# Objects and the grammar of countability

# Contents

# Chapter 1

# Introduction and Overview

## 1.1 Central themes

Among the key phenomena that have motivated theories of countability in the last thirty years or so are, broadly, intricate mismatches in the mappings between what is lexicalized as count or mass nouns, on the one hand, and what language users tend to view as discrete objects, on the other. Specifically, our focus is on two phenomena. First, there are mass nouns which, notionally speaking, denote what are taken to be discrete objects, and have some of the grammatical reflexes canonically associated with the grammatical properties of count nouns. In other words, we have **non-canonical grammatical reflexes of countability.** Second, there are many pairs of plural count and mass nouns that, at least prima facie, have the same denotation. I.e., the same property/concept can be lexicalized as a count noun in some language and as a mass noun in some other, or even in the same language. (We clarify what we mean by *properties/concepts* directly below in section 1.1.1.) Thus we also have **variation in count/mass lexicalization patterns**, within a particular language and across different languages.

While the two phenomena are well-known in the studies on the count/mass distinction, what has not yet been observed, let alone explained, is their intriguing connection: namely, the very same classes of nouns that have non-canonical grammatical reflexes of countability also contain instantiations of pairs of mass and plural count nouns, and thus exhibit variation in count/mass lexicalization patterns. This striking connection is the launchpad for much of the work in this volume.

We assume familiarity with compositional semantics enriched with Classical Extensional Mereology (CEM). (See Appendix A for definitions of the basic concepts as well as for an overview of other key definitions provided in this volume.) We argue that one of the central keys to understanding these two phenomena is whether a common noun has OBJECTS, or sums thereof in its extension.

As we will go on to clarify, intuitively, what we mean by *object* here includes what language users perceive in the structure of the world as separate discrete entities, such as individual apples, pencils, cars, and also individual lentils or grains of rice. However, it is one of the goals of this book to argue that we need a characterisation of the notion of *object* that goes beyond this intuitively straightforward and prima facie notion. We will argue that what counts as 'one' discrete object in the semantic representation of nouns, as required for their use in counting and quantificational constructions, not only depends on our mere observation of the world and entities in it, but also on on how we manipulate them, on their affordances, on our interactions with them in our daily lives, as well as on their topological properties (see also section 1.2.1). With this EXTENDED conception of *object* in hand we will provide an account of why certain classes of nouns have non-canonical reflexes of countability, and also why the very same classes of nouns have variation in count/mass lexicalization patterns. As part of this account, CONTEXT (modelled formally in the semantics of common nouns, building on the work of Kaplan 1989) will play a crucial role insofar as context can afford different ways of viewing the entities in the extension of a noun and so what counts as 'one' for that noun in that context.

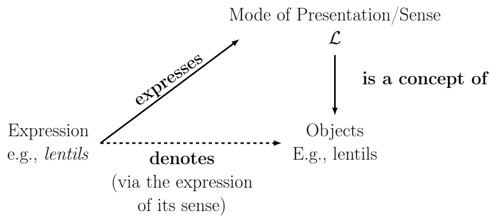
### 1.1.1 Properties, lexicalization and denotation

In this volume, we do not take a strong position on some of the central questions in the philosophy of language and mind such as whether meanings are 'in the head' or whether there is primacy of thought over language in explicating meaning. We work within the tradition of formal semantics in the Frege-Carnap-Montague tradition which locates us broadly in a non-psychologistic approach to semantics. However, since we will, at times, appeal to, for instance, cognitive factors and conceptualisations of objects, here at the outset, we wish to clarify some of our terminology.

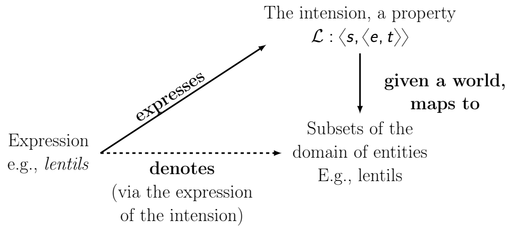
Let us start with a Fregean background (see Figure 1.1a). A common noun expresses a sense, or, more broadly, a *Mode of Presentation (MoP)* (which is in Frege's earlier work called a *concept*). To take the plural count noun *lentils*, as an example, it is via this MoP that an expression (can be used to) denote something in the world (lentils). Denotation is thus indirect as indicated by the dotted vectors in the diagrams in Figure 1.1.

For Frege, *concepts* were not psychological entities. For our purposes, we neither commit to nor reject such strong anti-psychologism. For us, it

Figure 1.1: The Frege and Carnap-Montague pictures of semantics




(a) The Fregean picture (based on a figure in Kaplan 1989)




(b) The Carnap-Montague picture of semantics

is sufficient to say that there is at least something, or a core of something, shared by many different agents such that what one grasps in understanding the expression *lentils* is in some sense the same as what the other grasps.

In Montague semantics, building on developments made by Carnap, Fregean senses/modes of presentation/concepts can be roughly equated with *intensions*, which for common nouns are canonically understood as *properties* (functions from worlds to sets of entities), see Figure 1.1b. Again, an expression like *lentils* denotes lentils via its expressing of its sense, and its extension (what *lentils* denotes) is a function of what world/situation that intension is evaluated with respect to.

To reiterate, one need not commit to *where* these properties such as that expressed by *lentils* 'live', but one can reasonably assume, as we do, that in grasping what *lentils* means, there is something, or some core of something grasped that agents share. This core meaning is shared between members of a language community. It is at least part of what mediates between form (the word, or use thereof) and the world (what is denoted by the word or use thereof), as it is sketched in Figure 1.1. For common nouns, this shared core we shall refer to as a (NUMBER NEUTRAL) CORE PROPERTY. For instance, for *lentil(s)* we use `lentil` for this core property. It is number neutral insofar as we assume that the entities that instantiate it need not only be single lentils, but could also be sums thereof. From now on, we will stick, almost exclusively to using *core property* instead of *(core) concept* as, Frege's notion of *concept* aside, we tend to prefer the less psychologistic *property*.

The discussion, so far, has only related to an expression from a single language. However, things get more complicated when looking cross-linguistically. For instance, whereas *lentils* is the plural form of the singular count noun *lentil*, in Czech, the corresponding expression is *čočka* ('lentil', Czech), is a mass noun.

A question that such data prompt is what gives rise to such countability distinctions. In this regard, we make the following assumption, A1:

**(A1)** The count/mass category of a common noun is determined (at least in part) by the lexical semantics of that common noun.

A1 implies that, for instance, there is some semantic distinction between the interpretation of *lentils*, on the one hand, and *čočka* ('lentil, mass, Czech), on the other, such that this difference is at least part of the explanation for why *lentils* is a plural count noun and *čočka* is a mass noun. That is to say that it cannot be the case that ⟦lentils⟧ = ⟦čočka⟧.

However, taken at face value, this conclusion is in tension with another intuition, namely one that relates to *lexicalization* embodied by assumption A2.

**(A2)**: Lexicalization is a relation between a property, $\mathcal{P}$ and a lexical item $l$ ($l$ lexicalizes $\mathcal{P}$). Mass and count pairs of expressions (across or within languages) may lexicalize the same number-neutral core property.

To be clear, A2 is not intended to rule out that there be fine-grained extensional differences between the meanings of expressions across languages, for instance, but rather that, in some sense of 'same', *lentil* (here we do not need the plural) and *čočka* lexicalize the same number-neutral core property and also can be used to denote the same entities in the real world.

The tension arises as follows. Given that we do not wish to endorse any strong form of the Sapir-Whorf hypothesis (Whorf, 1956), we are committed to the claim that e.g., *lentils* and *čočka* lexicalize the same number-neutral core property (setting aside any micro variation between speakers within or across languages). However, a prima facia plausible view is that if two different nouns lexicalize the same core property `P`, then these two different nouns (possibly with addition of number morphology) also express that same number-neutral core property, $\mathcal{P}$. I.e., whereas the arrows labelled 'expresses' in the graphics in figure 1.1 map from expressions to modes of presentation/intensions, *is lexicalized by* would just be the inverse arrow from the same modes of presentation/intensions to the expression. Herein lies the tension, for when we consider examples such as *lentils* and *čočka*, given A1, this cannot be the case, since, if it were, we would lack any explanation for why the former is count and the latter mass.

Our resolution of this tension, in this volume, is to conclude that even though e.g., *lentils* and *čočka* LEXICALIZE the same number-neutral core property, `lentil`, there must be some difference(s), however slight, between the property that *lentils* expresses and the property that *čočka* expresses: 'expresses' and 'is lexicalized by' are not true inverses of one another, as shown by variation in count/mass lexicalization patterns:

(1.1) a. At least to some degree of similarity, setting aside micro variation across languages or across speakers, both *lentil* and *čočka* are lexicalizations of the same CORE PROPERTY `lentil` (which we assume is number neutral).

b. The core property `lentil` is a part of (in some sense of the word 'part') the lexical entries of both *lentil* and *čočka*. This explains why the extensions of *lentils* and *čočka* are, for all intents and purposes, the same.

c. However, *lentils* does not express the same intension as *čočka*, because, given assumption A1, there must be at least some differences between the intension that *lentils* expresses and the intension that *čočka* expresses in order to explain why the for why the former is count and the latter is mass.

d. Therefore at least one of *lentils* and *čočka* cannot merely express (have as their intensions) the core property `lentil`. (Spoiler: we will later propose that `lentil` is 'part' of but not identical to the intensions of either *lentils* or *čočka*.)

Let us briefly elaborate on (1.1c) and (1.1d). As we detail in section 1.3 and chapter 4, we will propose that there are functions $\mathcal{Q}$ and $\mathcal{N}$ that apply to number-neutral core properties.[1] $\mathcal{Q}$ *quantizing function* is only defined for properties that are instantiated by objects. $\mathcal{N}$ is an *object-neutral* function that does not quantize the property to which it applies (and developing a precise characterisation of its application conditions will be a part of what this volume is about):

(1.2) For a property, `P`, there are two functions $\mathcal{Q}$, $\mathcal{N}$ such that:

a. `P` can be lexicalized as a count noun if $\mathcal{Q}$ is defined for `P`

b. `P` can be lexicalized as a mass noun if $\mathcal{N}$ is defined for `P`

For example, we will claim that the core property `lentil` can be lexicalized as either *lentil* or as *čočka*. Furthermore *lentil* expresses $\mathcal{Q}$(`lentil`), *lentils* expresses $^*\mathcal{Q}$(`lentil`) and *čočka* expresses $\mathcal{N}$(`lentil`) such that `lentil` is the common core between the the meanings of these expressions.

As such, in the Fregean sense, *lentils* and *čočka* express a different *mode of presentation* on lentils in the world, one which allows for grammatical counting and the other which does not.

Of course, the kind of picture sketched out in (1.2) crucially turns on providing an explanation of which core properties $\mathcal{Q}$ and $\mathcal{P}$ are defined for

[1] This is a slight simplification. In order to account for other relevant data, we will later assume that these functions must be indexed to context.

i.e., as which core properties can be lexicalized as count and which as mass, and furthermore with what propensity (e.g., why are some core properties frequently lexicalized as count and as mass, but others almost always count or almost always mass). We elaborate further on this in summary form this chapter and in full in chapters 4 and 5.

As a summary, again keeping our running example of *lentil(s)* and *čočka*:

| | | |
|---|---|---|
| `lentil` | i. | The core property that *lentil*, *lentils* and *čočka* lexicalize. |
| | ii. | The core property that, in some sense of 'part' is at least part of what *lentil*, *lentils* and *čočka* express. |
| $[\![$lentil$]\!]$ | | The lexical entry of *lentil*, derived as a function $\mathcal{Q}$ on `lentil`. |
| $[\![$lentils$]\!]$ | | The interpretation of *lentils*, derived as a pluralisation function on $[\![$lentil$]\!]$. |
| $[\![$čočka$]\!]$ | | The lexical entry of *čočka*, derived as a function $\mathcal{N}$ on `lentil` (the result of which is not identical to $[\![$lentil$]\!]$ or $[\![$lentils$]\!]$). |

### 1.1.2 The two phenomena that this book is about

Having laid out some of our basic theoretical assumptions in the broad domain of formal semantics, what common nouns express and what they lexicalize, we now can characterise the two main phenomena that this book is about: first, the non-canonical grammatical reflexes of countability found for some nouns, second, the variation in count/mass lexicalization patterns of the core properties that underpin such nouns, and the perhaps surprising connection between the two.

#### Non-canonical grammatical reflexes of countability

As is now well known, for some nouns, there are mismatches between our conceptions of the structure of entities in the world, i.e., as objects or undifferentiated stuff, on the one hand, and the *count* and *mass* grammatical categories of expressions having those entities in their extensions.[2] For example, *furniture*, *jewellery* and *kitchenware* denote entities that are, notionally speaking, objects (e.g., tables, chairs, rings, bracelets, pots and pans), but they are mass nouns.

These considerations have motivated the now widely shared conclusion that the count/mass distinction is fundamentally a grammatical distinction,

[2]See, e.g., McCawley 1975, and, to some extent, Quine 1960. Quine however, did not recognise a pre-linguistic concept of **object**.

not determined by our conceptions of the structure of the matter in the world (see Chierchia 1998a, 2010; Rothstein 2010, amongst others). However, such conceptions are not entirely irrelevant to semantics, as they may have grammatical reflexes. For example, object mass nouns like *furniture*, *jewellery* and *kitchenware* have different grammatical reflexes from canonical mass nouns like *water* or *air* insofar as they can be felicitously used in two contexts that are associated with canonical count nouns: namely, in combination with *stubbornly distributive predicates* (Rothstein, 2010; Schwarzschild, 2011), and in comparative constructions, where they have a cardinality interpretation (Barner & Snedeker, 2005). This is due to object mass nouns having what we view as discrete objects in their extensions, while canonical mass nouns do not, they express properties of what we view as undifferentiated substances.

Let us consider a few examples. With respect to stubbornly distributive predicates, such as *small*, *big*, *large* and *round*, the object mass nouns in (1.4) pattern with the count nouns in (1.3), not with the substance-denoting mass nouns in (1.5). The defining characteristic of a stubbornly distributive predicate is that when used with a noun, e.g., *small chairs* as in (1.3), the only reading is that each chair is small. There is no reading in which the chairs taken together are small.

(1.3) a. small/big/large/round chairs/tables/houses/hedges
b. The chairs/tables/houses/hedges are small/big/large/round.

(1.4) a. You won't find any small coffee tables in Al's furniture warehouse, they only sell big furniture/furniture that is big.
b. if you have a round face, do not wear round jewellery or round glasses[3]

(1.5) a. #small/big/large/round oil/air/mud/honey
b. #The oil/air/mud/honey is small/big/large/round

Regarding cardinality interpretations in comparative constructions, both count nouns and object mass nouns have this reading, as we see in (1.6a), but substance-denoting mass nouns do not, as we see in (1.6b).

(1.6) a. Alex has more chairs/cats/furniture/jewellery than Billie.
Possible reading: 'Alex has a greater number of chairs/cats/items of furniture/items of jewellery than Billie.'
b. Alex has more oil/air than Billie.
Not a possible reading: 'Alex has a greater number of portions of oil/air than Billie.'

[3]From *Born to Be Beautiful: How to Look and Feel Amazing During and After Pregnancy* by Donna Kennedy. Liberties Press. 2015.

**Stubbornly distributive predicates**

All count nouns allow for distributive quantification. It can be induced by quantifiers such as *each*, but also via certain adjectival modifiers known as *stubbornly distributive predicates* such as *square* and *small.* For instance, for a count noun N, *square Ns* can only denote Ns, each of which is square.

**Cardinality comparison readings**

For comparative constructions of the form *$x$ has more N(s) than $y$*, there may be two different kinds of readings. The *measure comparison reading*, associated canonically with mass nouns, is such that $x$ has more N(s) than $y$ in terms of some measurement such as volume or weight. The *cardinality comparison reading*, associated canonically with count nouns, is such that $x$ has more N(s) than $y$ in terms of the number of Ns/items of N that they have, regardless of difference in terms of measure.

Restricting ourselves, for now, to concrete nouns that denote objects or stuff, the data in (1.3)-(1.6) mean that our semantic theories of countability must be able to distinguish at least three classes of nouns: mass nouns that denote substances (e.g., *mud*), mass nouns that denote objects (e.g., *furniture*), and count nouns that denote objects (e.g., *chair*).[4]

In short, we have mismatches between the notional object/substance distinction and the grammatical count/mass distinction. Furthermore, we can use the tests such as those exemplified in (1.3)-(1.6) to demarcate those mass nouns that denote (collections of) objects from those that denote substances.

One of the reasons why object mass nouns have been such a central focus in the formulation of theories of countability is that they pass the above tests, just like count nouns, and so are non-canonical mass nouns (in our sense). As exemplars of the mismatch with respect to the canonical correspondence ‘count : mass = object : substance’, object mass nouns have been used as a window on the intricacies of the count/mass distinction, and also a litmus test for the adequacy of proposed theories.

[4]See, amongst others, (Barner & Snedeker, 2005; Deal, 2017; Landman, 2011) for a similar point.

### Variation in count/mass lexicalization patterns

The second phenomenon addressed in this volume is variation, both intra- and cross-linguistic, with respect to whether a core property is lexicalized as count or mass. For example, the core property `jewellery` is lexicalized as the mass noun *jewellery* in English and as the count noun *koru(t)* ('piece(s) of jewellery') in Finnish. Both have discrete objects in their extension, and the core property `jewellery` grounding both is instantiated by objects.

In order to be able to be clear about what constitutes variation in count/mass lexicalization patterns, for most of this work, we will restrict our focus to languages that have a robust and morphosyntactically transparent count/mass distinction. However, we address languages that do not fit this category in the penultimate chapter of this volume.

At first blush, variation in count-mass lexicalization patterns goes beyond the mismatches with respect to the canonical correspondence 'count : mass = object : substance', which we have just mentioned, and illustrated with the core property `jewellery`. For instance, 'granular' core properties such as `lentil` and `bean`, 'filament' core properties such as `asparagus` and `hair`, and core properties that are instantiated by certain kinds of (typically) interconnected entities such as `fence` and `hedge` also display variation in their count/mass lexicalization patterns. For example, as observed above, we have count/mass pairs of granular nouns such as *čočka* ('lentil', Czech, mass) and *lentil(s)* (count), but also filament nouns such as *asparagus* (mass) and *asperge* (count, French), and interconnected count/mass pairs such as *fence* and *fencing*. Despite work on this topic, including by ourselves (e.g., Sutton & Filip 2016c, 2021b), it remains an open issue what the sources of and constraints upon such count/mass variation are.

It must also be stressed that much of the focus on non-canonical grammatical reflexes of countability has been on object mass nouns, largely to the exclusion of other notional categories of nouns, count or mass. A deeper investigation into whether there are non-canonical reflexes of countability for other nouns has been underexplored, with notable exceptions of Allan 1980 and Grimm 2012, 2018. A reason for this might be that perhaps variation in count/mass lexicalization patterns has been seen as a rather broad and messy phenomenon. Furthermore, with respect to the stubbornly distributive predicate and cardinality comparison tests, to the extent that observations regarding granular mass nouns have been made, they have typically, at least tacitly, been grouped together with substance denoting nouns. Nouns that express properties of filament-like entities such as `asparagus` and `bamboo` are even less widely discussed.

### 1.1.3 The main empirical findings of this book

The main empirical findings of this book concern two aforementioned phenomena: variation in count/mass lexicalization patterns across and within languages, and the ways in which nouns, mass or count, can diverge from having the canonical grammatical reflexes expected of the count/mass distinction in their respective languages. Our main observation is that, despite first appearances, these two phenomena are not unrelated.

In chapter 2, drawing primarily on Czech, English, Finnish, and German, we provide a large amount of data regarding both these phenomena. We make the striking finding that the classes of nouns for which variation in count/mass lexicalization patterns has been observed all have at least some non-canonical reflexes of countability.

Guided by the patterns we find in these non-canonical countability reflexes, we identify three notional classes of nouns: *interconnected* nouns (like the English count noun *fence* and mass noun *fencing*), *granular and filament* nouns (e.g., count nouns like *lentils* and mass nouns like *rice*,*bamboo*) and *functionally combinatorial* nouns (e.g., object mass nouns like *furniture* and *jewellery*). Fascinatingly, **each has distinct non-canonical grammatical reflexes associated with countability**: *interconnected* nouns specifically when count, and *granular and filament* and *functionally combinatorial* nouns specifically when mass. Our finding underlines that both the quantity of nouns that have non-canonical reflexes of countability, and the types of non-canonical grammatical reflexes attested are broader than has been previously recognised.

*Functionally combinatorial* nouns

We introduce the term *functionally combinatorial nouns* as an umbrella term to include object mass nouns (i.e., *functionally combinatorial* mass nouns) and the count counterparts of these nouns. For instance, *jewellery* is a *functionally combinatorial* mass noun, whereas *koru-t* ('item-s of jewellery', Finnish) is a *functionally combinatorial* count noun.

*Interconnected* nouns

We introduce the term *interconnected nouns* as an umbrella term to include count nouns such as *fence* and *hedge* and mass nouns such as *fencing* and *hedging*. We use the expression *interconnected*, since, on a pre-theoretical level, the entities they describe can be connected together (are so need not be disjoint). For instance, fences may be connected together and overlap (e.g., share corner posts).

As first reported in Filip & Sutton 2017, for the class of *interconnected* count nouns such as *fence*, *hedge* and *wall*, we see non-canonical reflexes of countability in pseudopartitive (measure) constructions. In these constructions, *interconnected* count nouns can be used bare in the singular as the 'downstairs' NPs as in *three kilometres of fence/wall*.

