasons as given by Landman (2011), overlapping base sets make counting go wrong, hence *furniture* is mass.

\[
[furniture]_{c_l,\pi_l} = \langle FURN_{\pi_l}, IND(FURN)_{c_0,\pi_0} \rangle \quad (14)
\]

However, now if we try providing a lexical entry in line with the count schema, we see a different effect. Now the base set is indexed to the counting context of utterance/evaluation \( c_l \), not the null context \( c_0 \). This means that at every context, the base set is disjoint and non-empty and so fit for use in counting. In other words, this lexical entry would be appropriate for a count noun with the same denotation as *furniture* such as the Finnish *huonekalu* (‘(items of) furniture’) as in (15).

\[
[huonekalu]_{c_l,\pi_l} = \langle FURN_{\pi_l}, IND(FURN)_{c_l,\pi_l} \rangle \quad (15)
\]

6.3.3 Homogenous objects: *fence* versus *fencing*

The same pattern as with superordinate artifacts emerges with homogenous objects. Indexing to a specific counting context yields a count noun such as *fence* in (16), because the base is non-empty and disjoint. Indexing to the null counting context yields a mass noun such as *fencing* in (17), because the base is non-empty and overlapping.

\[
[fence]_{c_l,\pi_l} = \langle FENCE_{\pi_l}, IND(FENCE)_{c_l,\pi_l} \rangle \quad (16)
\]

\[
[fencing]_{c_l,\pi_l} = \langle FENCE_{\pi_l}, IND(FENCE)_{c_0,\pi_0} \rangle \quad (17)
\]

6.3.4 Granulars: *rice* versus *lentils*

The lexical entry for *rice* is given in (18). The body is the number neutral predicate \( RICE \) interpreted relative to a precisification context. In some precisification contexts, this will include single grains of rice, in others it will not. The base set does not contain the single grains of rice, since it is interpreted relative to the (supervaluated) null precisifying context \( \pi_0 \). This set is, therefore, empty, so provides no counting schema. Therefore, even when a single grain is sufficient to count as *rice* in the context of utterance, the counting base does not pick single grains out for grammatical counting. *Rice* is mass.

\[
[rice]_{c_l,\pi_l} = \langle RICE_{\pi_l}, IND(RICE)_{c_0,\pi_0} \rangle \quad (18)
\]

The lexical entry for *lentil* is shown in (19). The body is the number neutral predicate \( LENTIL \) interpreted relative to a precisifying context.
There are now two possible cases. One is where the precisifying context does include single lentils. The other is where it does not. When $\pi_t$ does admit single lentils, then the base is the set of single lentils. The base set is non-empty and disjoint since it is indexed to $\pi_t$. Interestingly, in the case where the precisifying context of utterance does not include single lentils in the denotation of lentils, this account predicts that access to the individual lentils should be obscured.

At first this may not seem like a validated prediction. Is not lentils a straightforward count noun? Yet, in contexts, say where lentils are being served for dinner, perhaps in a stew, it is decidedly strange to ask the question in (20):

(20) How many lentils would you like?*

The extent to which one can interpret this is actually more akin to a mass-count coerced packaging reading (e.g. How many SPOONFULS OF lentils would you like?). The lexical entry in (19) leads to a prediction that the question in (20) should not be answerable unless the precisifying context is shifted. Note that one could answer (20) with “Around 500”, but this is almost some kind of joke. Perhaps part of the joke is answering as if from a different standard of precision.

6.3.5 Substances, liquids and gases: mud

The lexical entry for mud is given in (21). The body is the number neutral predicate MUD interpreted relative to a precisification context. The base set is empty, since nothing intuitively counts as ‘one mud’ whether in a specific precisifying context or in the null precisifying context. The base set therefore provides no counting schema, so mud is mass.

$$\llbracket \text{mud} \rrbracket_{c_i, \pi_t} = \langle \text{MUD}_{\pi_t}, \text{IND} (\text{MUD})_{c_0, \pi_0} \rangle$$

(21)

However, let us see what happens if we try to apply the count noun schema to mud, the result being (22). Just as with the reverse operation with cat, this makes no difference. The base set is still empty and so provides not counting criterion: mud is still mass.

$$\llbracket \text{mud'} \rrbracket_{c_i, \pi_t} = \langle \text{MUD}_{\pi_t}, \text{IND} (\text{MUD})_{c_i, \pi_t} \rangle$$

(22)

6.4 Summary

In this section we have seen how sensitivity to precisifying contexts and sensitivity to counting contexts gains a great deal in developing a semantics for countability in nouns. We can predict the distributional patterns of mass and count we should expect to find cross- and intralinguistically based on semantic criteria. Furthermore, building on this, we have given representations for nouns across the classes that do and the classes that do not display mass/count variation. Based on these representations, we have been able to explain why the lexicalization of both a mass noun and a count
noun is probable in some cases (granulars, superordinate artifacts, and homogenous objects), and much less probable in others (prototypical objects, and substances liquids and gasses).