However, the more widespread divergence from canonical countability patterns can be seen in mass nouns. In chapter 2, we show that, for core properties that display variation in count/mass lexicalization patterns across and within languages, all mass noun lexicalizations of these properties are felicitous with stubbornly distributive predicates such as *small*, *big* and *square* (modulo specific lexical restrictions). Specifically, we present new data from Czech, English, Finnish and German showing that it is not the case that only object mass nouns have this status: 'granular mass nouns' such as *rice*, *pollen*, and *gravel*, and 'filament mass nouns' such as *asparagus*, *bamboo* and *grass*, and interconnected mass nouns such as *fencing*, *walling* are also felicitous with stubbornly distributive predicates. A sneak-peak summary of our empirical findings is given in Table 1.1.

In order to bolster this result regarding *granular and filament* mass nouns, we conducted two corpus studies, one in Czech and one in English, the results of which we also report in chapter 2. In these studies, we found that *granular and filament* mass nouns and object mass nouns pattern significantly differently to canonical mass nouns when it comes to their modification with stubbornly distributive predicates. As observed above, the felicitous use of stubbornly distributive predicates with object mass nouns has been an important piece of evidence in the formation of theories of the count/mass distinction. By the same token, the felicitous use of stubbornly distributive predicates with *granular and filament* mass nouns, and their other grammatical reflexes, should receive not less attention and theories of the count/mass distinction should provide an adequate analysis for them.

In addition, and, to a large extent what motivated us to undertake writing this book, is that excitingly, the above data show that variation in count/mass lexicalization patterns is a very good predictor of non-canonicity

| **Noun class** | **Example of variation** | **Summary of non-canonical grammatical reflexes** |
|---|---|---|
| *Canonical Count* | N/A | None |
| *Functionally combinatorial* | *koru-t* (item-s of jewellery, Finnish, count); *jewellery* (mass) | When mass: felicitous with stubbornly distributive predicates; have cardinality comparison readings |
| *Granular and filament* | *lentils* (count); *čočka* (lentil, Czech, mass) | When mass: felicitous with stubbornly distributive predicates; some have cardinality comparison readings |
| *Interconnected* | *fence* (count); *fencing* (mass) | When count: felicitous when singular as the ‘downstairs’ NP in measure constructions When mass: felicitous with stubbornly distributive predicates |
| *Canonical Mass* | N/A | None |

Table 1.1: Summary of the empirical landscape. When a noun class displays variation in count/mass lexicalization patterns, at least some of the nouns (count or mass) display non-canonical reflexes of the count/mass distinction.

in grammatical reflexes. If a core property displays variation in its count/mass lexicalization patterns, then either the count or mass lexicalizations of this property will have non-canonical grammatical reflexes. As we show, the relation is not quite bidirectional, since, for instance, although mass nouns like *pollen* and *sand* have non-canonical grammatical reflexes of countability, as far as we are aware, the core properties `pollen` and `sand` are never lexicalized as count (at least in number-marking languages with a robust count/mass distinction).

**Main empirical observation**

Variation in count/mass lexicalization patterns is a good predictor of non-canonicity in the grammatical reflexes of countability.

The strong correlation between these two phenomena, we propose, is no mere coincidence. To our knowledge, the tight connection between variation in count/mass lexicalization patterns and felicitousness with stubbornly distributive predicates as part of a wider pattern of non-canonical grammatical reflexes, has, until now, gone unnoticed. A major goal of the rest of this book is to explain the connection between these phenomena.

### 1.1.4 Why this matters for count/mass theories

Up until now, core properties such as `furniture` and `jewellery`, which can be lexicalized by object mass nouns, as in English *furniture* and *jewellery*, have taken centre-stage in discussions of the non-canonical reflexes of countability. There has been an under-appreciation of data such as (1.3)-(1.6) which show that core properties of granulars such as `lentil` and `rice` when lexicalized as mass also have some non-canonical grammatical reflexes of countability: they too can be felicitously modified by stubbornly distributive predicates.[5] For us, this means that granular mass nouns like the English mass noun *rice* or the Czech mass noun *čočka* 'lentil(s)' have accessible discrete objects in their denotation, unlike canonical mass nouns such as *water* that are not acceptable with stubbornly distributive predicates.

Moreover, core properties of granulars can be lexicalized not only as mass, as we have just seen with *rice* and *čočka* 'lentil(s)' (Czech), but also as count nouns, as in the English *lentil(s)*. We submit that variation in count/mass lexicalization patterns is a good predictor of non-canonicity in the grammatical reflexes of countability, which has not been noticed so far. Recall that the direction is not bidirectional, given that granular mass nouns like *sand* have non-canonical grammatical reflexes of countability (as our corpus data attest), but the core property `sand` it lexicalizes is uniformly lexicalized as mass, and never as count in number-marking languages with a robust count/mass distinction, as far as we know.

Ideally, we should want the central theoretical tenets of our count/mass theories to be able to explain the following two observations. First, why some nouns have non-canonical grammatical reflexes of countability, and second, why almost all of the core properties that these nouns lexicalize display variation in their count/mass lexicalization patterns. Crucially, this includes core properties such as `furniture` and the count and mass lexicalizations thereof, and core properties such as `bean` and the count and mass lexicalizations thereof. However, no extant count/mass theory is in a good position to provide such an explanation.

In chapter 3, we discuss semantic state-of-the-art theories of countability, including theories based on disjointness (e.g., Landman 2011, 2016), stable

[5] Grimm (2012) is an exception here. We discuss Grimm's proposal in chapters 2 and 4.

atomicity (e.g. Chierchia 2010, 2015), semantic atomicity (Rothstein, 2010, 2017) and mereotopology (e.g., Grimm 2012). Here, by way of illustration, we address the first two, and outline why they do not account for the data that we have just mentioned, and which are central to this volume.

Chierchia (2010, 2015) proposes that all properties ('core properties' in our terms, approximately) are either stably atomic or not stably atomic. A property is stably atomic if it has a non-empty set of atoms shared across all contexts (see chapter 3). For instance, `furniture` is a stably atomic property, but `bean`, `hair` and `rice` are not (see, for instance, the discussion of *rice* and the Romanian mass noun *fasole* 'bean(s)' in Chierchia 2010). Core properties such as `furniture` and `jewellery` are treated as special, because they are stably atomic, but can be lexicalized as mass nouns. This is used to motivate their well-known non-canonical reflexes of countability.

Landman (2011, 2016) proposes that all nouns are either *neat* or *mess*. *Neat* nouns have a disjoint set of minimal entities in their extensions *mess* nouns do not have a disjoint set of minimal entities in their extensions. Mass nouns such as *furniture* are *neat* (they are *neat-mass nouns* in Landman's terminology) and mass nouns such as *rice* and, presumably, mass nouns such as *fasole* ('bean', Romanian) are *mess*. Mass nouns such as *furniture* and *jewellery* are treated as special, because they are *neat*, but also mass. Landman then uses this to motivate that some *neat-mass nouns* have non-canonical reflexes of countability (e.g., cardinality readings in measure constructions).

For both Chierchia and Landman, therefore, core properties (again in our sense) of granulars like `bean` and `rice` and their mass noun lexicalizations such as *rice* and *fasole* ('bean(s)', Romanian) are in some sense 'ordinary' and no more interesting to count/mass theories than core properties such as `mud` and the canonical mass nouns such as *mud* that lexicalize them.

Consequently, the theoretical division of core properties that Chierchia's and Landman's theories are built on does not track the divide between *all* mass nouns that have non-canonical reflexes of countability which extends also to e.g., granular and filament mass nouns, and those mass nouns that do not. Nor does such a division of core properties align with the split between those core properties that display variation in their count/mass lexicalization patterns, and those that do not.[6]

As a result, neither stable atomicity, nor the neat/mess distinction can motivate why mess mass nouns such as *fasole* ('bean(s)', Romanian, mass)

[6]Landman (2020) briefly discusses *lange rijst* ('long rice', Dutch). As *rijst* is analysed as a mess mass noun, such data are explained in terms of a portioning operator: "The semantics of *groot* ['big', Dutch] involves distribution, which requires a salient disjoint distribution set to be made available. For mess mass nouns like *vlees* ['meat', Dutch] such a disjoint set is only available via portion shift." (p. 265.)

and *rice*, which lexicalize non-stably atomic properties are felicitous with stubbornly distributive predicates. Nor can stable atomicity or the neat/mess distinction account for why properties such as `furniture` and properties such as `bean`, `hair` and `rice` display variation in their count/mass lexicalization patterns.

Therefore, on both Chierchia's and Landman's theories, we are forced to assume that there are two types of mismatches that must be distinguished when it comes to the way in which conceptual structure is related to grammatical structure. First, there are mass nouns like *furniture* and *jewellery* in English that lexicalize core properties that are stably atomic or neat mass. These nouns exemplify a mismatch, since they are mass, but share properties with count nouns.

Now, for both Landman and Chierchia, granular mass nouns *fasole* 'bean', in Romanian or *čočka* 'lentil', in Czech do not exemplify mismatches, they are completely 'normal' mass nouns, since they lexicalize non-stably atomic properties (Chierchia) and are mess mass nouns (Landman). This, however, has a surprising consequence, since it forces one to view count granular nouns such as *bean* and *lentil* in English as a second sort of mismatch: they are count, but lexicalize non-stably atomic properties (Chierchia) and count counterparts of mess mass nouns (Landman).

With respect to variation in count/mass lexicalization patterns, to address this second type of mismatch, it is assumed, explicitly by Chierchia (2010) that granular core properties are lexicalized as count via the application of partition operation on the relevant core properties (i.e., `bean` and `lentil`). Landman does not explicitly discuss count granular nouns, however, on the assumption that e.g., *bean* and *fasole* ('bean(s)', Romanian, mass) both lexicalize the same core property, it seems plausible to assume that, for him, the countable entities in the lexical entry for *bean*, but not for *fasole*, would be derived from `bean` via a grid (a special kind of portion operation).[7] We discuss this issue at length in chapter 3.

To summarise, with respect to non-canonical reflexes of countability, and to variation in count/mass lexicalization patterns, theories based on stable atomicity (Chierchia) and the neat/mess distinction (Landman) face challenges. These result, because they classify granular mass nouns (e.g., *fasole*, 'bean', Romanian, mass) (and the properties they lexicalize) as being

[7]Landman (ibid., p. 240) views grains of rice as "natural objects that have the internal coherence of natural objects", but also that, since grains of rice are made of rice, *rice* is mess mass. For highly specialised contexts where *more rice* can mean 'more grains of rice' (see chapter 2 for more discussion) "the context makes the disjoint grid *grain of rice* accessible" and "a grain of rice is a special kind of *portion* of rice" (p. 263). Landman does not discuss count granular nouns in detail.

of a fundamentally different sort than object mass nouns (e.g., *furniture*) (and the properties they lexicalize). This makes it unclear why both *fasole* and *furniture* have non-canonical reflexes of countability, and why core properties `bean` and `furniture` both display variation in their count/mass lexicalization patterns.

In short, if we are interested in explaining why only some classes of nouns have non-canonical grammatical reflexes of countability, and why almost all of the core properties that these nouns lexicalize display variation in their count/mass lexicalization patterns, then both the stably atomic/non-stably atomic, and the neat mass/mess mass distinctions cut the cake in the wrong way.

We argue that the data we present in chapter 2 suggest an alternative picture in which *objects* play a central role, however, crucially, *object*, for us, includes more entities than many others have posited. As all agree, the core properties that object mass nouns lexicalize are all instantiated by *objects*. As we emphasise, granular and filament core properties such as `bamboo`, `bean`, `grass`, `hair`, `lentil`, and `rice` are also instantiated by objects, namely, rods of bamboo, grains of rice, whole beans and lentils, blades of grass, and strands of hair.

Regarding non-canonical reflexes of countability, the question of why stubbornly distributive predicates are felicitous with object mass nouns and *granular and filament* mass nouns becomes somewhat simple from our object-centred perspective: stubbornly distributive predicates can be used with any nouns that denote objects.

Variation in count/mass lexicalization patterns, is, of course, complex, but from our object-centred perspective, it appears far less random, and we only really have one thing to explain: why some properties that are instantiated by objects, such as `furniture` and `bean`, can be lexicalized as mass.[8]

## 1.2 Main questions and claims

We submit that it is not coincidental that we find variation in the count/mass lexicalization patterns of `furniture`- and `jewellery`-like properties and also of filament and granular properties like `bean` and `hair`. Nor is it coincidental that every noun that lexicalizes these properties is felicitous with stubbornly distributive predicates, or that nouns in these classes have other non-canonical

[8]Of course, at least for number marking languages with robust countability distinctions, the question of why core properties that are instantiated by substances are lexicalized as count does not arise, since we do not find count lexicalizations of properties such as `air` and `oil` in these languages.

reflexes of countability. This empirical landscape provides challenges for state-of-the-art semantic theories, especially in terms of providing a unified account for these observations. Of course, the onus is clearly on us to provide an explanation of these phenomena and the connection between them.

Our main question is therefore as follows:

> Main Question
>
> **What underpins the connection between variation in count/mass lexicalization patterns and the non-canonical reflexes of the count/mass distinction that we find across and within languages?**

To address this question, we break it down into some component parts, based upon some further empirical observations. We take these in turn.

### 1.2.1 Count lexicalization and felicitous modification with stubbornly distributive predicates

Our first two subsidiary questions are prompted by the following observations. Observation 1 is widely recognised. Observation 2 is, to our knowledge a novel data point not previously noticed.

> Observation 1: stubbornly distributive predicates and the canonical reflexes of count nouns
>
> Canonical count nouns, but not canonical mass nouns, are felicitous with stubbornly distributive predicates.

> Observation 2: count/mass variation and stubbornly distributive predicates
>
> If a core property displays variation in its count/mass lexicalization patterns, then mass nouns that lexicalize this property are felicitous with stubbornly distributive predicates.

As was summarised in Table 1.1, the most pervasive form of non-canonical reflexes of the count/mass distinction relates to stubbornly distributive predicates: If a core property displays variation in its count/mass lexicalization properties, then any mass nouns that are lexicalized from these properties are felicitous with stubbornly distributive predicates. Now, given that straightforward compatibility with stubbornly distributive predicates is characteristic of count nouns, it prompts us to hypothesise that **there is a connection between that which licenses a property to be lexicalized as count, and that which makes a noun felicitous with stubbornly distributive predicates**. To explore this proposal, we ask two questions. *Question 1* addresses the nature of the properties that are lexicalized as count nouns:

QUESTION 1 **What are the necessary conditions for a property to be lexicalized as count?**

Put in the simplest terms, our answer to *Question 1* turns on a single necessary condition, namely that a core property must be instantiated by objects in order to be lexicalized as a count noun. In this sense there is a dependency between countability distinctions and the structure of the world, namely as a necessary precondition of count lexicalization (for concrete properties at least): all concrete count nouns are lexicalizations of properties that are instantiated by objects (but not vice versa).

Our second question concerns the conditions under which a noun can be felicitously modified with a stubbornly distributive predicate:

QUESTION 2 **What are the necessary conditions for a 'concrete' noun to be felicitous with stubbornly distributive predicates?**

A noun, be it count or mass, must denote objects in order to be felicitously used with a stubbornly distributive predicate. Indeed our claim, and our justification for presenting these two questions together, is that we contend that objects underpin the answer to both.

Of course, we must say more about what we mean by 'objects', something we do at length in chapter 4. In brief, however, we view objects as being definable either in terms of their perceptual and topological properties as with entities like balls, cats, and chairs, but also in terms of their functional properties. For instance, we claim that fence-objects are defined at least in part by their function as enclosing or cordoning off spaces, and we also claim that items such as mortars and pestles can be viewed as single objects, because both are needed to fulfill a single function (i.e., grinding). We return to a discussion of objects in section 1.3. Moreover, in chapter 4, we not only explicate the role of objects in relation to whether a noun is felicitous with stubbornly distributive predicates, but also in relation to the other non-canonical reflexes of countability as were described in Table 1.1.

Fundamentally, then, one of our main claims is that objects are central to the connection between variation in count/mass lexicalization patterns and non-canonical reflexes of the count/mass distinction:

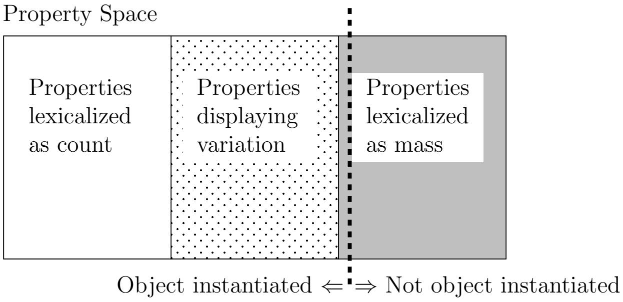



Figure 1.2: Object-instantiated properties are properties that are instantiated by objects. Properties that display the variation in the count/mass lexicalization are *all* object-instantiated properties.

**Main Claim: Questions 1 & 2**

Being instantiated by objects is a necessary condition for a core property to display variation in its count/mass lexicalization patterns and for its count or mass lexicalizations to have non-canonical grammatical reflexes.

The intuitive basis for this *Main Claim* is represented graphically in Figures 1.2 and 1.3.

As shown in Figure 1.2, the property space is divided into three fields. The two fields to the left of the dotted line are occupied by properties that are instantiated by objects. The left-most one is that of core properties that are lexicalized only as count, and the middle field contains core properties that can be lexicalized as either mass or count in a given language or across different languages: e.g., `bean`, `lentil`, `hair`, `furniture` and `jewellery`. All object-instantiated properties are lexicalized by nouns, either count or mass, that are felicitous with stubbornly distributive predicates. The field to the right of the dotted line is occupied by properties whose instantiations lack objects, and hence are lexicalized always as mass, and are infelicitous with stubbornly distributive predicates.

### 1.2.2 A need for contexts of individuation

Any theory of countability in natural language must motivate not only what underpins the grammatical properties of mass nouns, both canonical and non-canonical, but also the grammatical properties of count nouns, including, for instance, their canonical felicitous use in numeral constructions. This is

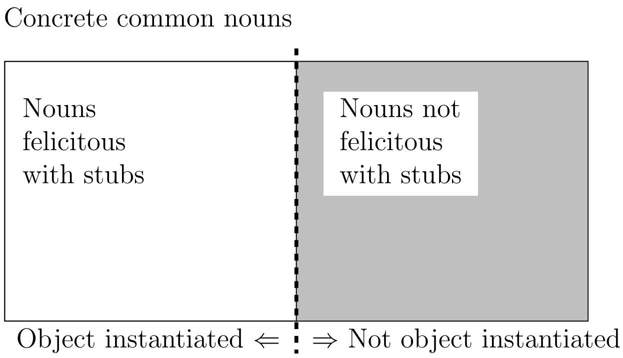



Figure 1.3: The selectional restrictions of stubbornly distributive predicates. Stubbornly distributive predicates select for nouns with objects in their extensions, i.e. lexicalizations of object instantiated properties.

problematic for a theory built upon objects such as the one we have presented thus far. It cannot be that, if a noun has objects in its extension then the noun can be used in e.g., a numeral construction. In other words, this prompts another important question:

QUESTION 3 **Why are the non-canonical reflexes of countability restricted to felicitous use with stubbornly distributive predicates, for instance, and not use in numeral constructions and with strong universal quantifiers such as *each* and *every*?**

Part of the answer to Question 3, we claim, is that the lexical entries of count nouns, but not mass nouns, make available the set of objects that instantiate the relevant property available to grammatical counting and quantificational operations. However, what such objects are may also depend on context, that is, having objects in the extension of a noun may on its own be insufficient. Take, for instance, Rothstein's (2010) example of fencing surrounding a square field. In this example, the whole lot of fencing and each side can be characterised as a fence object, but we do not have five fences (each side plus the whole lot). For this reason, we, like Rothstein (but see also Filip 2000; Zucchi & White 1996, 2001) see a crucial role for individuating contexts encoded in the grammar of a theory of countability. I.e., we have our Main Claim with respect to Question 3.

**Main Claim: Question 3**

Denoting objects alone is not sufficient for grammatical countability. At least for concrete nouns, the lexical entries of count nouns, but not mass nouns, make available a quantized set of objects that instantiate the relevant property available to grammatical counting and quantificational operations. For a well-defined class of count nouns, the set of objects in their extensions is not quantized, therefore, at least for these nouns, counting is counting objects relative to a context of individuation.

**Quantization**

A second-order property of sets first characterised by Krifka (1986). A set is quantized if and only if no two members of the set, taken pairwise, stand in a proper part relation. For example, the set containing oil is not quantized, since there are smaller quantities of oil that are proper parts of larger quantities of oil.

The semantic theory that we build on the basis of these two first main claims, we dub **Object-Centred Contextualism**.

### 1.2.3 Constraints on Variation

The object centred, contextualist proposal we develop in chapter 4 provides necessary conditions for what it means for a noun (or, at least , a concrete noun) to be grammatically count: it must specify a quantized set of objects relative to a context of individuation. In chapter 5, we turn to setting out, at least in part, the related sufficiency conditions for a noun to be grammatically count.

Although many properties that are instantiated by objects are never lexicalized as mass (e.g., `ball`, `car`), the empirical picture beyond this is somewhat messier. For instance, some properties that are instantiated by objects are only lexicalized as mass (e.g., `pollen` and `sand`), and between these two extremes, we find a continuum of cases. For instance, despite the focus in the literature on object mass nouns (*functionally combinatorial* mass nouns in our terminology) the properties underpinning *functionally combinatorial* nouns are lexicalized as count in many languages. Indeed some languages have few if any *functionally combinatorial* mass nouns (we have found only one in Finnish, for instance). In contrast, for many properties of granular entities, whether this property is lexicalized as count or mass seems to be more or less a matter of chance. For instance, *lentil(s)* and *grape(s)* are count in English, but *čočka* ('lentil') is mass in Czech and *vinigrad* ('grape') is mass in Russian.

However, despite this, so to speak, apparent messiness of the empirical landscape, the following two observations give us some basis for optimism in addressing this issue:

**Observation 3:**

Properties that display variation in their count/mass lexicalization patterns are not a homogeneous class.