7 LACUNA

Despite making progress in unraveling some of the complexities and puzzles in the semantics of the mass/count distinction, our account leaves a sizable lacuna. The lacuna is, what are the mechanisms that underpin the mapping the IND predicate makes from a number neutral predicate to the entities that count as ‘one’ for that predicate. We briefly address this issue in this section by assessing what has been said on this matter in the mass/count literature that we have discussed in this paper, and in relation to work we have done in a frame-based framework, Type Theory with Records (TTR, Cooper (2012)).

To some extent, our IND predicate plays a similar role to Krifka’s (1989) natural unit measure function (NU), except that we have enriched this notion to be counting context sensitive (following Rothstein (2010)), and to be applied to a predicate at a precisification context. Krifka does briefly discuss some constraints on NU (which is the equivalent of OU in Krifka (1995):

“we can assume that NU yields the same measure function for entities of a similar kind. For example, the unit for all living beings is constituted by the organism. Then, NU(cattle’) and NU(game’) should denote the same measure function.” (Krifka 1989, p. 84)

“The operator OU could reasonably be interpreted in such a way that it yields the same measure function for, say, bears and cats, that is, OU1(Urus) = OU1(Felis) in both cases the unit is derived from the notion of a biological organism and may be identified with OU1(animal).” (Krifka 1995, p. 401)

As noted by Zucchi and White (1996, 2001) and later Rothstein (2010), Krifka’s notions of natural unit and quantization do not apply well to nouns such as string and fence which do not come in natural units. However, it is also not clear how the above considerations affect the individuation of nouns which denote artifacts such as chair, let alone more complex cases such as furniture and kitchenware. Indeed, it pushes the use of ‘natural’ to describe artifacts as natural units at all. Perhaps a better nomenclature for artifacts would be functional unit.

The notion of counting as ‘one’ in Chierchia (2010), insofar as he has one at all, is reduced to the notion of stable atom. However, as we have seen, this wrongly predicts that for crosslinguistic pairs such as lentil-{s1+c,pl} and čočka{-c} (‘lentil’, Czech), there are entities that count as ‘one’ for lentils, but not for čočka.

Counting as ‘one’ also features in both Rothstein (2010) and Landman (2011). Rothstein (2010) enhances Krifka’s natural units by making this function context sensitive (a device that we have adopted here). However, part of this notion is still
pretheoretical, since there are no constraints in Rothstein’s account on what an acceptable or admissible counting context is. For example, why a portion of picket fencing in London and a portion of chain-link fencing in Berlin cannot, as a sum, count as ‘one’.

Landman constrains counting as ‘one’ with his definition of generator set, namely a set that must generate the full denotation under complete mereological sum. However, as Landman is aware, provided that some elements of a set are sums of other elements, there will be more than one set that satisfies the definition of generator set. In other words, for any predicate, the mechanism that selects a generator set as the set of entities that counts as ‘one’ is assumed to be pretheoretical.

One response to the lacuna is simple to discharge oneself from the responsibility of filling it. After all, there are enough puzzles, complexities and data to account for even if one does take counting as ‘one’ as a pretheoretical notion. Indeed, this is not an incoherent position to adopt. One way of framing this position could be to draw a divide between compositional and lexical semantics. Counting as ‘one’ in relation to a predicate could be classed as a task for lexical semantics and so dispensed as a duty for projects in compositional semantics. However, this does not exclude the possibility of combining insights from lexical semantics with compositional semantics and outlining how they feed into compositional semantic representations.

Grimm’s work (Grimm 2012), is one example of how this can be done. Grimm (2012) argues that mereology is insufficient to capture the notion of individual and argues that semantics should be enriched with mereotopological relations. For example, he gives the following lexical entry (Grimm 2012, p. 151):

\[
[\text{dog}] = \lambda x_0 [R(x_0, \text{Dog}) \land \text{MSSC}(x_0)]
\]  

(23)

Where MSSC stands for the mereotopological predicate maximally strongly self-connected: “An [mereological]-individual is Maximally Strongly Self-Connected relative to a property if (i) every (interior) part of the individual is connected to (overlaps) the whole (Strongly Self-Connected) and (ii) anything else which has the same property and overlaps it is once again part of it (Maximality)” (Grimm 2012, p. 135).