**Observation 4:**

The count/mass lexicalization patterns we observe are neither random nor completely unsystematic.

Observations 3 and 4 lead us to look at both the features specific to our notional classes of nouns (*functionally combinatorial*, *granular and filament*, and *interconnected* nouns), and how these may relate to the extent of variation found in their count/mass lexicalization patterns. This leads us to suspect that **variation in count/mass lexicalization patterns must therefore be connected to (possibly multiple) generalisations that hold across core properties or across subsets of properties that exhibit variation in their count/mass lexicalization patterns**.

Furthermore, from our object-centred, contextualist perspective, we also argue that the stubbornly distributive predicate and lexicalization pattern variation data entails that we should be framing our theoretical questions in a way differently to that found in other analyses. Namely, instead of asking why properties such as `furniture` and `jewellery` can be lexicalized as mass (e.g,. Chierchia (2010) or Landman (2011, 2016)) and why core properties, such as `bean` and `hair` can be lexicalized as count, we wish to pose the more unifying question: Why can any of these properties, all of which support striking variation with respect to count/mass lexicalization patterns, and are all instantiated by objects, be lexicalized as mass. For example, while *bean* is count in English, *fasole* is mass in Romanian.

Question 4a **Why can core properties that are instantiated by objects be lexicalized as mass nouns?**

Questions like Question 4a have been asked before, but only in relation to core properties underpinning object mass nouns, such as `furniture` or `kitchenware`. Indeed, such questions are usually not asked in such a way that they include *granular and filament* mass nouns[9] as we saw in our discussion of the theories proposed by Chierchia (2010), based on stable atomicity, and Landman (2020), based on disjointness.

Now, whereas some parts of our object-centred contextualist approach are encoded in the grammar of common nouns, specifically, indexing to contexts of individuation, we do not think that this is the right place to encode constraints on count/mass variation.

The systematicity we see in count/mass lexicalization patterns, we claim, turns on at least three identifiable perceptual-interactive constraints. We propose that if a core property that is instantiated by objects satisfies at least one of these constraints, then that property can be lexicalized as mass. Normally, this will lead to variation in the count/mass lexicalization patterns of this core property. In some cases, (e.g., `sand`), the property may never be lexicalized as count. Indeed, we use this system of three perceptual-interactive constraints to predict where we should expect to find variation in count/mass lexicalization patterns. The first of these is loosely based around how (in)discriminable objects that instantiate a property are. The second is based around whether objects are used together as participants (primarily instruments) in some typical associated eventuality (the details of this claim are related to and build upon those in Grimm & Levin 2017, however see chapter 5). The third, is based upon how we interact with objects and whether they are often used in such a way that requires them to (first) be split apart or broken up.

**Main Claim: Question 4a**

There is a system of at least three perceptual-interactive constraints based upon how we perceive and interact with objects that instantiate properties that determine whether a property that is instantiated by objects can be lexicalized as mass at all, i.e., whether it can display variation in its count/mass lexicalization patterns.

Now, *Question 4a* merely asks under what conditions the mass lexicalization of a property should be possible. But this leaves open the further issues of why some properties that are instantiated by objects are more frequently lexicalized as mass than others and why others seldom if ever are. For example, why are core properties such as `pollen` and `sand` never (to our knowledge) lexicalized as count (despite our sensorimotor awareness that they are made up of objects, albeit small ones)? And, why can core properties, such as `potato` and `carrot`, be lexicalized as mass, as in Russian, besides their more

[9] A notable exception is Grimm (2012).

common lexicalization as count? Hence, in contrast, to previous accounts, we also raise the following question that is equally important:

QUESTION 4B **Why are some of the properties that are instantiated by objects more frequently lexicalized as count and others more frequently lexicalized as mass?**

From our perspective, the core properties underpinning canonical count nouns (e.g., `ball`), *functionally combinatorial* nouns (e.g., `jewellery`) and *granular and filament* nouns (e.g., `lentil`) are all instantiated by objects, but only the latter two of these classes display variation in their count/mass lexicalization patterns. As is well-known, lexicalizations of properties of animate and/or clearly demarcated entities, such as `cat`, `ball` or `chair` are grammatically count in languages that have grammatical reflexes of countability. Hence for us, question 4a not only includes *granular and filament* nouns, but arises centrally from an object-centred perspective.

Importantly, as is shown in Figure 1.2, there are some properties that we class as object-instantiated, for which we have not found cases of count lexicalizations. These include, `pollen` and `sand`. The onus is on us, therefore, to explain why we find such lexicalizations, such apparent exceptions. Put another way, when it comes to the lexicalization patterns associated with properties that are instantiated by objects, we observe a certain uneven distribution over the mass and count domain, cross- and intra-linguistically. Some are always lexicalized as count (e.g., `cat` and `ball`), others seldom if ever lexicalized as count (e.g., `pollen` and `sand`), and others vary to greater and lesser extents from language to language (e.g., `lentil`, `bean`, `jewellery` and `furniture`). For instance, *bean* is count in English, but *fasole* ('bean(s)') is mass in Romanian, and *furniture* is mass in English, but *huonekalu* ('item of furniture') is count in Finnish. These patterns are in need of an explanation.

To address Question 4b, we propose to use the same system of perceptual-interactive constraints that we develop in answer to Question 4a. While we claim it suffices for a property to be lexicalized as mass if it satisfies at least one of these three constraints, we claim that the degrees to which a property fulfils them can be used to predict the relative propensity for a property that is instantiated by objects to be lexicalized as mass, from very seldom, to virtually always.

**Main Claim: Question 4b**

Relative to an ordering, the three perceptual-interactive constraints can be used to predict the propensity for a property that is instantiated by objects to be lexicalized as mass.

In chapter 5, we develop this proposal via means of a weighted constraint model. We use techniques from distributional semantics to estimate the degree to which various properties satisfy the three perceptual-interactive constraints, and propose a weighted ordering on the constraints themselves to derive a score for each property that indicates its relative likelihood to be lexicalized as mass cross linguistically. This model contributes a new dimension to studies into countability, namely, as a fusion of theoretical formal semantics, quantified empirically, yielding concrete predictions about variation in count/mass lexicalization patterns across and within languages.

## 1.3 Object-centred contextualism in a nutshell

We hope that the framing of our main questions and our schematic answers to them is sufficient to urge any readers who have got this far to continue to read the rest of the volume. However, for those that would like more details before making such a commitment, we provide here a highly condensed summary of our object-centred, contextualist semantics and system of conceptual constraints.

As indicated above, in chapter 2, we present our main data and observations and in chapter 3, we provide the reasons why these observations are challenging for previous approaches. Our object-centred contextualism is detailed in chapters 4 and 5. We extend this account to non-number-marking languages and to some abstract nouns in chapter 6. In the following, sections 1.3.1, 1.3.2 and 1.3.3 summarise chapters 4, 5, and 6, respectively.

### 1.3.1 Object-centred contextualist semantics

Let us start by sketching the intuition behind what we mean by 'objects'.[10] (For details, see chapter 4.) Core properties that underpin canonical count nouns such as *cat* and *chair* are instantiated by objects insofar as they are properties of things that a pre-linguistic child would categorise as objects,

[10] If core properties are represented as (partial) functions of type $\langle s, \langle e, t \rangle\rangle$, we will say that these properties are instantiated by objects if they return a set of objects at some worlds, at least.

i.e., *Spelke objects* , namely "bodies that are cohesive, bounded, spatiotemporally continuous, and solid or substantial; they move as connected wholes, independently of one another, on connected paths through unoccupied space." (Soja et al. 1991, p. 183).

Core properties of artefacts like `kitchenware` and `jewellery` are also instantiated by cohesive objects, namely, individual items of kitchenware and jewellery like pots, pans, bracelets and rings. However, more mereologically complex entities such as food processors (with multiple attachments), pans with their lids or a pair of earrings also instantiate these properties, and these more complex entities may also count as single 'objects' (albeit complex ones), because they may jointly function as one object in appropriate contexts (see also Landman (2011) for related observations). These are also 'objects' in our sense, but crucially they are not cohesive in the sense referred to in the definition of Spelke objects.

Moreover, 'object' in our sense also applies to filament entities, such as a strand of hair or a rod of bamboo as well as to granular entities, such as a grain of rice. For us, even grains of pollen and specks of dust count as objects, albeit rather small, barely perceptible ones relative to our perceptual acuity. Notice, for example, that even if single grains of pollen are not visible with the naked eye, our senses can distinguish pollen as powder-like (and so made up of tiny things), which contrasts with water or oil that are only perceivable as undifferentiated stuff.

In the simplest of terms, then, objects, in our sense, are the things that we might want to count as 'one' on either perceptual or functional grounds (or both, as in the case of a hammer or a chair). Based on this characterisation, properties that are instantiated by objects *should*, in principle, be accessible to grammatical counting operations (be lexicalized as count), however, this is not always so. Some evidence of this and for how the two facets of individuating objects cuts across the count/mass divide are given in Table 1.2.

| Noun | Countability class | Denotes only Spelke Objects? | Objects also functionally characterised? |
|---|---|---|---|
| *apple* | Count | ✓ | ✗ |
| *chair* | Count | ✓ | ✓ |
| *rice* | Mass | ✗ | ✗ |
| *jewellery* | Mass | ✗ | ✓ |

Table 1.2: Some examples of how functionally and perceptually individuated objects in the extensions of count and mass nouns.

In short, we propose that it is necessary for count/mass variation and sufficient for felicitousness with stubbornly distributive predicates if the following holds: on a certain delimitation of 'object', the relevant property is instantiated by objects. Therefore, we claim that, for a property such as `asparagus` that displays variation in its count/mass lexicalization patterns (*asparagus* is mass in English and *asperges* is count in French, for example), it must be the case that `asparagus` is instantiated by objects, and because it is instantiated by objects, lexicalizations of this property can be felicitously combined with stubbornly distributive predicates even when lexicalized as mass as we see in (1.7):

(1.7) a. Select large white asparagus. Peel each stalk to near the point, take twenty-four stalks for each jar,... [EnTenTen]

b. If you use small asparagus, peel them and keep the spears. [EnTenTen]

Thereby, the very same criterion explains when we can use stubbornly distributive predicates: they select for nouns with objects in their extensions (i.e., nouns that denote objects). This finding, we argue, justifies putting objects to the fore in a semantic account of countability. In chapter 4, we therefore put forward an object-centred semantics.

Our theory is object-centred, given the fundamental importance that the notion of 'object' will play within the theory: for concrete nouns at least, count nouns denote sets of objects. However, our theory is also contextualist. One might think that, for properties that are instantiated by objects, to derive a count noun interpretation, it would be sufficient to simply assume some function that outputs the relevant set of objects. However, we claim that this is not sufficient. One reason for this is that there are (number-neutral) core properties that are instantiated not only by (minimal) singular entities that count as one object, but also sums of these entities that also count as one object. In other words, the sets of objects that instantiate some core properties are not *quantized*. Take, for instance, objects such as pans and their lids or pairs of earrings that instantiate `kitchenware` and `jewellery`, respectively. As discussed above, there are such objects that have proper parts that are also objects. Alternatively, take objects that instantiate the core property `fence`. There can be what we recognise as several fence-units (objects) linked together to form what might be viewed as functioning as one fence (one object) in a given context (see, Rothstein, 2010). Therefore, in addition to object-centredness, we also assume a context relative to which expressions are evaluated, such that the extension of a noun such as *fence* (or indeed *object*!) can vary across contexts.

In chapter 4, we show how, enriched with a Kaplanian notion of context-sensitivity (Kaplan, 1989), we can capture all of the main facts for concrete nouns in number marking languages, including accounting for contextual variation in counting, providing an analysis for stubbornly distributive predicates, and also for addressing the ‘coextensionality puzzle’, namely how we can have pairs of mass and plural count nouns that denote the same sets of entities in the real world. Our contextualist semantics is then specified in Kaplanian terms. It adds extra dimensions in which nouns can be context sensitive to those dimensions that are already well established, such as time, location, etc. All common nouns are sensitive to contextual domain restrictions when used in DPs, which, as we show, can be modelled in Kaplanian terms, and some common nouns such as *student, pedestrian* are also indexed to the time contextual parameter (Musan, 1999; Tonhauser, 2007b). We propose that the kind of context sensitivity that is observed in count nouns such as *fence* is just one extra dimension, in addition to those provided by Kaplan (1989), to which common nouns may be sensitive. That is to say that we assume that common nouns have both a *character*, and a *content* (i.e., an intension) such that the character of an expression is a function from contexts to intensions. (Simplifying slightly, if $c$ is the type for contexts, common nouns would be of type $\langle c, \langle s, \langle e, t\rangle\rangle\rangle$.)

Now, since, we assume that the core properties that underpin the lexical entries of nouns are number-neutral (modelled as functions in the domain of and of type $\langle s, \langle e, t\rangle\rangle$), to derive a lexical entry for a common noun of type $\langle c, \langle s, \langle e, t\rangle\rangle\rangle$ (i.e. a character formalised as a context-indexed property) requires a function from properties to characters. We propose two such functions, one which applies to a core property and outputs an expression that is part of the lexical entry for a count noun, the other which applies to a core property and outputs an expression that is part of the lexical entry for a mass noun. We call these the *object-centred quantizing function* and the *object-neutral function*, respectively.

The object-centred quantizing function is only defined for properties that are instantiated by objects. It applies to a property and outputs a function from contexts to a property that is instantiated by a quantized set of objects in each context. However, we further distinguish between two classes of object-instantiated properties: those for which the set of objects that instantiate them is quantized and those for which the set of objects that instantiate them is not quantized. This is justified along the following lines. For canonical count nouns, the objects in their extensions are Spelke objects, and therefore form a quantized set. For some nouns, the objects in their extensions are characterised in terms of function. For instance, what counts as *a fence* is, in part, determined by what area is being enclosed or partitioned. Therefore, a fence object, such as that enclosing a field can itself be formed of fence objects (those that partition each side of the field), and so this set of objects is not quantized. Therefore if the lexical entry for *fence* were just the property `fence`, the set of objects *fence* denotes would not be quantized.

For cases such as `fence`, importantly, the object-centred quantizing function involves binding the *quantizing contextual parameter*, i.e., a parameter in the context that maps properties that are instantiated by a non-quantized set of objects, to a property that is instantiated by a quantized set of objects at each context. The result is a lexical entry for a count noun with a *variable character* with respect to the quantizing contextual parameter: a noun, the counting criteria of which may vary with context. In this way we account for the observation that what is *one fence* in the denotation of *fence* varies with context.

Expressions with a constant character, in the sense of Kaplan, have an intension which does not vary with context. If the set of objects that instantiate property is already quantized (as, we argue, is the case with properties such as `ball` and `cat` that are instantiated by Spelke objects), then this results in a lexical entry for a count noun with a *constant character* relative to the quantizing contextual parameter. I.e., what is 'one' in their denotation is constant across all *quantizing contexts*. That said, the property may vary with respect to other contextual parameters such as the one governing contextual domain restriction. Therefore, setting other contextual parameters aside, the extension of the resulting count noun will simply be the set of objects that witness the underpinning property (e.g., the set of single ball objects that witness the property `ball`).

Our object-centred contextualism thus allows us to provide an analysis of canonical count nouns, such as *ball* and *chair*, as well as of count nouns based on properties that display variation in their count/mass lexicalization patterns such as *fence* and *hedge*. The account also covers count nouns based on granular properties like *lentil* in English, filament properties like *il capello/i capelli* in Italian, and also `furniture`-like properties lexicalized as count nouns *huonekalu* ('item of furniture') in Finnish, for instance, all of which are instantiated by objects.

The object-neutral function also maps core properties to characters, however it differs from the object-centred function in two crucial ways. First, it applies to any property (whether instantiated by objects or not), and does not make any such objects foregrounded. Second, it does not bind the quantizing contextual parameter. In other words, it allows for the resulting noun to be sensitive to e.g., contextual domain restrictions, but does not result in a quantized set of entities for counting. If the object-neutral function is applied to a core property, then the output is a lexical entry of a noun that is mass and has a constant character with respect to the quantizing contextual parameter.

Our account predicts that properties that are not instantiated by objects are never lexicalized as count (at least in number-marking languages). This leads us to a straightforward answer to our Question 1: for a property to be lexicalized as count it must be instantiated by objects (the necessary condition). Using this account, we also show how we are able to straightforwardly explain the distribution of stubbornly distributive predicates such as *round* and *small*, and so also the answer to our Question 2: they select for nouns with objects in their extensions (i.e., nouns that lexicalize object instantiated properties). Our account also provides an answer to Question 3. The difference between count nouns that are compatible with stubbornly distributive predicates and mass nouns that are also compatible with stubbornly distributive predicates is that the former specify a quantized set of entities for counting at each context, and the latter simply have a set of objects in their extensions. For all count nouns, the object-centred quantizing function makes the set of objects available to grammatical counting operations, and for nouns like *fence* it also indexes this set to the quantizing contextual parameter. For mass nouns, the object neutral function does not give any privileged status to any objects that instantiate the relevant property.

We then turn to cardinality comparison readings of comparative constructions (i.e., *Who has more N?*). As we argue in chapter 2, the availability of such readings is more nuanced than previously thought. There, we provide new data showing that cardinality comparison readings are even available for some granular mass nouns such as *pollen*. Based on these data, we hypothesise that there is a difference between mass nouns that straightforwardly license cardinality comparison readings, such as *furniture* and *pollen*, and those that do not such as *rice* and *gravel*. This difference is that there are objects in the extensions of *furniture* and *pollen* that are also minimal, or atomic, entities in the extension set, but for *rice* and *gravel*, this is not the case: there are parts of rice grains that count as *rice* and parts of bits of gravel that count as *gravel*. We formalise this in terms of *object atomicity*: a property is object atomic if it is instantiated by objects AND these objects are also atoms relative to this set (e.g., `furniture` and `pollen` are both object atomic). Therefore, unlike any other approach that we are aware of, we propose that, although the licensing conditions for stubbornly distributive predicates and cardinality comparison readings often coincide, they are nonetheless distinct, a welcome result, given that the set of nouns that can be used with stubbornly distributive predicates and the set of nouns that licence cardinality comparison readings is distinct (see Table 1.1).

### 1.3.2 Addressing constraints on variation

Having addressed Questions 1-3 in chapter 4, we turn to Questions 4a and 4b regarding constraints on variation in chapter 5. For properties that are instantiated by objects, there are perceptual-interactive constraints upon when it is possible to apply the object-centred quantizing function and when it is possible to apply the object-neutral function to a property. In other words, there are perceptual-interactive constraints which determine which properties are in the far left hand cell in figure 1.2 (‘Properties lexicalized as count’), and which are in the central cell (‘Properties displaying variation’). Our proposal for when it is possible to apply the object-centred quantizing function to a core property, and so derive the lexical entry for a count noun, is straightforwardly defined in terms of objects:

(1.8) If a core property is instantiated by objects, one possible lexicalization of this core property is as a count noun (modelled via an application of our object-centred quantizing function).

Aside from the few exceptions to this that we have noted (e.g., `sand` and `pollen`), this already demarcates those properties in the left-hand and central cells in figure 1.2 (properties that are lexicalized as count or display count/mass variation) from those properties in the right-hand cell (properties that are lexicalized as mass). The more complex questions we must answer are our Questions 4a and 4b above: why can properties that are instantiated by objects be lexicalized as mass nouns at all, and why are some of the properties that are instantiated by objects more frequently lexicalized as count and others more frequently lexicalized as mass?

Our answer to the first of these Questions, 4a, is based upon the following three perceptual-interactive constraints C1-C3. We propose that if a property satisfies at least one of C1-C3, it is possible for it to be lexicalized as mass. These three perceptual-interactive constraints, discussed in detail in chapter 5 are as follows:

(C1) **Indistinguishability:** For a property `P`, the objects that instantiate `P` are, perceptually speaking, either too small or similar to one another (relative to average human perceptual acuity) for us to individuate, or are clustered together in such a way to be hard for us to track as individuals.

(C2) **Collective uses of Instruments:** There is a typical associated eventuality with a property `P` such that in many cases, there is a least upper bound for the fulfilment of INSTRUMENT role in this eventuality, namely (usually heterogeneous) sums of objects that instantiate $P$. I.e., any proper part of these sums of instruments would not normally facilitate bringing that eventuality about.

(C3) **Object splitting:** Objects that instantiate `P` are often used in such a way that requires them to (first) be split apart or broken up.

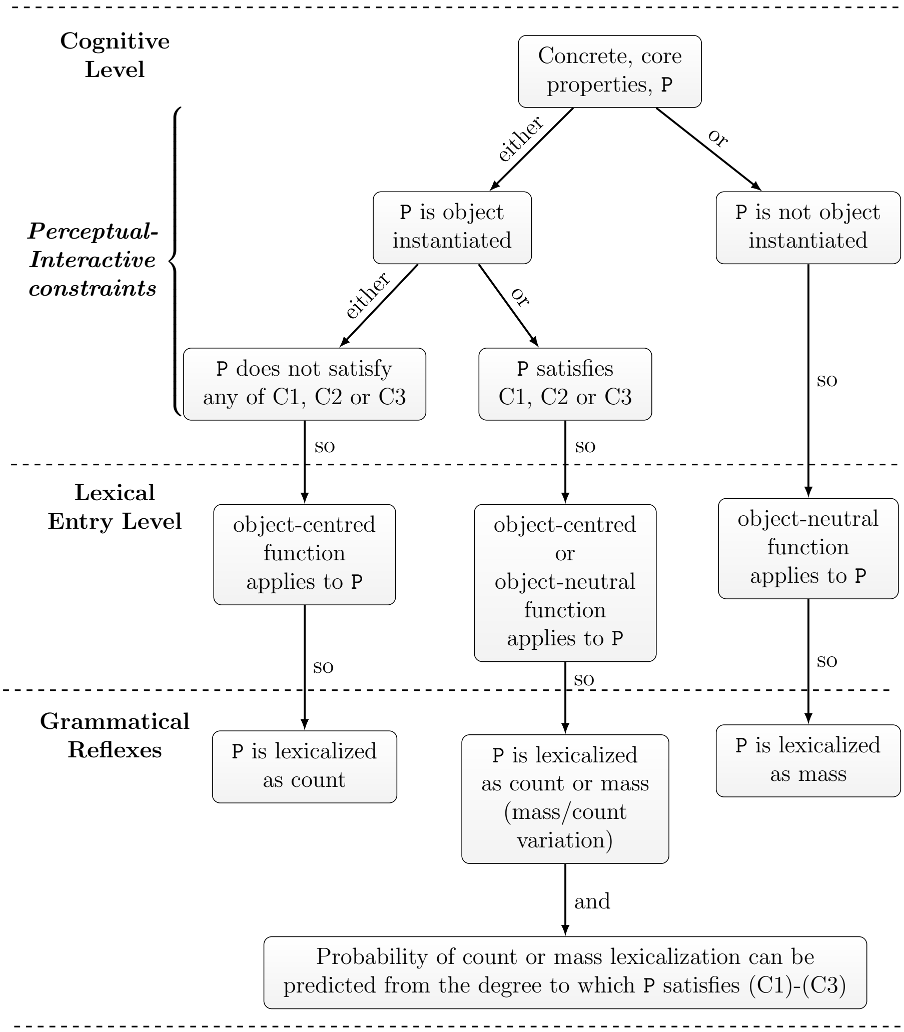
In the simplest terms, C1 relates to the distinguishability of objects relative to our perceptual acuity while C2 and C3 relate to the use to which the objects are put. As examples, the property `rice` satisfies C1, since rice grains are too small to be easily perceptually distinguishable from one another. `kitchenware` satisfies C2. One typical eventuality associated with kitchenware as an instrument is preparing a meal, and in many cases, some of multiple items of kitchenware is needed to bring this about (the instruments are used collectively). The property `melon` satisfies C3, since we often use melons for consumption, and to do so, typically, we cut them up into pieces in order to consume them.

Similar ideas behind constraints C1-C3 have been proposed, albeit in an informal way, by Wierzbicka (1988). For instance, she discusses the importance of how distinguishable entities are in terms of size and similarity (cf. C1), that entities in the denotations of nouns such as *furniture* are linked by a common purpose (cf. *typical associated eventuality* in C2), and identified "heterogeneous classes of substances and choppable things" (ibid., p. 560) as part of a class including *vegetables* (cf. C3). Furthermore, the impact of distinguishability and how we interact with entities has found some empirical support in studies with novel nominal expressions (Middleton et al., 2004). Additionally, constraint C2 is a development (albeit with some important alterations and differences), of (parts of) the proposal in Grimm & Levin 2017.

The concrete core properties underpinning common nouns, as well as our system of perceptual-interactive constraints that operate over them are independent of any specific language/linguistic expressions. That is to say, first, distinct lexical items in different languages, we assume, can lexicalize the same core property. Second, the system of perceptual-interactive constraints are meant to reflect generalisations about how humans perceive and interact with the objects that instantiate those properties.

The generalisations that can be made are: If core property `P` is instantiated by objects and does not satisfy any of C1-C3, then only the object-centred function can apply to the property, and consequently `P` is lexicalized as count. If `P` is instantiated by objects and does satisfy at least one of C1, C2 or C3, then either object-centred or the object-neutral function can apply to the property. This explains count/mass variation for lexicalizations of `P`: count with the object-centred perspective and mass with the object-neutral

Figure 1.4: Conceptual constraints and count/mass lexicalization patterns. Edges marked ‘either’/‘or’ indicate partitions of the property space. Edges marked ‘so’ indicate implicational relations.



perspective. This answers question 4a, why can (some) properties that are instantiated by objects be lexicalized as mass nouns. Our answer is because they satisfy at least one of constraints C1-C3.

We then answer Question 4b but making further use of constrains C1-C3 based on the degree to which a property satisfies C1-C3. We propose a model to derive an ordering for properties with objects that are instantiated by objects which reflects the relative likelihood that that property will be lexicalized as mass crosslinguistically. The inputs to the model are a weighting on the constraints and a score for the degree to which a property satisfies the constraints. For C1 and C3, we derive the constraint scores based on distributional corpus based methods (for C2, which is more conceptually complex, we simply assign a categorical score for each property). For instance, for C3, if a noun that lexicalizes a property is modified, relative to its total frequency, frequently by adjectives like *chopped* and *grated* or features as the DO argument of verbs like *chop* and *grate*, the C3 score for this property will be higher than if for some other noun and property, the noun is not frequently used in these environments (relative to its total frequency). In other words, we provide an empirically grounded way of making predictions about why some properties that are instantiated by properties are more frequently lexicalized as count and others more frequently lexicalized as mass, and answer to Question 4b.

The basic architecture of our analysis of the count/mass distinction which relies on the above perceptual-interactive constraints is summarised in Figure 1.4.

### 1.3.3 Extending the account

The two main limitations of our proposal, up until the end of chapter 5, is that we focus on number-marking languages with clearly grammatical count/mass distinctions and within those languages, only on 'concrete' nouns that denote physical objects and stuff. In chapter 6, we outline how our theory can be extended beyond these boundaries. First, we show how we apply our approach to numeral constructions in two non-number-marking languages: Mandarin and Yudja. These languages have very different morphosyntactic reflexes from number-marking languages. For instance, Mandarin is an obligatory classifier language, and, in Yudja all nouns can be directly combined with numeral expressions (Deal, 2017; Lima, 2014b,a). Semantically, in both of these languages, common nouns are also commonly assumed to express kinds (as opposed to properties) and we show how our semantics can be extended to such languages.

Second, building on our recent work (Sutton & Filip, 2019, 2020), we show how our theory can naturally be extended to abstract nouns that denote informational entities, taking nouns such as *belief*, *fact*, *information*, *knowledge* and *statement* as a case study. We argue that informational entities (roughly, propositions) are treated as objects in the countability reflexes of natural languages. However, unlike 'Spelke objects', what counts as an informational object is of course not constrained by e.g., cohesiveness, boundedness, and spatiotemporal contiguity etc. We show that this, along with our object-centred contextualist account makes the correct prediction that all count nouns that denote informational entities have a variable character with respect to what counts as one. For instance, an utterance of 'Taxes will be cut and spending increased' can count as either *one statement* or *two statements*, since it is underspecified whether the proposition expressed by the utterance is treated by the grammar as one informational entity or as two. Finally, we then lay out how countability with respect to the eventuality denoting senses of *belief*, *knowledge* and *statement* can be derived in terms of differences in aspectual classes (STATE vs. EVENT) and, developing the ideas in Grimm 2014 via anchoring to eventuality participants.

# Chapter 2

# Variation in count/mass lexicalization patterns and the non-canonical reflexes of countability

This chapter provides empirical support for the relatedness of two phenomena. First, we examine variation in count/mass lexicalization patterns. We divide the nouns that display variation in their count/mass lexicalization patterns into three notional classes in order to facilitate an explanation for why we find them realised as either count or mass nouns: *functionally combinatorial* nouns (e.g., *furniture*, *huonekalu-t* ('item-s of furniture', Finnish, count)), *interconnected* nouns (e.g., *fence*, *fencing*), and *granular and filament* nouns (e.g., *bean*, *lentil*, *bamboo*, *hair*).

Second, we show that the classes of nouns that display non-canonical grammatical reflexes of the count/mass distinction include the above three classes of nouns. Primarily, not only all count nouns, but also all mass nouns, in the above categories can be felicitously combined with stubbornly distributive predicates such as *round*, *small*, or *thick* (modulo specific lexical restrictions on precisely which stubbornly distributive predicates can be combined with which nouns). This sets these mass nouns apart from canonical mass nouns like *air* and *mud*. To this extent, variation in count/mass lexicalization patterns is more systematic than has been previously realised: whether a mass noun can be used with a stubbornly distributive predicate seems to be intricately related to whether the relevant core property which that mass noun lexicalizes is also lexicalized as a count noun within the same language or in other languages. For instance, we predict that *small fencing* should be acceptable, precisely because in English, there is also a count counterpart *fence*. This is attested for example in (2.1) in which it is not the case that the fencing in the garden as a whole is small, rather that each of the fencing enclosures or stretches of fencing in the garden is small.

(2.1) For a nicer and cleaner finish, add some small fencing around your garden. [enTenTen21]

In addition to the data with stubbornly distributive predicates, building on our previous work (e.g., Filip & Sutton, 2017; Sutton & Filip, 2016c, 2021b), we also provide evidence that some of these subclasses of nouns that display non-canonical grammatical reflexes of the count/mass distinction, rather than being merely idiosyncratic, indicate their own distinctive grammatical profiles. This suggests intricate, but still systematic interactions between features of the core properties that common nouns lexicalize (such as whether they are instantiated by discrete objects), the grammar of countability, and the systematic variation these core properties have in their count/mass lexicalization patterns. For instance, take singular *interconnected* count nouns such as *fence* in English and *zed'* ('wall') in Czech. Both of these nouns have a mass counterpart, namely *fencing* in English and *zdivo* 'walling', 'masonry', 'brickwork' in Czech. We observe that *interconnected* count nouns are felicitous in some canonically mass contexts. For instance as the 'downstairs' NP of a pseudopartitive (measure) phrase, they can be used as bare singular count nouns. This can be seen with the English *fence* in *three yards of fence*, and with the Czech *zed'* ('wall') in *tři metry zdi* 'three meters of wall (GEN)'.

Put simply, we show that the following two connections hold: If a count noun displays some of the grammatical reflexes of a canonical mass noun, such as *fence* in English or *zed'* ('wall') in Czech), the core property that this noun lexicalizes is likely to be lexicalized as mass in the same and/or another language as well, namely, e.g., *fencing* in English, *zdivo* 'walling', 'masonry', 'brickwork' in Czech. In these cases, we observe that, at least for English and Czech, the mass noun is morphologically derived from the count noun. Conversely, if a mass noun displays some grammatical reflexes of a canonical count noun, such as felicitous modification by stubbornly distributive predicates, which we observe with granular mass nouns like *štěrk* ('gravel/pebbles', Czech, mass) and *gravel* in English, then it is a reasonable expectation that the core property that this noun lexicalizes will also be lexicalized as count in at least one language as well (e.g., *oblázky* ('pebbles', Czech, count) *pebbles* in English).

From this it follows that variation in count/mass lexicalization patterns extends well beyond the class of object mass nouns, which are notorious for this phenomenon, to other lexical semantic classes of nouns. For instance, *interconnected* count nouns and *granular and filament* mass nouns, we show, are also characterised by their own distinct grammatical profiles, and are thus deserving of an analysis that addresses this variation in a more comprehensive way. Indeed, in chapter 3, we show how these data provide the basis for both theoretical and empirical challenges to some of the state-of-the-art theories of countability.

In section 2.1, focussing on Czech, English, Finnish, and German, we introduce the evidence for lexicalization pattern variation for three classes of nouns: *Functionally combinatorial* nouns such as *furniture*, *interconnected* nouns such as *fence*, and *Granular and Filament* nouns such as *bean* and *straw*. In each case, we also provide evidence that while nouns in these categories pattern non-canonically with respect to their morphosyntactic count/mass reflexes, within a particular language and cross-linguistically, they still exhibit their own distinct and systematic grammatical profiles. In section 2.2, we present the results of a corpus study on *functionally combinatorial* mass nouns and *granular and filament* mass nouns in Czech and English. We show that, in both languages, *functionally combinatorial* mass nouns (e.g., *furniture*) and *granular and filament* mass nouns (e.g., *rice*) pattern together with respect to their distributions with stubbornly distributive predicates. These nouns pattern significantly differently from canonical mass nouns (e.g., *air*), but can also be distinguished from canonical count nouns (e.g. *car*).

## 2.1 The grammatical reflexes of count/mass variation

### 2.1.1 Lexicalization pattern vs. Morphosyntactic variation

As a preliminary terminological note, when we discuss variation in count/mass lexicalization patterns, we will sometimes drop the 'count/mass' and sometimes say *variation in lexicalization patterns* tout court. This variation can be crosslinguistic as well as intralinguistic. The core property `asparagus` gives rise to variation in its crosslinguistic lexicalization patterns. For example, it is lexicalized as mass in English (*asparagus*) and count in French (*asperge*). The core property `fence` gives rise to variation in its intra-linguistic lexicalization patterns. For example, it is lexicalized as count and as mass in English *fence* and *fencing*. So when the same core property is lexicalized as count in one language but mass in another we have cross-linguistic count/mass variation in the lexicalization pattern, and when a core property is lexicalized as pair of lexical items in the same language, one count and one mass, we have an intralinguistic count/mass variation in the lexicalization pattern.

**Lexicalization pattern variation**

Suppose that common noun $N_1$ is in language $L_1$ and common noun $N_2$ is in $L_2$. If $N_1$ and $N_2$ both lexicalize a core property P, but $N_1$ is classified as count relative to the morphosyntactic tests for countability in $L_1$ and $N_2$ classified as mass (non-count) relative to the morphosyntactic tests for countability in $L_2$, then $N_1$ and $N_2$ are instances of lexicalization pattern variation. This variation is crosslinguistic if $L_1 \neq L_2$ and intra-linguistic if $L_1 = L_2$.

We distinguish *lexicalization pattern variation* from *morphosyntactic variation* in the grammatical reflexes of countability. Whereas lexicalization pattern variation relates to variation in the lexicalization of properties as count or mass nouns cross- and intra-linguistically, morphosyntactic variation relates to variation in the morphosyntactic generalisations associated with the reflexes of the count and mass categories in the grammars of different languages. In English, an indicator that a noun is mass, or is used as a mass noun (inclusive of dual life nouns), is its felicitous use in syntactic mass context or with mass morphology. For example, it can be used bare in argumental positions. Count nouns cannot be so used (excluding a limited class of count nouns in specific contexts, e.g., *They hunt rabbit*, for nouns denoting game animals). Of course, in languages without an article system, like Finnish, the use of a bare noun in an argumental position is, unsurprisingly, not an indicator of countability. This contrast is an instance of morphosyntactic variation in the grammatical reflexes of countability. This morphosyntactic variation is different from *lexicalization pattern variation*, an example of which for English and Finnish is the way that the core property `furniture` is lexicalized: as a mass noun in English (*furniture*), and as a count noun in Finnish (*huonekalu-t*, furniture-PL, 'pieces of furniture').

To take another example of *morphosyntactic variation* , the count/mass distinction in English is evidenced by whether an intervening classifier-like or a measure expression is needed in numeral constructions, mass nouns require one, count nouns do not. In contrast, nouns in Mandarin generally require an intervening classifier in numeral constructions. Classifiers fall into two main groups: count classifiers and mass classifiers (*massifiers*), and not all nouns can be combined with count classifiers (Cheng & Sybesma, 1999).[1]

[1] Massifiers occur not only with mass nouns, but also with count nouns, and, as such 'massifier', is perhaps unfortunate terminology: "Since [massifiers] create units of measure,

Such distributional facts are taken to indicate that in classifier languages like Mandarin the mass/count distinction is reflected in the syntax-semantics of their classifier system (e.g., Chierchia 2010).

Neither the licensing of bare count nouns in Finnish, nor the requirement for intervening classifiers in numeral constructions in Mandarin are instances of variation in count/mass lexicalization patterns. Instead, they are examples of variation in how languages morphosyntactically reflect countability distinctions.

### 2.1.2 Mismatches between notional and grammatical categories

It is widely accepted that, even for concrete nouns, the structure of entities in the world (as physical objects or substances) does not determine the grammatical countability class of nouns denoting those entities. Some of the first detailed discussion of this point is in Quine 1960 and McCawley 1975, who observed that the same things in the external world can be referred to by near-synonymous nouns that differ in the count/mass category (*shoes–footwear*). But this means that straightforward form–meaning correspondences 'count–individuated object' and 'mass–undifferentiated stuff' must be rejected. However, the puzzling nature of the mismatches between the two sets of distinctions 'count/mass' and 'object/undifferentiated stuff' was perhaps hidden from Quine due to his view that the concept 'object' is acquired linguistically. Furthermore, empirical work in psychology determined that Quine's view is invalid and that the object/stuff distinction is learned pre-linguistically (see e.g., Soja et al. 1991; Spelke 1988).

Despite these early findings, attention to such mismatches lapsed throughout the 70s and 80s (however, see Wierzbicka 1988 and Pelletier & Schubert 1989/2002, as well as e.g., Sharvy 1979; Ware 1979 in Pelletier 1979). It was not until Chierchia 1998a,b, Doetjes 1996, and Barner & Snedeker 2005 that object mass nouns, which have a discrete individuation structure of their denotata, such as *footwear* and *furniture*, assumed a prominent place in theoretical semantics discourse. One of the starting points for this work was a criticism of Quine in light of the growing psychological evidence that revealed the truly puzzling nature of object mass nouns, namely that they denote things that we pre-linguistically conceive of and recognise as discrete objects, but are nonetheless lexicalized as mass. The existence of object mass nouns is standardly used to show that the count/mass distinction is fundamentally

they can also occur with nouns that have a natural partitioning as part of their semantics (a group of people, a pound of beans)" (Cheng & Sybesma, 1999, p. 515).

a *grammatical* distinction, not a notional/conceptual one (seem, amongst others, Chierchia 2010; Landman 2011; Rothstein 2010). For example, object mass nouns, such as *furniture* and *jewellery* denote objects such as chairs, tables, rings and bracelets, but they are syntactically mass nouns insofar as they display more or less the same morphosyntactic properties of canonical mass nouns such as *mud* and *air* when it comes to the felicitousness of their straightforward use as bare singulars in argumental positions, or incompatibility with numerals and distributive determiners, for instance.

The prima facie mismatch between the two sets of distinctions, the syntactic 'count/mass' and notional 'object/undifferentiated stuff', as we observe it with object mass nouns, has overly dominated research on countability, perhaps driven by a focus on English data, on data from some other Germanic languages, and, to a lesser extent, on Romance languages. However, similar mismatches between syntactic and notional categories are manifested in a number of intriguing ways also when we look beyond object mass nouns. For example, Grimm (2012) drew attention to *collective* nouns such as *cacwn* ('hornet', Welsh) that are not count and denote a mereotopologically connected group, such as a swarm of hornets. However, via singulative morphology, a singular count noun can be morphologically derived. Relatedly, in Czech mass nouns can be derived from canonical count nouns such as *pero* ('feather', Czech, count neuter) via the nominal suffix *-í*, giving us *peří* ('plumage', Czech, mass neuter). (See also Grimm & Dočekal 2021.) Even in English, we also have morphological means of deriving mass nouns from count nouns, albeit not as productively as in Czech. For instance *fencing*, a mass noun in English with the count noun *fence* as its morphological root, can denote fences or multiplicities of fences, as in *Fencing was put up to prevent trespassers.*

In addition, there are *granular nouns*, an admittedly vague term, which we will use to refer to nouns that denote small-ish entities that are more-or-less similar with respect to their perceptual properties. Examples in English include *cherry*, *grape*, *bean*, *gravel*, *lentil*, *oat*, *rice*, *sand*, and *pollen*. Now, whereas sand and gravel seem to be more substance-like, beans, grapes and cherries are more object-like. However, as observed by Wierzbicka (1988), the nouns denoting cherries and grapes in Russian are mass and, as noted by Chierchia (2010), *fasole*, the noun denoting beans in Romanian is also mass.

Furthermore, what we will call *filament nouns*, nouns that denote strand-like, or long-ish, thin-ish entities, such as *hair*, *straw*, and *wheat*, also display similar lexicalization pattern variation across and within languages. For example, in English, *hair* is a dual life noun (i.e., it has a count and a mass sense), and in its mass use, it refers to the totality of hair on one's head, or to some mass of hair-stuff, and there are perfectly felicitous uses of *hair* as a count noun:[2]

(2.2) *Context: cleaning and grooming the ears of a dog.*
Fold back the ear flap, and briskly pull out one or two hairs at a time, in the direction of growth. (BNC, ACM)

This raises the problem about where the notional dividing line between substance-denoting nouns and object-denoting nouns lies. We may ask questions like 'Are cherries objects?' and 'What about grains of sand, grains of pollen, or strands of hair?' Of course, there is a great deal of difficulty in judging the answer to such questions on intuitive notional grounds, and so attention has been rightly placed on whether or not some mass nouns display grammatical reflexes that set them apart from other mass nouns that display what we take to be distributional/grammatical properties of canonical mass nouns, and likewise for count nouns. In sections 2.1.3–2.1.5, we provide an overview of such grammatical reflexes for our three groups of nouns: *functionally combinatorial* nouns (including object mass nouns such as *jewellery*), *interconnected* nouns (such as *fence*), and *granular and filament* nouns (such as *lentil* and *hair*).

### 2.1.3 Functionally combinatorial nouns

As noted in section 2.1.2, looking at a wide array of languages, the class of mass nouns that denote objects arguably goes far beyond that of object mass nouns, namely, collective, granular, and filament mass nouns, as well as mass nouns such as *fencing*). Nonetheless, object mass nouns are an interesting class of nouns both in terms of their grammatical reflexes and the fact that they have coextensional plural count noun counterparts crosslinguistically. Since there is no established umbrella term for both object mass nouns and their (plural) count noun counterparts, we will use the term *functionally combinatorial* to apply, not only to object mass nouns, but also to these count noun counterparts.[3]

To begin with object mass nouns, these mass nouns denote objects, but importantly, the objects they denote are united by a kind of combined function. Erbach's (2021) list of object mass nouns in English is given below:

[2]Data annotated with *BNC* were extracted from the British National Corpus (BNC Consortium, The British National Corpus, XML Edition, 2007, Oxford Text Archive, `http://hdl.handle.net/20.500.14106/2554`), accessed via the *Sketchengine* platform (Kilgarriff et al., 2004). For BNC citations, we also provide the 3-character BNC reference code.