An alternative approach is argued for in Sutton and Filip (2016a, 2016b). Sutton and Filip develop a mereological version of probabilistic Type Theory with Records (Cooper et al. 2015). A major benefit of adopting a TTR framework is that they combine frame theoretic lexical semantic representations inspired by Fillmore (1975, 1976), with compositional semantics in the Frege-Montague tradition. Sutton and Filip (2016b) begin to investigate and formally model how perceptual information and conceptions of function interact with semantic learning and can lead to different conceptions of counting as ‘one’. A major drawback of the two-dimensional semantics presented in this article, which is detailed in a relatively conservative model-theoretic framework, is that it is fundamentally unclear how one could include such a rich variety of information within the constrains of this framework.

To put things simply, suppose we call the investigation into the notion of what ‘counts as one’ the development of a theory of individuation, and the development of an
account of the mass/count distinction a theory of countability. It is then likely that the
development of a theory of individuation will inform the development of a theory of
countability, and vice versa. However, if that is the case, then both should be explored
within a formal framework capable of representing a rich enough range of
information to encapsulate both. To this end, the probabilistic, mereological frame-
based formalism developed by Sutton and Filip (2016a, 2016b) is a good contender.

8 SUMMARY AND CONCLUSIONS

The account we proposed here can accommodate a much broader range of mass/count
data than other leading proposals. For the classes of nouns we have identified:

Prototypical objects: Nouns in this class have a strong tendency to be count. This is
because they are counting-context and precisification-context insensitive. They have
non-empty, disjoint sets of entities that count as ‘one’ at all counting and
precisification contexts. They even have non-empty, disjoint sets of entities that count
as ‘one’ at the null counting and precisification contexts.

Superordinate artifacts and Homogenous objects: Nouns in this class display a lot of
mass/count variation. This is because they are counting context sensitive, but not
precisification context sensitive. They have non-empty sets of individuals that count as
‘one’, but this set is disjoint only when interpreted at specific counting contexts. It is
not disjoint at the null counting context. This means that mass/count lexicalization
turns on whether they are indexed to a specific counting context or the null-counting
context. Hence, we expect mass/count variation.

Granulars: Nouns in this class display a lot of mass/count variation. This is because
they are precisification context sensitive, but not counting context sensitive. When
non-empty, the set of entities that count as ‘one’ are disjoint, but this set is not non-
empty at some precisifications. This means that mass/count encoding turns on
whether these nouns are interpreted at a specific precisification context or at the null
precisification context. Hence we expect mass/count variation in this class.

Substances, liquids, and gasses: Nouns in this class have a strong tendency to be
mass. This is because they are precisification context sensitive in the sense that they
always lack a set of entities that count as ‘one’, and they are undefined for being
counting context sensitive, since they lack a set of entities that count as ‘one’ so are
undefined for disjointness. This means that at no counting or precisification context
(including the null contexts) is there a set suitable to form a counting base. This is
why we expect fairly consistent mass encoding.

We have argued that at least two semantic sources must lie behind the semantics of
mass and count nouns. This is because, with a single, categorical criterion for whether
a noun will be mass or count, one cannot account for the full range of variation in
mass/count lexicalization patterns. However, there are further puzzles that our
framework may be able to untangle. There are severe restrictions on the felicity
conditions for cases of mass-to-count coercion. For example, granular and
superordinate artifact mass nouns resist object ‘packaging’ readings: Three furnitures
cannot be read as ‘Three ITEMS OF furniture’, and Three rices cannot be read as ‘Three GRAINS OF rice’. The fact that mass nouns, on our account, are indexed to the null counting and precisification contexts may hold the key to explaining this. For example, to pragmatically substitute ITEM OF into Three furnitures would constitute removing the null counting context $C_0$ from the lexical entry for furniture, and replacing it with $C_t$, the counting context of utterance. However, this is an operation above and beyond the usual ‘packaging’ coercion found in cases such as Three waters meaning e.g., ‘Three GLASSES OF water’.

Representing how different aspects of context interact and allow, or debar both mass and count conceptualizations of entities better accommodates mass/count lexicalization patterns, can lead to predictions regarding the precise behavior of nouns in different classes, and, in future research, may help to explain hitherto unaccounted for restrictions on mass/count coercion.

REFERENCES


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The nouns fence and cow may be context sensitive in other respects.

An exception is arguably in Brazilian Portuguese (Pires de Oliveira and Rothstein 2011) in which all count nouns potentially have mass readings when in the bare singular.

We are aware, however, that in some languages such as Yudja (Lima 2014), all nouns seemingly have straight-forward, non-coerced count uses (e.g. can be combined directly with numerals). Our current account does not accommodate these interesting data, however, we plan to address them in future work.

It is also forced to ask How much lentils would you like?, this has to do with a clash with the input requirement of the determiner much. We also find it hard to interpret How much lentil would you like? except in cases where the answer would be, for
example, *half a lentil*. In this sense, *lentil* behaves a stubbornly count noun. The fact that nouns like *lentil-s* resist both ‘how much’ and ‘how many’ questions is a puzzle, we intend to return to in more detail at a later time.