[3]In prior work we have proposed the term 'collective artefact nouns', however, this was problematic, since 'collective' is a somewhat ill-defined term.

> ammunition, apparel, armor, art, artillery, artwork, autumnwear, baggage, bakeware, beachwear, bedding, change, china, clothing, clutter, coinage, crockery, cutlery, decoration, dishware, equipment, earthenware, freight, furniture, footwear, gear, glassware, hardware, inventory, jewelry, knitwear, ladieswear, laundry, legwear, lingerie, loot, luggage, mail, menswear, merchandise, [...], outerwear, packaging, paperwork, plasticware, rigging, seating, shapewear, silver, silverware, software, sportswear, [...], stock, swag, tackle, teaware, tupperware, underwear, weaponry (Erbach, 2021, p. 201)

For instance, *crockery* denotes things like teacups, saucers, plates and bowls, all made of earthenware or china, each of which have their own function or purpose, but that as a whole, somehow combining or summing all of these functions together, give us a set of things with an overarching function, e.g., that of things that facilitate our ingestion of food and drink as containers, receptacles etc.

This point is similar, but distinct to one made by (Grimm & Levin 2017, manuscript), who observe that object mass nouns have an ill-formed taxonomic hierarchies "mail is delivered, but the purported sub-kind nouns do not inherit this property, since not all magazines are delivered nor is being delivered an essential property of a magazine." (ibid., pp. 7-8). Contrast this with a natural kind that has a more well-formed hierarchy.[4] Take, the kind *mammal*: there are properties of mammals in general (e.g., having a four-chambered heart) that all subkinds of mammals have.

Our point differs from that of Grimm & Levin. They emphasise that the properties of higher-level categories are not (always) inherited by their daughter categories. In this sense, they look downwards from mother categories to daughter categories. In contrast, we instead emphasise that, for *functionally combinatorial* nouns, the functions of higher-level categories are formed or generalised from a combination of (at least elements of) the functions of the daughter categories. For instance, *preparing food* for *kitchenware*, is at least partially decomposable into things like chopping (that knives afford), cooking (that saucepans afford) and stirring (that wooden spoons afford) etc. As such, we look up from daughter categories to mother categories. This, in turn, we argue, can help motivate why properties such as `kitchenware` can be lexicalized as mass. We return to a more detailed discussion of the differences

[4]We note that natural kind hierarchies are not always well-formed. Most would accept 'Birds have wings' as true, but as a generic sentence, this statement has an exception-tolerating property. Indeed, at least one, now extinct, species of bird is believed to have had no wings at all.

between our proposals in chapter 5.

*Functionally combinatorial* mass nouns, which are exemplified by what are traditionally taken to be object mass nouns, are mass nouns insofar as they have many of the same morphosyntactic reflexes as other mass nouns in a given language. These mass nouns usually denote heterogeneous sets of entities, but have a collective flavour in so far as they are unified by a single overarching function. In English, they resist use in numeral constructions without an intervening classifier (#*two furniture(s)* versus *three pieces of furniture*) and combination with distributive determiners (#*every/each furniture* versus *every/each piece of furniture*). They can also be used in syntactic environments that select for mass nouns, as in the bare singular argumental positions, for instance (e.g., *Learning a little about the way furniture is made helps you make better shopping decisions*).

In other languages, however, lexicalizations of the properties that underpin such object mass nouns in English need not be grammatically mass. For example, in Finnish, there are count-counterparts to many of the above listed nouns such that a Finnish plural count noun is coextensional with its object mass noun counterpart in English. To give just a few examples, we have lexical count-counterparts of English object mass nouns such as *huonekalu-t* (furniture-PL, '(items of) furniture'), *koru-t* (jewellery-PL, '(pieces of) jewellery'), *astia-t* (crockery-PL, '(pieces of crockery)'). Now, although nouns such as *huonekalu* ('item of furniture', Finnish) are canonical count nouns, it is justified to include them under the umbrella term of *functionally combinatorial* nouns because they, even in their singular count noun realisation express a property that covers specific heterogenous entities, which are albeit united by the same overarching combined functionality. For instance, whether we talk about *furniture* or *huonekalu* ('item of furniture', Finnish), these nouns subsume entities with specific functions (e.g., chairs for sitting on, shelves for storing items), but also evoke an overarching function such as things used for furnishing rooms or spaces (indeed, the literal translation of *huonekalu* is 'room.thing').

Some intralinguistic variation is also attested for such *functionally combinatorial* nouns. For example, as observed in Landman 2011, Dutch has both an object mass noun *meubilair* ('furniture', mass singular) which correspond to the English *furniture*, and also a count noun with its regular plural counterpart to refer to furniture: namely, *meubel* ('item of furniture', count singular) and *meubel-s* ('item-s of furniture', count plural), similarly to Finnish. In Dutch, there is also compound with a classifier-like term *meubelstuk* ('furniture-piece'), which lexicalizes the classifier-like concept that is inherent in the singular count noun *meubel*. In German, *Möbel* ('furniture') takes plural agreement and so appears to be a pluralia tantum noun, where single items of furniture are denoted by the compound *Möbelstück* ('furniture.piece', count) with the classifier-like noun *Stück* 'piece'. In order to state the generalisations concerning such cross-linguistic and also intra-linguistic variation, we therefore use the term *functionally combinatorial* nouns to refer to all such nouns, be they count or mass.

It is worth emphasising that, despite receiving a significant amount of attention in the literature, including from ourselves (see, e.g, Sutton & Filip 2016a, 2017c), *functionally combinatorial* mass nouns seem to be less common than other types of nouns in natural languages. For instance, when it comes to number marking languages, it has been claimed that Greek lacks *functionally combinatorial* mass nouns. (See Tsoulas 2006 on object mass nouns, but also Alexiadou 2019a and Erbach 2019 for a discussion of this claim.) Finnish seems to have only one *functionally combinatorial* mass noun that we have been able to discern, namely *siipikarja* ('poultry', Finnish, lit. 'wing stock')[5].

When it comes to languages without number marking, *functionally combinatorial* mass nouns seem to be even more scarce. Chierchia (2015) tentatively claims that only number marking languages can have object mass nouns (i.e. *functionally combinatorial* mass nouns). We note though that Erbach et al. (2017) found some evidence that *functionally combinatorial* nouns in Japanese (which has no number marking) pattern differently with respect to certain countability-sensitive quantifiers, but these results were not sufficiently strong to establish that Japanese has object mass nouns.

English, a number-marking language, on the other hand, is a relatively rich source for *functionally combinatorial* mass nouns. Furthermore, it is not clear that this is due to a correlation between morphological suffixes and countability. On purely formal morphological grounds, for instance, *furniture* and *jewellery* could easily have had a plural form (as with, e.g., *creatures*,

[5] *Siipikarja* is either used to refer to meat or to the animals, just as *poultry* is in English. In the Finnish Web 2014 (fiTenTen14) corpus, there is only one instance of the plural of *siipikarja*, and this has a subkind reading. In contrast, there are 2622 instances in the singular (422 uses in the nominative singular). For example, in (i), we see a contrast between the plural count noun forms of *sika* ('pig') and *nauta* ('cow'), which contrasts with a singular form of *siipikarja* ('poultry'), indicating the use of the latter as a mass noun.

(i) Siipikarjalla ja naudoilla yleisimmin esiintyvä [Finnish]
poultry.ADES and cow.PL.ADES common.INSTR.SUP appear.PTCPL
laji on C. jejuni ja sioilla yleisin on C. coli.
kind is C. jejuni and pig.PL.ADES common.SUP is C. coli
'The most commonly appearing species in poultry and cows is C. jejuni and in pigs is C. coli.'

This and other such data are interesting in and of themselves, since they are the only attested cases we are aware of object mass nouns in Finnish.

*ligatures*, *overtures* and *bakeries*, *batteries*, *mysteries*, *oileries* and *owleries* respectively).[6]

Slavic languages are notable among number-marking languages in so far as besides monomorphemic object mass nouns, they have morphological means available for deriving mass nouns from singular count nouns, but also from verb stems, and some of these derived mass nouns would traditionally be classified as object mass nouns (*functionally combinatorial* mass nouns). For instance, in Czech these are predominantly suffixes, much less commonly also prefixes or the combination of both (Petr et al., 1986). The most common and productive suffixes are *-í*, *-oví*, *-stvo/-ctvo* (ibid., p. 309), all of which derive (singular) mass nouns that belong to the neuter gender class. They are attached to singular count nouns denoting natural kinds or artefacts, which are either masculine, feminine or neuter. However, these mass nouns are notionally diverse, even if they are all uniformly mass neuter singular and intuitively refer to some 'accumulation' of objects (*hromadnost* in Czech, approx. 'collectivity', '(ac)cumulation', 'multitude', 'plurality', see Petr et al. 1986 Vol. 1, p. 255). Although all have what we would easily judge to be objects, taken in a broad sense, in their denotation, only some are *functionally combinatorial* mass nouns (i.e., as object mass nouns in the sense that is usually used in the literature), namely, artefact-denoting nouns like *furniture, kitchenware, crockery* in English. Many of these morphologically derived nouns are akin to Grimm's (2012) collective nouns (e.g., *malinoví* 'thicket(s) of raspberry plants'), others are what we shall call *granular* mass nouns (e.g., *zrní* 'grains').

(2.3) *-í*: [Czech]

a. *Functionally combinatorial* nouns derived with *-í*:
*prut* (masc) 'rod', 'stick (elastic, bendable, pliable)' → *proutí* 'wicker material/sticks'
*dřevo* (neuter) 'wood' → *dříví* 'wood material', 'pieces of wood' (also used as fuel)

b. Collective nouns derived with *-í*:
*list* (masc) 'leaf' → *listí* 'foliage'
*malina* (fem) 'raspberry' → *maliní* 'raspberry hedging', 'a tangle of raspberries'
*pero* (neuter) 'feather' → *peří* 'plumage' (also a granular when understood as 'down')
*trn* (masc) 'thorn' → *trní* 'thorns', 'thorny bush(es)', thorny

[6] However, see Zamparelli (2020) for an investigation into the connection between morphology and countability for abstract nouns.

undergrowth'
*smrk* (masc) 'spruce' → *smrčí* 'a grove of spruces'
*dub* (masc) 'oak' → *dubí* 'oak growth'
*ořech* (masc) 'nut' → *ořeší* 'a collection of nut trees/plants'

c. Granular nouns derived with *-í*:
*kámen* (masc) 'stone' → *kamení* '(a collection of) stones'
*zrno* (neuter) 'a single grain' → *zrní* 'grains'

(2.4) *-oví*:

a. *Functionally combinatorial* nouns derived with *-oví sloup* (masc) 'column' → *sloupoví* 'portico', 'columns'
*lano* (neuter) 'rope' → *lanoví* 'rigging', 'cordage'
*lat'* (fem) 'bar', 'balk', 'strut' (made out of wood) → *lat'oví* 'battens'
*plachta* (fem) 'sail' → *plachtoví* 'canvas for sails', '(a collection of) sails (as on a single boat)', 'sailage'
*trám* (masc) 'beam' → *trámoví* 'timberwork'

b. Collective nouns derived with *-oví strom* (masc) 'tree' → *stromoví* 'a tree growth'
*malina* (fem) 'raspberry' → *malinoví* 'a raspberry thicket'
*větev* (masc) 'branch' → *větvoví* 'intertwine of branches', 'branchwork'
*jedle* (fem) 'fir' → *jedloví* 'a fir growth'
*vrba* (fem) 'willow' → *vrboví* 'willow growth'

(2.5) *-stvo/-ctvo*:

a. *Functionally combinatorial* nouns derived with *-stvo/-ctvo šaty* (plural tantum) 'dress' → *šatstvo* 'wardrobe', 'outfits' *sval* (masc) 'muscle' → *svalstvo* 'musculature'
*nerv* (masc) 'nerve' → *nervstvo* 'nerve system'

b. Collective nouns derived with *-stvo/-ctvo hora* (fem) 'mountain' → *horstvo* 'mountain range'

In Czech, such mass nouns (singular neuter gender) can also be derived by means of the suffix *-ivo* from verb stems, which are most often imperfective[7], but may also be perfective (Petr et al., 1986, Vol. 1, p. 245). This suffix is reported to be productive to 'an average to low degree' (ibid., Vol. 1, p. 247), and deverbal nouns it forms are also characterised in terms of the feature of *hromadnost* (approx. 'collectivity', '(ac)cumulation', 'multitude', 'plurality') (see ibid. Vol. 1, p. 255).

[7]Apparently, the mass noun 'beer' is also tied to this derivational pattern: *pít* 'to drink' → *pivo* 'beer'.

(2.6) *pálit* (ipf) 'to burn' → *palivo* 'combustible stuff', 'fuel'
*topit* (ipf) 'to heat' → *topivo* 'fuel', 'heating material'
*krmit* (ipf)'to feed' → *krmivo* 'feed', 'fodder'
*léčit* (ipf) 'to heal' → *léčivo* 'medication', 'remedy', 'medicine'
*obvázat* (ipf) 'to bandage', 'to swath' → *obvazivo* 'bandage material(s)'
*stavit* (ipf) 'to build' → *stavivo* 'construction material'
*střelit* (pf) 'to shoot (pf)' → *střelivo* 'ammunition'

The suffix *-ivo* (neuter) can also be applied to nouns:

(2.7) *zed'* 'wall' → *zdivo* 'walling'
*kámen* (masc) 'stone' → *kamenivo* '(crushed pieces of) stone', 'stone aggregate'

### The grammatical reflexes of count *functionally combinatorial* count nouns

When count, *functionally combinatorial* nouns distributionally pattern with other count nouns in their respective languages. For example, they can be used in numeral constructions, as we see in the examples below with count *functionally combinatorial* nouns in Finnish, which are contrasted with their English mass counterparts, which cannot be felicitously used in numeral constructions. The Finnish data are from Sutton & Filip 2016a:

(2.8) a. ?I bought three furnitures: a table and two chairs.
b. Ost-i-n kolme huonekalu-a pöydä-n ja [Finnish]
buy-PST.1SG three furniture-PAR table.ACC and
kaksi tuoli-a.
two chair-PAR
'I bought three items/pieces of furniture: a table and two chairs.'

(2.9) a. ?I took two footwear(s) from the shelf.
b. Ot-i-n kaksi jalkine-tta hylly-ltä. [Finnish]
take-PST-1SG two footwear-PAR shelf-ABL
'I took two pieces/items of footwear from the shelf.'

(2.10) a. ?I'm looking for two gold jewellery/jewelleries.
b. Etsi-n kah-ta kultais-ta koru-a. [Finnish]
look.for-1SG two-PAR gold-PAR jewellery.PAR
'I'm looking for two pieces/items of gold jewellery.'

### The grammatical reflexes of *functionally combinatorial* mass nouns

The grammatical reflexes of *functionally combinatorial* mass nouns (i.e., object mass nouns), have been studied in depth for approximately twenty-five years (amongst others Barner & Snedeker 2005; Chierchia 1998a,b; Erbach 2019; Grimm 2012; Landman 2011; Sutton & Filip 2016a, 2017c). Object mass nouns pattern in terms of distribution like all other mass nouns in most environments that are relevant to determining the countability of a lexical item, but they pattern differently in at least two ways.

First, in comparative 'more than' and superlative 'most' constructions, object mass nouns allow, or even tend to primarily convey, a comparison based upon cardinality as opposed to a measure comparison (see, amongst others, Barner & Snedeker 2005; Inagaki & Barner 2009; Rothstein 2017 for comparatives, and Landman 2011 for a discussion of Dutch superlatives). For example, in English, the question 'Who has more furniture?' is usually answered in line with who has more items of furniture in terms of cardinality, whereas 'Who has more mud?' does not permit a cardinality comparison reading.

However, as pointed out by Grimm & Levin (2017) and Rothstein (2017), object mass nouns do permit measure comparison interpretations in some contexts, *pace* claims made by Barner & Snedeker (2005). For instance the following is from Rothstein 2017, p. 122:

(2.11) John has more furniture than Bill, so he should use the larger moving truck.

> "[...] John and Bill are moving house, and John has a grand piano, a large sofa, a double bed and his grandmother's heavy wardrobe (= four pieces of furniture). Bill, in contrast, has four folding chairs, a small table and a rolled-up mattress (= six pieces of furniture). In this situation, [(2.11)] is judged by native speakers to be true, because in the context of choosing a moving truck, the volume of the furniture is relevant and not the number of pieces."

Thus, the correct empirical claim is that *functionally combinatorial* mass nouns in English, and we hypothesise is a plausible general claim for *functionally combinatorial* mass nouns in all languages, is that they (easily) admit of cardinality comparison interpretations, whereas canonical mass nouns do not. The parenthetical 'easily' is included, since cardinality comparison interpretations for other mass nouns are available in some contexts, but this can require quite a lot of contextual support (for instance most *granular* nouns, see section 2.1.5). Corresponding examples with object mass nouns in measure comparison constructions in other languages are easy to find. Take, for example, *nádobí* ('dishware/crockery', mass) in Czech[8]. Let us suppose that Hana and her friend Honza pack pieces of crockery to be safely shipped without getting broken or cracked, and so need the appropriate packaging material and supply of it to wrap each piece individually. If they have two big serving plates and one soup terrine, but Honza has two small side plates and two espresso cups, then the answer to the question below would be felicitously answered with *Honza má víc nádobí* - 'Honza has more crockery', because arguably his crockery takes up more space and requires more packing material than Hana's:

(2.12) Kdo má víc nádobí?
who has more crockery
'Who has more crockery?'

Second, object mass nouns are compatible with *stubbornly distributive* predicates such as *large*, *small*, *big* and *round* (Chierchia, 2010; Rothstein, 2010; Schwarzschild, 2011), whereas substance denoting nouns are not. Stubbornly distributive predicates are predicates that "allow for distributive readings but not for collective readings" (Schwarzschild, 2011, §2.2). Modulo certain lexical restrictions, stubbornly distributive predicates are straightforwardly felicitous with count nouns, but also with object mass nouns. They are not felicitous with mass nouns that denote substances. For example, we get contrasts between examples such as (2.13) and (2.14), on the one hand, and (2.15), on the other.

(2.13) a. small/big/large/round chairs/tables/houses/hedges
b. The chairs/tables/houses/hedges are small/big/large/round.

(2.14) a. You won't find any small coffee tables in Al's furniture warehouse, they only sell big furniture/furniture that is big.
b. if you have a round face, do not wear round jewellery or round glasses[9]

(2.15) a. #small/big/large/round oil/air/mud/honey
b. #The oil/air/mud/honey is small/big/large/round.

Third, object mass nouns strongly resist mass-to-count coercion either for referring to individual items or to subkinds (Rothstein, 2015; Sutton & Filip,

[8]It seems that *nádobí* can also be used to apply to some items of kitchenware such as pots and pans, perhaps due to a generalisation from the fixed expression *nádobí na vaření* ('crockery for cooking').

[9]From *Born to Be Beautiful: How to Look and Feel Amazing During and After Pregnancy* by Donna Kennedy. Liberties Press. 2015.

2016a, 2017c)[10], as the following examples from Sutton & Filip 2017c show for *furniture* in contrast to *water*:

(2.16) a. #I ordered three furnitures from Ikea: one table and two chairs.

b. #I ordered two furnitures from Ikea: chairs and tables.
c. #I ordered two furnitures from Ikea: bedroom and living room furniture.

(2.17) a. Three waters, please!
e.g. three [GLASSES/BOTTLES OF] water. (portion)
b. I ordered three waters for the party: still, sparkling, and fruit-flavoured
for the kids.
i.e. three [KINDS OF] water (subkind)

### ***Functionally Combinatorial*** **Nouns: Summary**

This class of nouns shares the property that each of them denotes a set of heterogenous entities, but unites them under some overarching shared functionality. This is the property, as we hypothesise, that motivates that they are syntactically either mass or count in a given language and also across different languages; i.e., this property systematically gives rise to variation in the mass/count lexicalization patterns. English is one of the languages that has a systematic class of *functionally combinatorial* mass nouns, which exhibit a distinct grammatical profile, and also some are derived by semi-productive morphological means. Most importantly, we adduced some data showing that *functionally combinatorial* Mass Nouns are a class of mass nouns with distributional patterns that are distinct from substance mass nouns, that is, what are taken to be canonical mass nouns, that lexicalize properties like `water,mud,meat`, e.g., *water, mud*, and *meat* in English, which to the best of our knowledge tend to be monomorphemic. Non-monomorphemic members of this class include substance mass nouns that denote artefacts such as *gunpowder*, *lemonade* and *tarmac* (a compound consisting of *tar* and the truncation of the eponym of *MacAdam*, its inventor) as well as many borrowed scientific terms for base elements viz. *oxygen*, *nitrogen* etc. Comparable classes are also attested in German and French, for instance.

Other languages (e.g. Finnish) have few *functionally combinatorial* mass nouns, and instead have a count noun lexicalization of the relevant 'collective'

[10] Erbach & Schoenfeld (2022) report findings from a naturalness judgement study in which object mass nouns in Hungarian do not get significantly lower judgements for counting subkinds compared to other noun classes.

property that denotes single items or pieces of that 'collection' when used in the singular, and also their sums when used in the plural.

Yet other languages (Czech) have not only basic, monomorphemic *functionally combinatorial* mass nouns, but also productive or semi-productive means of forming them via derivational affixation.

**Looking ahead.** Having concluded the summary of our introduction to *functionally combinatorial* mass nouns, by way of preview of the next two sections, let us observe that it has often been implicitly assumed that *functionally combinatorial* mass nouns (i.e., object mass nouns), are special among mass nouns in so far as they differ in their distributional patterns from substance mass nouns (canonical mass nouns), in tandem with assumptions concerning their denotational differences (i.e., having discrete, disjoint entities in their denotation, unlike substance mass nouns). However, there are two more classes of nouns that we will address next, that also display non-canonical, but systematic, grammatical reflexes of countability for the languages in which their occur. Taking English, as an example, these are *interconnected* nouns such as *branch, fence, fencing,* and *hedging*, and *granular and filament* nouns such as *rice, lentils, straw* and *hair*. What is striking is that both of these classes of nouns are underpinned by properties that also display variation in their count/mass lexicalization patterns. We take this to mean that the phenomenon of the variation in count/mass lexicalization patterns, and the ways in which nouns exhibit their specific grammatical variation profiles, extends beyond the class of object mass nouns and is thus deserving of an analysis that addresses this phenomenon as a whole.

### 2.1.4 *Interconnected* nouns

In mereological approaches to the count/mass distinction, nouns such as *branch*, *fence*, *hedge*, *twig*, and *sequence* first garnered attention given that they, unlike canonical count nouns, failed to denote quantized sets of entities, or do not have quantized reference, in Krifka's terminology (see Krifka 1989, fn. 5, also following Partee p.c., Rothstein 2010; Zucchi & White 1996, 2001). A set is quantized if no two members of that set stand in a proper-part relation. For example, a proper part of a branch on a tree can also itself count as a branch on that tree. Think for instance of a branch that forks. Each proper part after the fork can itself count as a branch. As emphasised by Rothstein (2010), also inspired by previous accounts of Zucchi & White (1996, 2001), such nouns do have quantized (or, alternatively, disjoint) reference under a particular *counting perspective*, as Rothstein calls it, which she formalises in terms of a *counting context*. To take her example, imagine fencing surrounding a square field, from one counting perspective or 'guise', we can 'see' this as one fence running all the way around the field. However, especially with some extra contextual information, such as that each of the four different sides of the fencing running around the field is owned by a different farmer, we can also view this same entity as four fences. So these count nouns are context sensitive, or perhaps better, counting perspective/context sensitive.

As pointed out by Sutton & Filip (2016b), count nouns that display this kind of context sensitivity, and it is a non-negligible class indeed, besides *fence*, it includes *hedge*, *wall* and *shrub*, for instance, often have derivationally related intralinguistic mass counterparts like *fencing*, *hedging*, *walling* and *shrubbery*. (Such data underpin Krifka (1989)'s observation that count nouns like *fence*, out of context, fail to be quantized.) What we also observe is that the entities denoted by these nouns are usually, in some sense, connected with each other, even when they are counted as distinct individuated entities. For example the fences around a field are linked together, as are, typically, panels of fencing. Therefore, we refer to this class as a whole as *interconnected* nouns, where an example of an *interconnected* count noun is *fence*, and an example of an *interconnected* mass noun is *fencing*. Some examples from the British National Corpus are:

(2.18) a. In those days Open Championship crowd-control was done with **miles of wooden fencing**. (ASA)

b. Consider reducing any **dense shrubbery and tall hedging** that offers concealment. (CCX)

c. **The existing stone walling** was retained and the original massiveness of the east elevation was preserved and even emphasised... (A79)

At least in British English, the mass lexicalizations of *interconnected* nouns can be used with the same reference (2.19a, 2.20, 2.21a). Some speakers of American English report that, for them, nouns like *fencing* denote the stuff fences are made of, however, this is not the case for all speakers of American English as we see in (2.19b), in which *fencing* denotes some partition of fences, not merely the stuff fences are made of.[11]

(2.19) a. We will, of course, have to erect rabbit-proof fencing around all the new plantations. (BNC, J54)

b. Not only does she have walls and metal fencing surrounding her house but there is thick wire mesh forming a roof over her

[11] These examples were sourced using the CoCA corpus (Davies, 2008).

back garden. (CoCA)

(2.20) These castles differ from Norman ones in that they are built in concentric rings of walling , studded with mural defence towers, with an open space in the centre. (BNC, HR1)

(2.21) a. . . . 4 km (21/2 miles) of hedging will ultimately be planted in a total of 24 hectares (60 acres). . . (BNC, GXJ)
b. . . . toss cigarette butts and Lifesaver wrappers and Diet Coke cans and Corona bottles over the railing and into the box hedging. (CoCA)

There are some other differences between UK and US English in the use of *interconnected* mass nouns. At least based on the uses in the Contemporary Corpus of American English CoCA (Davies, 2008), in US English, *walling* seems almost exclusively to have a verbal use (especially *walling x off from y*), and uses of *hedging* as a noun referring to plants, although attested (e.g., 2.21b) seems to be less common than in British English.

We also note that attested mass uses of nouns such as *sequence* are not difficult to find (despite occasional claims to the contrary, which we encountered, that such nouns are 'strongly count'). This should not be surprising given that in Zucchi & White (1996), Zucchi & White (2001) *sequence* is given as a paradigm example of count nouns that fail to be quantized, so in that sense are not 'strongly count', according to the original definition of Krifka (1989) (and elsewhere). Most attested examples, perhaps unsurprisingly given the use of the term, come from the genetics literature (data is taken from the EnTenTen20 corpus):

(2.22) a. The item total is the sum of the sizes of the duplicated sequences. Not both sides though, just one side. This indicates how much sequence is duplicated.
b. Generally speaking, how much genetic sequence does one need to construct an accurate phylogeny at the species level?
c. Turning a peppermill is as much sequence as it is technique.[12]

Similarly in Slavic languages, such as Czech, we also find variation in count/mass lexicalization patterns for *interconnected* nouns where mass nouns are derived from count ones:

(2.23) a. *oplocení* 'fencing' > *plot* 'fence'
b. *zdivo* 'masonry' > *zeď* 'wall'

[12] Context: making a peppermill with a lathe.

Now, in contrast, in German, we have only found a limited number of *interconnected* count/mass pairs. For example, we have the count noun *Strauch* ('bush/shrub', masc.) to which there is a derivationally related compound *Strauchwerk* ('shrubbery', neuter), which is mass or at very least predominantly mass. It has no plural form, and there is only one instance of *Strauchwerk* used in a numeral construction in the deTenTen20 corpus. See also example (2.40) below.[13] Indeed, many *interconnected* count nouns in German do not seem to have morphologically derived mass counterparts, which contrasts with our observations for Czech and English. Instead, they often have morphologically related count nouns.

Overall, therefore, we found significantly fewer examples of *interconnected* derived mass nouns in German than in English or in Czech. For instance, to the *interconnected* monomorphemic count noun *Zaun* ('fence', masc.), there are semantically related nouns that are derived from it by means of the feminine suffix *-ung* and several prefixes: e.g., *Abzäunung*, *Umzäunung* and *Einzäunung*, all of which can be translated loosely as 'fencing'. Unlike derivationally related nouns with the stem meaning 'fence' in Czech and English, these derivationally complex German nouns are not unambiguously mass, but rather they have many if not all of the grammatical reflexes of count nouns. The reason for this is, we suggest, that the prefixes with which they are formed do not modulate their countability class, but, instead, add further topological specifications to the objects that are already in the denotation of their count noun stem *Zaun*, which is underspecified in this respect.

Let us sketch how the topological differences in the shape of objects denoted by these three nouns are tied to the meaning of the prefixes with which they are derived. *Umzäunung* and *Einzäunung* are often used with reference to a fence that forms a complete enclosure. This is because the prefix *um-* is related to the preposition *um* which is a free monomorphemic word, and both have meanings/uses roughly amounting to 'around'. The prefix *ein-* in the context of *Einzäunung* 'enclosure' roughly means 'inside', 'within', i.e., it is comparable to the Latin prefix *in-* in the verb *inclūdere* 'close' or 'inside-shut' (literally), from which the English *enclosure* originates. Both these prefixed nouns, therefore, denote discrete, completely closed, bounded spaces (rectangular, square, oval or round). In contrast, *Abzäunung*, in abstracted topological terms, corresponds to a line that divides some space, but whose ends are open-ended, which follows from the meaning of the prefix *ab-* 'away',

[13] We note that the *-werk* ('work') suffix does not (always) derive an *interconnected* noun (be it count or mass) from an *interconnected* count noun, since in some cases, it derives an substance mass expression that refers to the stuff the referent of the head noun is made of, as we see with *Mauer* ('wall', count, fem.) versus *Mauerwerk* ('masonry/brickwork', mass, neuter). Thanks to Maximilian Gottwein (p.c) for drawing our attention to these data.

'from', 'off'. *Abzäunung* refers to fencing that closes off some space, but does not (necessarily) entirely enclose it. For example, if the police fence off the entrance to a cul de sac, the fencing can be referred to as *Abzäunung*: it fences off the width of the road, but does not enclose it along its length dimension, as a whole topological object.

To illustrate this basic topological difference among these three 'fence'-based nouns, suppose that what is at stake is a prison with a fence, which typically serves to prevent its inmates from escaping, and so such a fence must form a perfect enclosure. In this case, the most natural and common expression is *Umzäunung des Gefängnisses* (as in 2.24)[14], less commonly we may also find *Einzäunung des Gefängnisses* (as in 2.25)[15]. However, *Abzäunung des Gefängnisses* cannot be used with reference to such a complete enclosure around a prison, and is not attested:

(2.24) Wie die Polizei mitteilt, hatten unbekannte [German]
how the police reported had unknown
Komplizen mit zwei Autos die äussere Umzäunung
accomplices with two cars the outer fence
des Gefängnisses durchbrochen.
of.the prison breached
"According to the police, unknown accomplices had broken through the outer fence of the prison with two cars."

(2.25) Die neue transparente Polycarbonat-Einzäunung des [German]
the new transparent polycarbonate-fencing of.the
Gefängnisses hat eine Gesamtlänge von 934 Metern. Sie
prison has a total.length of 934 meters. It
umfasst eine Fläche von 48900 Quadratmetern.
covers an area of 48900 square.meters
"The prison's new transparent polycarbonate fencing has a total length of 934 meters. It covers an area of 48900 square meters."

All these three prefixed nouns are count, though *Umzäunung* and *Einzäu-*

[14] https://www.pilatustoday.ch/diverse-news/spektakulaerer-gefaengnisausbruch-in-orbe-136675478. Last accessed 12.2023.

[15] https://www.alamy.de/bernburg-deutschland-10-november-2022-die-neue-transparente-polycarbonat-einzaunung-des-gefangnisses-hat-eine-gesamtlange-von-934-metern-sie-umfasst-eine-flache-von-48900-quadratmetern-und-ist-550-meter-hoch-die-justizvollzugsanstalt-bernburg-fur-suchtige-wurde-mit-einem-hochsicherheitszaun-und-einem-neuen-zentralen-tor-ausgestattet-rund-89-millionen-euro-wurden-aus-mitteln-des-landes-sachsen-anhalt-ausgegeben-quelle-heiko-rebschdpaalamy-live-news-image490599166.html Last accessed 12.2023.

*nung* have more robust grammatical countability reflexes than *Abzäunung*, which, as we propose, might be related to the observation that *Umzäunung* and *Einzäunung* denote complete enclosures, hence clearly discrete objects, demarcated one from the other, while *Abzäunung* does not. They all occur with an indefinite article, though *Abzäunung* less frequently than the other prefixed nouns, it only has 36 tokens in the deTenTen20 corpus, while *Umzäunung* 306 and *Einzäunung* 445. All have a plural form. Again, *Umzäunung* and *Einzäunung* are more commonly used in the plural than *Abzäunung*: In the deTenTen20 corpus 929 from 7,389 of *Umzäunung* occurrences were plural (12.6%)), for*Einzäunung* 641 from 5,244 occurrences (12.2%). *Abzäunung* had the least total token occurrences, namely 430, out of which 103 were plural, but perfectly natural plural forms are attested, as we see below, which was elicited from a native speaker consultant:

(2.26) Die Polizei hat Abzäunungen errichtet. [German]
the police have fencing.PL built
"The police put up sections of fencing."

We also observe that all these three prefixed nouns tend to only rarely occur in numeral constructions, though we did find some attested occurrences of *Umzäunung*, such as the following one:[16].

(2.27) Einige AktivistInnen nutzten den Raum zwischen zwei [German]
several activists use the space between two
Umzäunungen zu einem "Atomwaffenfreien Picknick".
fencing.PL to an atomic.weapon.free picnic
"Several activists use the space between two (boundary) fences for an "atomic weapon free picnic".

For *Einzäunung*, we found only about seven uses in numeral constructions in the deTenTen20 corpus, while for *Abzäunung*, we found no such uses. This might have to do with a data sparsity issue (there are only 430 tokens of *Abzäunung(en)* in the corpus), but this would require a more careful examination and investigation into the morpho-semantics of German than

[16]In order to understand the meaning of the numeral construction *zwei Umzäunungen* in (2.27), it is important to know the context and the actual physical space in question. The sentence is taken from a newspaper report about a group of anti-nuclear weapon protesters at the Bundeswehr (German army) air base in the German city of Büchel. The protesters cut through the fencing around the air base, entered it, and held an 'atom-free picnic'. Various pictures of the Büchel air base show that there is a high fencing with barbed wire loops on top completely enclosing the air base, and the sentence implies that there are two such complete enclosures around the whole air base with some space between these two complete enclosures, which is what is counted. See `https://www.ippnw.de/atomwaffen/atomwaffen-in-deutschland/buechel/artikel/de/amtsgericht-cochem-vertagt-prozess-g.html`

would be practical to undertake in this book.[17] Depending on the resolution of this issue, it may turn out that *Abzäunung* is less robustly count than both *Umzäunung* and *Einzäunung*, which in turn might be related to its 'open-ended' or unbounded typology of objects it denotes. We might also add that a similar frequency noun that has a related meaning, namely *Umfassungsmauer* ('enclosing wall', fem., German) is used in numeral constructions in 36 of 7057 occurrences (0.5%). This contrasts with *Umzäunung* and *Einzäunung* which occur in numeral constructions only approximately 0.1% of the time in the same corpus (15/7389 and 7/5244, respectively).[18]

Another case of morphologically derived nouns with a subtly different interpretation from their morphologically simpler form in German are some (non-productive) uses of the nominal prefix *Ge-*. One example is *der Büsch* ('bush', German, count, masculine) versus *das Gebüsch* 'a collection of bushes' (approx.), German, neuter). However, *Gebüsch* is not obviously a mass noun, at least insofar as it does appear in the plural:[19]

(2.28) Sträucher, Gebüsche und Hecken sind ausgesprochen [German]
hedge.PL GE.bush.PL and hedge.PL are decidedly
wichtige Lebensräume für verschiedene Tier- und
important living.space.PL for varied animal- and
Vogelarten.
bird.species
'Shrubs, bushes, and hedges are decidedly important habitats for various animal and bird species'

The contrast between *Gebüsch* and *Büsch* is not easy to articulate, but it relates to the difference between a bush, usually in the form of a thick clump or shrub, on the one hand, and a collection thereof subject to a

[17]Using a search engine, we also searched for the pattern Numeral + *Abzäunungen* for German numerals 2-9. We found only two hits, both with *zwei* ('two'), one of which was clearly written by a non-native speaker, the other was from a book in English, translated into German, that itself was translated from Czech journal entries. It seems, therefore, that although *Abzäunung* is attested in the plural, we have no evidence for its systematic use in counting constructions. We also note that although *Abzäunung* is used with the definite and indefinite articles, the use of *Abzäunung(-en)* with any quantifiers was very rarely attested in the corpus.

[18]Now, speculating about the reasons why *Umzäunung* and *Einzäunung* tend to only rarely occur in numeral constructions, despite denoting clearly discrete objects, we may suggest that it might (also) be related to the fact that we typically encounter the discrete objects they describe in the actual world as single, particular entities. Hence, the occasion rarely arises for us to talk about their pluralities and count them. When used in the plural, they tend to not to be used in numeral or quantified constructions, often bare, and have a kind reference in characterising generic sentences.

[19]https://wp.wildvogelhilfe.org/de/vogelwissen/garten/lebensraeume-schaffen/hecken-straeucher-und-gebuesche/ accessed 21.06.2022.

specific topological constraint: namely, the individual members form a kind of aggregate, being arranged close to one another, and perhaps even overlapping.

### The grammatical reflexes of *interconnected* nouns

A question that arises is whether *interconnected* nouns have a distinct, non-canonical, profile with respect to their reflexes in count/mass-selecting environments, and so constitute a well-motivated systematic subclass of nouns on the countability scale, along with object mass nouns. For *interconnected* count nouns, as argued by Filip & Sutton (2017), such a grammatical reflex does show up in the distribution of pseudo-partitive measure constructions: nouns such as *fence*, *wall*, and *hedge*, in English, are felicitous in one of the grammatical contexts that is usually diagnostic of mass nouns, namely, they can be used as bare singular 'downstairs' NPs in pseudo-partitive (measure) constructions. For example, one can refer to *a 500 metre stretch of fence/wall/hedge* or describe this as *500 metres of fence/wall/hedge*, a fact that is surprising given that other, canonical count nouns cannot be used as bare singulars in the 'downstairs' NP slot of a a pseudo-partitive (measure) construction (*# 2 metres of sofa/chair*, *#150 metres of tower*). The following examples are from ibid., p. 347).

(2.29) a. #6 kilograms of baby
b. #You can find a heavy piece of baby in the nursery.

(2.30) a. Thick woolen drapes of red and gold covered every inch of wall. (COCA)
b. Thus a cm dry length of twig increased in dry weight by 0.047g. (*Community Ecology of a Coral Cay*, Heatwole et al. p.152)
c. The cages were 1 foot in diameter and enclosed a 3-foot length of branch. (*California Agriculture*. Mar-Apr, 1989 p.7)
d. 155 kilometers, or 96 miles, of wall encircled West Berlin (CNN "Berlin wall secrets")

Among other count nouns that can be used in the singular in measure constructions are: *belt, canal, candle, ceiling, hedge, hedgerow, line, pavement, pipe, pipeline, railway, river, road, roadway, runway, stream, street, wall, waterfront, waterway.* Below is a selection of data from the United Kingdom Web Annotated Corpus 2007 (ukWaC, Ferraresi et al. 2008).

(2.31) by varying the speed of the float by dragging between **1-3 foot of line** on the deck

(2.32) According to Mateus, from 1992 to the present land mines have been cleared from **7,337 kilometres of road**, 379 kilometres of power lines, **90 kilometres of railway**, and 3,500 hectares of land.

(2.33) This winter **500 metres of hedge** were laid by volunteers and 200 metres by contractors.

(2.34) The council believed the cost of culverting the **6.75 miles of canal** to be £90,000.

Similarly, in Slavic languages, which have a grammaticized mass/count distinction but no article system, we observe that count nouns of this *interconnected* noun type are straightforwardly acceptable as bare singular 'downstairs' NPs in pseudo-partitive (measure) constructions as we see in (2.35)[20] and (2.36):

(2.35) Tisíce kilometrů zdi [Czech]
thousands.PL.NOM kilometers.PL.GEN wall.SG.GEN
se táhnou Čínou.
REFL extend China.SG.INST
'Thousands of kilometers of wall span through China.'

(2.36) První den natřel tři sta metrů plotu.
first day painted.3SG three hundred meters fence.SG.GEN
'On the first day, he painted 300 meters of fence.'

This pattern is also attested in German and Finnish[21]:

(2.37) Allein in Berlin wurden 184km Mauer, 154km [German]
alone in Berlin got 184km wall 154km
Grenzzaun, 144km Signalanlagen und 87km
border.fence 144km signal.device.PL and 87km
Sperrgräben entfernt (deTenTen20)
moat.PL removed
"In Berlin alone, 184 km of wall, 154 km of border fence, 144 km of trip wires and 87 km of moats were removed."

[20] https://www.invia.cz/blog/velka-cinska-zed-kilometry-plne-poznani/. Last accessed 23.09.2022.

[21] https://fi.wikipedia.org/wiki/Ukrainan_ja_Ven%C3%A4j%C3%A4n_raja Last accessed: 22.08.2022.

(2.38) Ukraina on rakentanut 400 kilometriä [Finnish]
Ukraine is built 400 kilometre.PART
panssarintorjuntahautaa, 100 kilometriä
tank.prevention.trench 100 kilometre.PAR
aitaa ja 70 kilometriä piikkilankaa osana
fence.PART and 70 kilometre.PAR spike.wire part.ESS
Venäjän rajan rakentamista
Russia.GEN border.GEN construction.ELA
"Ukraine built 400 kilometres of anti-tank trench, 100 kilometres of fence, and 70 kilometres of barbed wire as a part of the construction of the Russian border."

When mass, *interconnected* nouns share some grammatical reflexes with object mass nouns. First, *interconnected* mass nouns, like object mass nouns, can be used with stubbornly distributive predicates (English examples from enTenTen20, German example from deTenTen20, Czech example in (2.41) found online[22]).

(2.39) a. For smaller areas, we have garden kits available, smaller fencing and netting, all affordably priced to save you money, [. . . ]
b. [. . . ] they also won't allow fencing except for small decorative fencing that just gets ran over by the riding mowers and damaged by their weed-whackers.

(2.40) Es gab nur kleines Strauchwerk da, aus welchem [German]
it gave only small shrubbery there out which
sie sich endlich mit Mühe Bäumchen zogen.
they REFL finally with effort tree.DIM cultivated
"There was only small shrubbery there, from which they finally, with difficulty, cultivated small trees.'

(2.41) Smetí, listí a drobné větvoví leží nastláné [Czech]
litter, leaves and fine branchwork lies spread.out
na cestě.
on road.LOC
'Litter, leaves and fine branchwork lies spread out on the road'.

Second, like *functionally combinatorial* mass nouns, *interconnected* mass nouns resist mass-to-count coercion:

[22] *Alej bez stromů* by Václav Chytil, 2014, Tilia.

(2.42) #The farmer put up three fencings/hedgings/wallings

However, interestingly, *interconnected mass nouns* do not pattern with *functionally combinatorial* mass nouns with respect to cardinality judgements. As we noted in §2.1.3, for *functionally combinatorial* mass nouns in comparative constructions, the cardinality comparison is the default reading, but measure readings are available, or even enforced, in some contexts. However, for *interconnected* mass nouns, the cardinality comparison reading is not (readily) available at all:

(2.43) Farmer A put up more fencing than Farmer B.

a. *Farmer A put up more fencing than Farmer B in terms of length or mass* (Measure)

b. ?*Farmer A put up more fences/fencing panels than Farmer B* (Cardinality)

**Summary.** In *interconnected* nouns, we have a class of nouns, which, if count, are context sensitive with respect to what counts as 'one'. Mass *interconnected* nouns seem always to be derived from morphologically simpler forms. Furthermore, such count/mass pairs may denote the same entities in the real world. For instance, one and the same structure can be described as *a fence* or as *fencing*. In other words, the properties underpinning these nouns are naturally conducive to variation in count/mass lexicalization. When count, nouns in this class systematically exhibit distinct grammatical reflexes that set them apart from other count nouns. Most notably, they can be used bare in the 'downstairs' NP of measure constructions. When mass, they systematically differ from canonical mass nouns like, say, *water*, insofar as they can be used with stubbornly distributive predicates and strongly resist mass-to-count coercion. However, unlike object mass nouns, they do not appear to easily licence cardinality comparison readings in comparative constructions.

### 2.1.5 Granular and filament nouns

Two further conceptual classes of nouns that have garnered some attention in analyses of the count/mass distinction are *granular* and *filament* nouns. Granular nouns lexicalize properties that are instantiated by discrete entities that range from very small (e.g., grains of sand) to not so small (e.g., potatoes, carrots), and any sizes in between (e.g., various berries, cherries). Their denotational structure is far more homogeneous than the denotations of *functionally combinatorial* nouns (they denote entities that are more-or-less similar with respect to their perceptual properties).

Filament nouns denote strand-like, long-ish and thin-ish entities, which we here dub as *filament entities*. Both granular and filament nouns denote entities that we usually encounter in clusters or groupings (e.g., bunches of grapes, mounds of sand, hair on one's head, and sheaves of wheat). We refer to the lexicalizations of these properties as *granular nouns* and *filament nouns*, respectively.

Granular nouns have played quite a prominent role in several theories of the mass/count distinction, including the vagueness-based approach in Chierchia (2010) and the mereotopological approach in Grimm (2012). Granular nouns, in English, include count nouns like *beans* and *lentils*, and also mass nouns like *corn*, *gravel*, *barley*, *pollen*, *wheat* (as a grain), and *rice*. We also observe a lot of lexicalization mass/count variation cross-linguistically. For example, *beans* has a mass counterpart in Romanian (*fasole*, Chierchia (2010)), *lentils* has a mass counterpart in Czech (*čočka*)[23].

It is worth noting that the size of entities in the denotations of granular nouns is not definitional of the class. For example, grapes and strawberries are larger than beans and rice grains, while potatoes are much larger than all of these. And we also find count/mass lexical variation with nouns that have entities in their denotation that are as large as beetroots or watermelons. For instance, in Russian, nouns denoting small fruits and berries such as grapes (*vinigrad*) and strawberries (*klubnika*) are mass (Wierzbicka, 1988, p. 503) as are nouns denoting relatively large root vegetables such as *kartoški* ('potato', Russian) and *svekly* ('beetroot', Russian):

(2.44) Ja kupil 5 kilogram kartoški/morkovki/svekly/ *kartošek/*morkovok/ *svekol. [Russian] (ibid., p. 552)
'I bought 5 kg of potato/carrot/beetroot/ potatoes/*carrots/*beetroots.'

Filament nouns which, in English, include *bamboo*, *chives*, *hay*, *hair*, *grass*, and *wheat* (as a plant), are less thoroughly discussed in the literature than granulars (however see Chierchia 2010 for some observations regarding *hair*). For example, *hair* is a dual life noun in English in that it has a count and a mass sense/use. Namely, *hair* as a mass term is used to describe all of the hair on someone's head, while the plural is *hairs* is often used when what matters are individual strands of hair. In languages, in which the singular form of the corresponding word is count, as in Finnish, *hius* ('(a) hair'), it only has a count sense with reference to a single strand of hair; (all of) the

[23]The count noun *čočka* is used with reference to lenses, e.g., camera lenses or contact lenses.

hair on a person's head is referred to with the plural *hiukset* ('hairs').

Comparable to the size of entities in the denotations of granular nouns, we observe that not all filament nouns denote what we would judge as very thin entities, even when mass. The circumference of entities in the denotations of filament nouns is not definitional of the class. We find variation in the lexicalization as mass or count even for nouns that denote entities that we perceptually classify as relatively thick. For example, *carrot* is count (or at least has a predominant count sense) in English, but *morkovki* (carrot, Russian) is mass (Wierzbicka, 1988), see (2.44). The noun *leek* is count in English, but in German the singular *Lauch* is mass, given that a collection of whole leeks can be referred to as *Lauch*. Also, *asparagus* is mass in English, but the French *asperge(s)* is count (2.45, French Web 2017 (FrTenTen17)).

(2.45) Enroulez chaque asperge d'une tranche de pancetta [French]
wrap each asparagus of.a slice of pancetta
'wrap each asparagus spear in a slice of pancetta'

That mass *granular and filament* nouns are categories sui generis and independent from object mass nouns can be seen as being supported by the observation that the existence and number of mass *granular and filament* nouns in a given language is independent of whether it has many object mass nouns. For instance, as we observed above, Finnish has very few (possibly only one) object mass noun, but has many mass granular nouns e.g., *hiekka* ('sand'), *kaura* ('oats'), *ohra* ('barley'), *riisi* ('rice'), *sora* ('gravel'), and mass filament nouns including *heinä* ('grass/hay') and *vehnä* ('wheat').

#### Grammatical reflexes of mass granular and filament nouns

A feature that all object mass nouns share is that they sanction a cardinality comparison reading. Indeed, this reading is arguably the default one, absent any further context. This is certainly not the case for mass *granular and filament* nouns. For instance *more rice* is most naturally understood as more in terms of, say volume or weight, not in terms of numbers of grains. Context does help, however. For example, Landman (2021) (who cites examples from Sutton and Rothstein p.c.) points out the comparison readings are available for *rice* in some contexts. (Sutton's example is based on a rice grain hunting competition in which contestants must find as much rice as possible in an allotted time. The intuition is that the winner would have the most grains, regardless of whether they found the most by weight or volume.)

The same is also true for filament nouns. For example, suppose there are two different grass-cutting competitions: the scissor-cutting competition and the lawnmower competition. Admittedly, the latter is a more likely and common competition/context. In the scissor-cutting competition, competitors must snip as much grass, blade-by-blade, as they can in the allotted time. In the lawnmower competition, competitors must mow as much grass as they can in the allotted time. In both competitions, if A has cut more grass than B, then A beats B. Our intuition, at least, is that the judges in the scissor snip competition will judge according to who has snipped the most blades of grass (a cardinality comparison), whereas the mowing event would be judged either on the volume of grass cut or on the area of lawn successfully mowed (a measure comparison by volume, weight or area).

That said, some mass *granular and filament* nouns have readily available cardinality readings in comparison constructions. For example, given that what matters for pollen allergies is the pollen count, i.e., the number of pollen grains, the question of whether there is more pollen in the air this month compared to last month, according to our judgements, turns on numbers of grains, not volume. For instance, supposing that last month, most of the pollen in the air was some small grass pollen, and this month, some larger tree pollen, if the numbers of pollen grains in the air are the same, it is not clear to us that 'There is more pollen in the air this month' is true.

As observed in Sutton & Filip 2021b, *granular and filament* nouns also display interesting restrictions when it comes to mass-to-count coercion, namely, while these mass nouns can be coerced into portion and subkind readings, they strongly resist being coerced to pick out single grains or single filaments in their denotations:

(2.46) a. We ordered the main courses with two plain rice, one egg fried rice and a nan, more than enough for the four of us.[24] e.g. two [BOWLS OF] plain rice (container or portion)

b. CONTEXT: three kinds of rice, Calmati, Texmati, Kasmati These three rices have basmati's viscosity and cooking style, but smaller individual grains.[25]

(2.47) a. #Three rices fell off my spoon.

b. #Drei Reis sind vom Löffel gefallen. [German]
Three rice.SG be.3.AUX from.the.DAT spoon fall.PST-PTCP
Int: Three rice(s) fell off the spoon.

Crucially, something that has not been widely noticed, to our knowledge, is that *granular and filament* nouns are felicitous with stubbornly distributive

[24] http://www.derbytelegraph.co.uk/speciality-dishes-star-turn-littleover-s-red/story-20536589-detail/story.html Last accessed: 10/10/2016

[25] *The Ultimate Rice Cooker Cookbook*, Harvard Common Press, 2003. p. 23.

predicates.[26] This observation is not restricted to English. To show this, we present a wide range of corpus data from Czech, English, German, and Finnish and in section 2.2 we report on the results of a corpus study in Czech and English that shows that *granular and filament* mass nouns pattern with object mass nouns with respect to being modified by stubbornly distributive predicates.

As a summary of the *granular and filament* noun empirical picture, we can make the following generalisations. *Granular and filament* nouns are a rich source of data when it comes to variation in count/mass lexicalization patterns. Although for some properties (e.g., `dust`, `pollen`, `rice`), we find only mass noun lexicalizations, other properties are distributed between count and mass. *granular and filament* count nouns have the grammatical reflexes of canonical count nouns, but *granular and filament* mass nouns do not have the grammatical reflexes of canonical mass nouns. For instance, some *granular and filament* mass nouns licence cardinality comparison readings in comparative constructions, especially *pollen*. Others do so only in highly specialised contexts. *Granular and filament* mass nouns strongly resist mass-to-count coercion with a unit reading (e.g., *three rices* cannot mean 'three grains of rice'). All *granular and filament* mass nouns seem to be compatible with at least some stubbornly distributive predicates, the evidence for which we will now present.

### 2.1.6 The modification of mass granular and filament nouns with stubbornly distributive predicates.

Below, we present a selection of data from Czech, English, Finnish and German. The data are sourced from the following corpora: British National Corpus (BNC, BNC Consortium 2007), ukWaC 2007 (Ferraresi et al., 2008), COCA (Davies, 2008), Finnish Web Corpus 2014 (fiTenTen14), German Web

[26]Pelletier & Schubert (1989/2002, p. 5), citing Bunt (1981, Appendix A), mention the felicity of stubbornly distributive predicates with ice and *hail*, about which they discuss proposals in the literature for making a count/mass distinction for adjectives:

(i) a. Bring me the spherical ice and leave the irregularly-shaped ice there.
b. Look at the fist-sized, perfectly spherical hail.
c. Mary has box-shaped furniture.

Also, Grimm (2012, p. 5) has the following examples:

(ii) a. The rice was spherical/small.
b. The grass was long/large.

However, these data do not play a subsequent part in his analysis.

2013 (deTenTen13), and Czech Web 2017 (csTenTen17) (Jakubíček et al., 2013). Excluding COCA, all corpora were searched using *SketchEngine*. These languages were selected based on our languages competencies, however, these languages also represent a good test sample. We can check if the data are attested in two fairly closely related Germanic languages with each other (English and German), then also check if this holds in the wider group of Indo-European languages with Czech (Slavic), and finally with a non-Indo-European language, Finnish (Uralic, Balto-Finnic).

We divide our examples by language. In all cases, we searched for attributive, predicative and comparative uses of stubbornly distributive adjectives (e.g., for *small rice*, *rice is small* and *rice is smaller than...*, respectively).

### Data from English

We start with granular mass nouns that have natural or manufactured units in their extension, namely *rice* (which includes grains of rice), *pasta* (which includes pasta pieces of different shapes and sizes, e.g., shells, rigatoni, farfalle), the mass use of *grain* (which includes whole individual grains), and *clover* (which includes single stems of clover). As we see from (2.48)-(2.50), we find evidence that the granular mass noun *rice* (which has been subject to much discussion in the literature), has attested uses with stubbornly distributive predicates such as *small*, *round*, and *fat*. This includes attributive uses of stubbornly distributive predicates ((2.48) and (2.49)), and predicative uses (2.50). In these contexts, it is clear that these predicates distribute down to grains of rice.

(2.48) ARBORIO A medium-grain Italian variety used for making the classic dish risotto. This **small, round rice** cooks to a soft, creamy consistency while maintaining a slightly firm center. (COCA)

(2.49) Talking of which, I opted for the Risotto Marinara (£7.95) from the specials blackboard - a fulsome mound of **fat rice**, heavily studded with prawns, squid, mussels, king prawn and other less easily identifiable seafood pieces, all encased in a smooth, slightly sweet, tomato and garlic sauce. (ukWaC)

(2.50) Short grain or pudding **rice is almost round** and slightly sweeter than long grain rices. (BNC, ABB)

(2.51) Anything **small, like rice** I find very difficult to locate, especially if it's under my tongue, so I have to rinse my mouth out to get rid of it.

Similarly, in (2.52)-(2.55) we find attested uses of the mass noun *pasta* with *small*, *big* and *round*.

(2.52) Macaroni Cheese Serves 2 4oz macaroni (or cut spaghetti or other **small pasta**) 1/2 pint cheese sauce (see Sauces)... (ukWaC)

(2.53) Don't miss the trademark pasta of Ferrara, cappellacci di zucca (**round pasta** stuffed with squash or pumpkin) (COCA)

(2.54) Conchiglie are pasta shells, but any reasonable **small pasta** will substitute. (ukWaC)

(2.55) You have to be really careful when you're eating because it's difficult to twist your fork properly because the **pasta is bigger than spaghetti**. It can get very messy. (ukWaC)

In (2.55) we have a comparative use of a stubbornly distributive predicate, a construction that has not, to our knowledge, been widely discussed in the context of stubborn distributivity, however, it is important to note that such comparative uses are stubbornly distributive: *the pasta is bigger than spaghetti* can only mean that each piece of pasta is bigger than each strand of spaghetti (unless these nouns are being used not to refer to only noodles, but instead to a whole dish, including sauce etc.). For example, if *the pasta* referred to Orzo (rice-grain-like pasta), then *the pasta is bigger than spaghetti* would be false.

We also found uses of the stubbornly distributive predicate *small* with the mass use of the noun *grain* (2.56) and with the stubbornly distributive predicate *large* with the mass noun *clover* (2.57).

(2.56) When the seasons are good, no ground in Clydesdale produces more plentifully; but even in the best years, **the grain is small**. Oats and barley are the common, or only crops. (ukWaC)

(2.57) The clover leaves have 3 leaflets, the more common form has cream flowers. **Red clover is larger**, with dark pink to red flower heads. (ukWaC)

Fascinatingly, we even find evidence that stubbornly distributive predicates are felicitous with nouns that denote tiny natural units such as *pollen*:

(2.58) **Pollen is very small** so you need the 40X objective of the microscope. (ukWaC)

(2.59) Many grasses are wind-pollinated, and have special adaptations for this. **Their pollen is very small**, and lacks the highly sculpted outside that insect-pollinated flower pollen has. (ukWaC)

(2.60) **Pine pollen is large** and is released in clumps. It generally falls to the ground quickly and does not aerosolize like **smaller pollens**. [EnTenTen20]

Turning now to granular mass nouns that do not denote natural units, but instead, bits and pieces of stuff, we see that the pattern is robust here, too: *gravel*, *dust* and *grit* can be used with the stubbornly distributive predicate *large* (see, (2.61)-(2.63)) and *sediment* can be used used in a comparative construction with *smaller* (2.64).

(2.61) If the tank has a fine gravel or sand substrate, I siphon the gravel and more water into another bucket. **If the gravel is too large** to be siphoned, then the gravel can be removed with a scoop or similar. (ukWaC)

(2.62) **Most of the dust was no larger than specks of cigarette smoke**. The largest grain detected was 40 mg, though the large particle that knocked the spacecraft out of alignment was estimated to be from 0.1 to 1 gram (ukWaC)

(2.63) Below temperatures of about -6°c it becomes pointless salting the roads, as even salt water freezes, so they put down grit. **This grit is much larger** and heavier than anything I have seen in England and I dread to think what it does to paintwork. (ukWaC)

(2.64) This work therefore identified the presence of a "carpet" of suspended grains up to 10cm above the seabed, but much of **this sediment was smaller in size than the grains over which it was moving.** (ukWaC)

When it comes to filament mass nouns (i.e. mass nouns that denote entities that are strand-like as opposed to granule-like), we also found examples of modification by stubbornly distributive predicates, however, here more commonly with *long*, *round*, *wide*, and *slender*.[27] For instance, filament mass noun *grass* has attested uses with *long*, *slender*, *narrow* and *wide*:

(2.65) The writer pointed out that **the grass was so long** it would take a scythe to mow down. (ukWaC)

(2.66) I prayed by the sweet thyme, whose little flowers I touched with my hand; by the **slender grass**; by the crumble of dry chalky earth I

[27] Although we also found many examples with *thin* and *thick*, we do not present them here. These adjectives are not true stubbornly distributive predicates, since they have non-distributive readings. For example, *thick grass* can mean grass that grows with a high density (even if the blades of grass are not thick).

took up and let it fall through my fingers. (ukWaC)

(2.67) Location 3, bottom of Waterfall Gully, had an abundance of bluebell, **wide grass** and lesser club-moss. Other and vigilance dominated the activity pattern at this location. Location 4 was situated at the top of Waterfall Gully, and had **narrow grass**, **wide grass** and bluebell as the main species. (ukWaC)

We also found uses of stubbornly distributive predicates with the mass sense of other filament mass nouns including *asparagus*, *bamboo*, *pipework*, and *straw*:

(2.68) For the mayonnaise: 1/3 cup mayonnaise 1 tablespoon fresh orange juice 1 teaspoon fresh lemon juice 1/2 teaspoon finely grated orange zest Pinch cayenne **1 pound large asparagus**, tough ends removed... (ukWaC)

(2.69) The peel is thinner on **slender asparagus**, so it doesn't need to be removed, but the juicy centre portion is smaller, too. With **fat asparagus**, the peel is thicker and more fibrous toward the bottom.[28]

(2.70) but this is the first square bamboo stick I've seen! And before you start wondering whether the bamboo growers had some fiendish method of making it grow this way, I can reveal (having done some work on the tip of this stick) that it's simply **round bamboo** that has been worked down to a square cross-section, probably using a sharp scraper. (ukWaC)

(2.71) The conch-shell is used, as it is all over the Pacific Islands, more as a war-trumpet than anything else. With the roll of mats or **big bamboo**, on which time is beaten for the Siva dancers, the catalogue of Samoan noise-producing instruments is complete. (ukWaC)

(2.72) your design should focus on slowing down the water using: 1. **Wide pipework** to and between chambers – include 4in pipework as this prevents 'jetting' and encourages water to move slowly through the filter.... (ukWaC)

(2.73) If **the straw is too short** the bales come apart very easily, **if it is longer** the bales are more compact but heavier. (BNC, BPK)

(2.74) You can still see variation for plant height and flowering time in the bulk population. These farmers selected the early plants with **long**

[28] Russ Parsons, *How to Pick a Peach: The Search for Flavor from Farm to Table*, Hougton Mifflin Company, p. 48.

**and thick straw**. (ukWaC)

### Data from German

For German, we relied on the deTenTen13 corpus.[29], and found similar patterns as in English for both *granular and filament* mass nouns. Numerous examples of modification with stubbornly distributive predicates are attested.

(2.75) Arborio-Reis wird gerne für die italienische Küche und besonders für Risotto verwendet. [German]
'Arborio rice is the preferred rice to use in Italian cuisine, especially for risotto.'

Dieser sehr feine **runde Reis** kann viel
this very fine **round rice** can much
Flüssigkeit aufnehmen ohne aufzuweichen.
liquid absorb without soften
'This very fine round rice can absorb a lot of liquid without getting mushy.' [DeTenTen13]

(2.76) Die Grundlage des Risottos ist jedoch immer gleich, hierzu
the basis the.GEN risottos is however always same to.this
wird **runder Reis** verwendet, der nach dem Zubereiten
is round rice used REL after the.DAT preparation
noch bissfest ist.
still bite.firm is
'The base for risotto is however always the same, to this goal round rice is used that is still al dente after cooking.'

(2.77) Die zum Patent angemeldete Textilstruktur verhindert das Eindringen selbst **kleinster Pollen** zu 87 Prozent.
'The patent-pending textile structure prevents the penetration of even smaller pollen by up to 87 percent.'

Bei **größeren Pollen** ist die Quote sogar noch höher.
by bigger pollen is the proportion even still higher
'For bigger pollen the rate is even higher.'

(2.78) Darunter ist der **kleine Pollen** des Vergißmeinnichts ein
underneath is the **small pollen** the.GEN forget-me-not a
echter Marker Berliner Honige
real mark Berlin honey.PL

[29]With the exception of example (2.78) which is from https://www.hymenoptera.de/Stadthonig%20versus%20Landhonig, last accessed 26.09.2022.

'Here included, there is the small pollen of forget-me-not a genuine marker of Berlin honeys'

(2.79) Hier gibt es überall winzig **kleinen Sand** in der Luft, der
here give it everywhere tiny little sand in the air REL
alles dreckig macht.
everything dirty makes
'Everywhere here, there's tiny little sand in the air that makes everything dirty.'

(2.80) ... Sorte Quarzsand. Dieser **Sand ist rund** und enthält kaum
... type quartz.sand this sand is round and contains little
Kalk, so dass Beschädigungen an den Kunstrasen-Fasern
chalk, so that damages on the artificial-fibres
vermieden werden.
avoided get
'... Type Quartz sand. This sand is round and contains little chalk, so that damage to the artificial fibres is prevented.'

(2.81) Der **Sand ist groß** und körnig. Er rieselt durch die Zehen und
the sand is big and grainy he slips through the toe.PL and
setzt sich schwer auf den Fuß.
sits REFL heavy on the foot
'The sand is large and grainy. It slips through your toes and weighs heavily on your foot.'

In German, filament mass nouns can also be felicitously modified with stubbornly distributive predicates, as we see for *Spargel* ('asparagus') in (2.82) and *Stroh* ('straw') in (2.82).

(2.82) Leider kochen viele nicht mehr oder wollen unheimlich [German]
sadly cook many not more or want uncannily
**dicken Spargel** der gut zu schälen ist.
thick asparagus that good to peel is.
'Sadly, many no longer cook or want incredibly **thick asparagus** that peels well.'

(2.83) eine Lage **langes Stroh oder Heu** mit Lehm beschmiert
a layer long straw or hay with clay smeared
'a layer of **long straw or hay** smeared with clay'

### Data from Czech

For Czech, we relied on the csTenTen17 corpus (Czech Web 2017)[30]. We found similar patterns as in English and German for comparable *granular and filament* mass nouns. Examples of modification with stubbornly distributive predicates are easy to find as well. Some representative examples are given below:

(2.84) Na rizoto použijeme krátkozrnnou **kulatou rýži** [Czech]
on risotto use.1.PL short.grained round rice
odrůdy Arborio
genus Arborio
'For risotto, we use short grained round rice of the Arborio variety'

(2.85) Nažloutlá zrnka velikosti **drobné rýže**
yellowish grain.DIM.PL size.GEN.SG fine.GEN.SG rice.GEN.SG
zvaná kuskus mají řadu kulinářských výhod.
so-called couscous have number culinary advantages
'yellowish little grains with the size of fine rice which is called couscous have number of culinary advantages'

(2.86) Květy šťovíků mají velká množství **drobného**
blossoms sorrels.GEN.PL have big quantities fine.GEN.SG
**pylu** zanášeného větrem na velké vzdálenosti.
pollen.GEN.SG carried wind on big distances.
'Blossoms of sorrels have substantial quantities fine pollen that is carried by wind over long distances.'

(2.87) proud vody v potoce odnášel i poměrně
current water.GEN.SG in brook away.carried even relatively
**velký štěrk**
large gravel
'the brook's water current carried away even relatively large gravel'

(2.88) Je to snopek, zhotovený ze 110 až 140 cm dlouhé **rovné**
is it sheaf made from 110 to 140 cm long straight
**slámy**
straw
'it is a sheaf consisting of straight straw that is about 110 to 140 cm long'

(2.89) přidat dostatek **drobné slámy** na stavbu hnízda.
add.INF enough fine straw on construction nest.GEN.SG

[30] Accessed on March 10, 2023.

'to add enough of fine straw for the building of the/a nest'

(2.90) paseky porostlé **dlouhou** **trávou**
pastures overgrown long.INSTRUMENT.SG grass.INSTRUMENT.SG
'pastures overgrown with long grass'

(2.91) Dno je všude bahnité s **tlustou**
bottom is everywhere muddy with fat.INSTRUMENT.SG
**trávou** a kotva nedrží úplně dokonale.
grass.INSTRUMENT.SG and anchor NEGholds entirely perfectly
'the bottom is completely muddy with fat grass (weed) and anchor does not hold entirely perfectly'

### Data from Finnish

We also found attested cases of Finnish granular mass nouns that are modified by stubbornly distributive predicates. In (2.92) we have the mass singular noun *pasta* ('pasta'), which just as the count plural noun *makaroni* ('macaroni'), is perfectly acceptable with the stubbornly distributive adjective *pieni* ('small'). The further examples below show that the singular mass nouns 'rice', 'gravel' and 'pollen' are also perfectly acceptable with stubbornly distributive adjectives.

(2.92) Olennaista on myös käyttää pieniä [Finnish]
essential.PART is also use small.PL.PART
makaroneja tai muuta **pientä**
macaroni.PL.PART or other.PART small.PART
**pastaa**.
pasta.PART
It is also essential to use small macaroni tubes or other small pasta.

(2.93) Arabikeittiöissä makluubaan käytetään **pyöreää**
arabic.cuisine.INES maqluba.GEN is.used round.PART
**riisiä**, mutta kyllä **pitkä riisikin** käy, tärkeintä, että
rice.PART but yes long rice.KIN works most.important that
on hyvälaatuista.
is good.quality.PART
'In Arabic cuisine **round rice** is used for Maqluba, but, sure, **long rice** also works, the most important thing is that it is of good quality.

(2.94) Toinen kentistä on hiekkapohjainen, sekä hieman suurempi. 'One of the fields is sandy and also a little bigger.'

Pohja on tasainen ja hiekka on **pientä** **soraa**.
base is flat and sand is small.PART gravel.PART
'The ground is flat and the sand is **small gravel**.'

(2.95) Tämän **savesta** polttamalla valmistetun **pyöreän**
this.GEN clay.ELAT fired.ADES made round.GEN
lecasoran raekoko on 3-10 mm.
Leca.gravel.GEN grain.size is 3-10 mm
'The grain size of this round Leca gravel, made from fired clay is 3-10 mm'
'The grain size of this round Leca gravel made from fired clay is 3-10 mm.'

(2.96) Monet valittivat rannan hiekan raekoosta, koska
many complained beach.GEN sand.GEN grain_size.ELAT because
se oli enemmän **pyöreää** **soraa** kuin hiekkaa.
it was more round.PART gravel.PART than sand.PART
'Many complained about the size of the grains of sand on the beach, since it was more round gravel than sand."

(2.97) Erinomainen apuväline **pienen** ja kevyen **pölyn**, kuten
excellent appliance small.GEN and light.GEN dust.GEN like
esim. **siitepölyn** poistoon.
e.g. pollen.GEN removal.ILLAT
'An excellent appliance for the removal of small and light dust such as pollen.'

While the above examples are perfectly natural, modifications of mass granular nouns with stubbornly distributive predicates in Finnish seem rarer than those in English, German or Czech.

Interestingly, there are a small number of Finnish granular mass nouns that can occur in the plural, which has been noticed for *jauho-t* (flour-PL) (see, e.g., Nenonen & Niemi 2010), but we also found *pöly-t* (dust-PL), which has not been discussed in the literature to our knowledge. These are not cases of mass-to-count coercion, since the interpretation is neither a 'packaged' or a subkind reading, as we see from the following example from a recipe in the fiTenTen14 corpus.

(2.98) Yhdistä jauhot ja neste keskenään ja sekoita [Finnish]
combine flour.PL and liquid together and mix
tasaiseksi.
smooth.TRA
'Combine the flour and liquid together and mix until smooth.'

When it comes to filament mass nouns, we also found some attested cases in Finnish, however, as with granular nouns, for the reasons stated above, these seem less numerous than in English or German. In (2.99), *heinä* ('hay/straw') is modified by *pitkä* ('long') and only has the reading that each piece of hay was long.

(2.99) Äkkiä **pitkä**, **paksu heinä**, sekalaiset rikkakasvit [Finnish]
suddenly long thick straw random weeds
ja jopa maasta esiin tunkevat puskien
and even ground.ELAT forward thrust bushes.GEN
juuret alkoivat tavoitella näistä otetta, ...
roots started chase they.ELAT grip.PART ...
'Suddenly, **long thick straw**, assorted weeds and even the roots of bushes thrusting out from the ground started to try and grip them, ...'

These data are evidence that *granular and filament* mass nouns are, in general, compatible with stubbornly distributive predicates. This means that, despite being mass, there are entities in their denotation that predicates such as *round* and *big* can distribute down to. As such, therefore, these data are a reason for not limiting focus on object mass nouns when it comes to examining the non-canonical reflexes of common nouns with respect to countability.

### 2.1.7 Summary: The empirical picture

Let us now summarise our overview of examples of variation in count/mass lexicalization patterns and the grammatical reflexes of different types of nouns given so far. Our emphasis is on the role of properties that underpin and give rise to the variation we observe:

i. **From variation to grammatical reflexes:** If there is a variation in the mapping from meaning to form, that is, if a core property `P` displays variation in its count/mass lexicalization patterns, then there are both mass nouns and count nouns that are lexicalizations of this core property. In which case, the mass nouns or count nouns (or both) will have non-canonical grammatical reflexes with respect to environments that are standard diagnostics of countability in the relevant language.

ii. **From grammatical reflexes to variation:** If either a count or a mass lexicalization of `P` has non-canonical grammatical reflexes with respect to environments that are standard diagnostics of countability in the relevant language, then there is a strong tendency for `P` to give rise to variation in count/mass lexicalization patterns.

Notice that there is **an asymmetry** in the strength of predictions between the non-canonical grammatical reflexes of mass and count nouns and properties that underpin them: according to (i), if a core property `P` can be lexicalized as a mass noun and also as a count noun, then we expect that both will behave like non-canonical mass and count nouns do with respect to standard diagnostics of countability in the relevant language. However, according to (ii), if a noun exhibits non-canonical grammatical reflexes for a count noun or a mass noun with respect to environments that are standard diagnostics of countability in the relevant language, then the core property `P` that underpins it is only strongly correlated with variation in count/mass lexicalization.

Point (i) holds, since, as we have shown, *granular and filament* nouns, our *functionally combinatorial* nouns, and *interconnected* nouns evidence variation in count/mass lexicalization patterns, and all can be modified by stubbornly distributive predicates, even if mass (see Table 2.1). On the assumption that mass nouns denoting undifferentiated stuff exhibit the kind of grammatical properties that canonical mass nouns should exhibit in a given language, then, since such mass nouns cannot be modified by stubbornly distributive predicates, we can conclude that the acceptable modification of mass nouns by stubbornly distributive predicates counts as a non-canonical grammatical pattern for mass nouns.

To give another example for what we mean by non-canonical grammatical reflexes with respect to environments that are diagnostic of a count or a mass grammatical status of a noun, take, for instance, another salient test for the robustness of the count/mass distinction: namely, cardinality comparison judgements. As indicated in the difference between the second and third columns in Table 2.1, in contrast to the patterns we see with stubbornly distributive predicates, only some mass lexicalizations of properties which give rise to lexicalization variation facilitate cardinality comparison judgements independently of heavy context-setting (see for instance the grass cutting competition example in §2.1.5). To take an example of a non-canonical pattern for singular count nouns, *interconnected* singular count nouns (e.g., *fence*) can be used in measure NPs (a canonically mass syntactic environment), and the properties that underpin these nouns display variation in their count/mass lexicalization patterns. This non-canonical pattern seems to be limited to *interconnected* count nouns however (see the fourth column in Table 2.1).

Point (ii) reverses the direction of the conditional in (i), but requires the hedge 'strong tendency', since for a few properties, especially those that denote very fine-grained granular entities (e.g., `sand` and `dust`), we have not found instances of these properties being lexicalized as count. This is something that we will seek to explain over the next few chapters. To anticipate, we will argue that the size and homogeneity of entities that instantiate granular

Table 2.1: Summary of the distributional patterns that contrasts different nouns classes countability, and morphosyntactic environments that are diagnostic of count and mass expressions (in English). *Key of Abbreviations:* NNCs = Numeral Noun Constructions; Card. Comp. = Cardinality comparison in comparative and/or superlative constructions; Stubs = felicity with stubbornly distributive predicates; SG NP Meas = felicitous as a singular downstairs NP in a pseudo-partitive (measure) construction; Bare SG = felicitous when used bare in an argumental position. Func. Combinatorial = functionally combinatorial

| | *Count diagnostic environments* | | | *Mass diagnostic environments* | |
|---|---|---|---|---|---|
| *Mass Ns* | NNCs | Card. comp. | Stubs | SG NP Meas | Bare SG |
| Canonical | ✗ | ✗ | ✗ | ✓ | ✓ |
| Interconnected | ✗ | ✗ | ✓ | ✓ | ✓ |
| Granular & Filament | ✗ | ✗/✓ | ✓ | ✓ | ✓ |
| Func. Combinatorial (object mass) | ✗ | ✓ | ✓ | ✓ | ✓ |
| *Count Ns* | | | | | |
| Interconnnected | ✓ | ✓ | ✓ | ✓ | ✗ |
| Func. Combinatorial | ✓ | ✓ | ✓ | ✗ | ✗ |
| Granular & Filament | ✓ | ✓ | ✓ | ✗ | ✗ |
| Canonical | ✓ | ✓ | ✓ | ✗ | ✗ |

properties will be one factor that affects that property's likelihood to be lexicalized as mass cross-linguistically.

Aside from canonical count and mass nouns, these observations regarding distributional patterns distinguish between (at least) three classes of nouns that cut across the count mass divide: (i) *Interconnected*, (ii) *Granular and filament*, and (iii) *Functionally combinatorial* nouns. When mass, nouns in these classes all differ from canonical mass nouns in terms of their grammatical reflexes. When count, *interconnected* nouns differ in their grammatical reflexes from canonical count nouns. These patterns are given in Table 2.1.

For mass nouns, they are either compatible with stubbornly distributive predicates or they are not. Canonical mass nouns that denote substances (*mud, air*) are not. Those mass noun classes that are felicitous with stubbornly distributive predicates can be further subdivided by whether they facilitate cardinality comparison readings in *more . . . than* constructions. *Interconnected* mass nouns (*fencing*, *hedging*) do not facilitate such cardinality comparison readings, but *functionally combinatorial* mass nouns (i.e., object mass nouns) do. *Granular and filament* mass nouns (e.g., *rice, grass, pollen*) do not pattern consistently with respect to cardinality comparison judgements. Some of them, e.g., *pollen*, have cardinality comparison readings. Others (e.g., *rice, grass*) only do, if at all, in rather specific, heavily set up and specialised contexts.

For count nouns, we have identified one environment diagnostic of mass nouns that some count nouns also license. Namely, mass nouns can be used as singular in measure constructions as the 'downstairs' NP, but count nouns cannot, with the exception, as we have shown, of *interconnected* count nouns licence. This means that *interconnected* count nouns pattern with all other classes of mass nouns in this regard.

One interesting upshot of the picture reflected in Table 2.1 is that it suggests an ordering of classes with respect to the degree to which they pattern like canonical count or mass nouns. This is clearly evocative of the *Scale of Individuation* proposed by Scott Grimm (2012), who also, like us, distinguishes between different classes of nouns, albeit on the basis of different data. Based upon grammatical distributional facts in languages such as English, Welsh and Dagaare, Grimm (ibid.) proposes the following ordering for different classes of common nouns, given below:

substances < granular aggregates < collectives < individual entities (ibid., p. 68)

Recall that in Grimm's work, *collectives*, such as *cacwn* 'hornet' in Welsh, are non-countable nouns which have collective reference and from which we can derive nouns referring to their individual members by means of a 'unit-extracting' singulative morphology.

Based on the patterns we have found for granulars and filaments, as well as on the previous work we have reviewed on *functionally combinatorial* nouns (comprising both object mass nouns and their count noun counterparts such as *jewellery* (mass) and *koru-t* ('piece-s of jewellery', count, Finnish)) and *interconnected* nouns, we also find evidence of a scale. The data, summarised in Table 2.1 show a picture made slightly more complex than that of Grimm's, since we take into account variation in count/mass lexicalization patterns. That is to say, that for a single core property, $\mathtt{P}$, its count lexicalizations may pattern more or less closely with respect to the grammatical reflexes of canonical count nouns, and likewise with its mass lexicalizations. The picture is as follows: At each pole of the scale, we have the canonical cases: mass lexicalizations of properties for which there are no count lexicalizations (e.g., *mud*), and count lexicalizations of properties for which there are no mass lexicalizations (e.g., *chair*). Between these two poles, we have our categories of *interconnected* nouns, *functionally combinatorial* nouns and *granular and filament* nouns.

| Canonical mass | $<$ | Inter-connected | $<$ | Granular & filament | $<$ | Functionally Combinatorial | $<$ | Canonical count |
|---|---|---|---|---|---|---|---|---|

*Interconnected* count nouns (e.g., *fence*) are the least canonically count, since they are felicitous in one paradigmatic mass environment: namely, their bare singular forms are acceptable in measure constructions. However, *interconnected* mass nouns like *fencing* are the most canonically mass, after the substance-denoting mass nouns like *air* or *mud* that denote undifferentiated substances, since they are compatible with stubbornly distributive predicates (unlike canonical mass nouns), but never get cardinality comparison readings. We take this as evidence for this class to be closest to canonical mass nouns on a scale of individuation. A result that we found surprising.

*Granular and filament* count nouns (e.g., *bean*, *chive*) and *functionally combinatorial* count nouns (e.g., *vehicle*, *koru-t* ('piece-s of jewellery', Finnish)) pattern with canonical count nouns. However, *granular and filament* mass nouns (e.g., *rice*, *grass*) and *functionally combinatorial* mass nouns (e.g., *furniture*) pattern distinctly from canonical mass nouns. Both can be used with stubbornly distributive predicates, but whereas a cardinality comparison reading is in principal available for all *functionally combinatorial* mass nouns, it is only available for some *granular and filament* mass nouns. This suggests that *granular and filament* mass nouns are closer on a scale of individuation to canonical mass nouns.

Our ordering and Grimm's are not directly comparable, given that our categories do not entirely align. However, the two orderings are generally in concord. There is a sense in which our *functionally combinatorial* nouns and Grimm's collective nouns are related. For Grimm, mereotopology is what unites sums of entities in collectives. For us, function is what unites sums of entities in denotations of *functionally combinatorial* nouns. Our scales do agree on the position of *granular and filament* nouns.

The one extra class we have are *interconnected* nouns (e.g., *fence*, *fencing*). It may be prima facie surprising that these nouns align more closely to canonical mass nouns on our scale. We surmise that this may be a reflex of the nature of the objects in the denotations of these nouns. Specifically, as observed by Krifka 1989, fn. 5, following Partee p.c., Zucchi & White 1996, 2001, and Rothstein 2010, the set of entities these nouns may be used to denote fails to be quantized. What *a fence* denotes may have proper parts that also fall under the same predicate *a fence*. This in turn suggests that quantization more generally, and non-quantization outside of a context of use specifically, are reflected in the grammars of natural languages. (See Filip & Sutton 2017 for more details.) The fact that we find such similarities between our results and Grimm's is especially striking, since they have been arrived at from completely independent motivations and considerations. In other words, based on different grammatical reflexes, we have both arrived at similar conclusions in relation to the way natural language predicates form an order on a scale of individuation such that our conclusions reinforce each other.

In order to give yet further empirical foundation to these distributional observations, and specifically to the claim that *granular and filament* mass nouns pattern with object mass nouns (i.e. *functionally combinatorial* mass nouns) when it comes to their co-occurrence with stubbornly distributive predicates, we conducted a corpus study, the results of which we now present in section 2.2.

## 2.2 Corpus study: Stubbornly Distributive Predicate Constructions in Czech and English

One of the reasons why the analysis of object mass nouns assumed a key role as a litmus test for evaluating the predictions of a given theory of the mass/count distinction is that they have properties that align them with count nouns, rather than mass nouns. For instance, they are compatible with modification by stubbornly distributive predicates, such as *small*, *big*, *round* and *square* (see, e.g., Chierchia, 2010; Rothstein, 2010; Schwarzschild, 2011). Excitingly, the data we have presented in section 2.1.6 regarding *granular and filament* mass nouns and stubbornly distributive predicates point towards a similar conclusion regarding their status as a litmus test for evaluating the predictions of a given theory of the mass/count distinction.

In this section, we take a rigorous look at both the object mass noun (i.e. *functionally combinatorial* mass noun) data and *granular and filament* mass noun data in order to get a clearer picture of their empirical significance and the theoretical conclusions to be drawn from them. That is to say, having found many instances of stubbornly distributive predicates being used to modify *granular and filament* mass nouns, and given the now well-known reported judgements concerning the compatibility of stubbornly distributive predicates with object mass nouns, we address the following question to put such observations on firmer empirical ground:

> How strong is the empirical evidence that *granular and filament* mass nouns, on the one hand, and object mass nouns, on the other, differ from canonical mass nouns with respect to their use with stubbornly distributive predicates?

We should stress that, that *granular and filament* mass nouns are felicitous with stubbornly distributive predicates is not an uncontroversial claim. A reviewer, for instance, questioned whether the data for *granular and filament* mass nouns and stubbornly distributive predicates is robust, suggesting that it may be attributable to special contexts or specialised uses of the relevant nouns.

To assess our empirical question, we will look at the relative frequencies of stubbornly distributive predicate constructions in corpora for a range of mass nouns in three of our four noun classes (canonical mass, object mass, and granular and filament mass), as well as patterns with canonical count nouns. We conducted two corpus studies, one on English, the other on Czech. In sections 2.2.1–2.2.5, we describe these two studies and then present and discuss our results.

### 2.2.1 Hypotheses

The purpose of these studies is to determine, when it comes to modification with stubbornly distributive predicates, whether (a) *granular and filament* mass nouns and object mass nouns pattern significantly differently from canonical mass nouns, and (b) whether *granular and filament* mass nouns object mass nouns pattern significantly differently from each other. That is to say, that we take the occurrence of canonical mass nouns in stubbornly distributive predicate constructions as a floor-level baseline, and then compare nouns from other classes with this. For completeness, we also include canonical count nouns to see if the occurrence of *granular and filament* mass nouns and object mass nouns in stubbornly distributive predicate constructions are comparable with nouns in this class.

Our independent and dependent variables are as follows:

| | |
|---|---|
| Independent variable | Noun Class: GRANULAR AND FILAMENT MASS NOUNS, OBJECT MASS NOUNS, CANONICAL COUNT NOUNS, CANONICAL MASS NOUNS. |
| Dependent variable | Whether nouns in the class are modified by stubbornly distributive predicates (henceforth, the STUB-CONSTRUCTION). |

We define the STUB-CONSTRUCTION for a common noun $N$, and stubbornly distributive predicate $A$ to include any of the following:

(2.100) The STUB-CONSTRUCTION:

a. $A$ modifies $N$ attributively

b. $A$-comparative modifies $N$ attributively

c. $A$-superlative modifies $N$ attributively

We make the following assumptions, all of which are based on the observations about stubbornly distributive predicates that have been made in the literature.

(2.101) **Assumptions.**

a. Canonical mass nouns are not felicitous in STUB-CONSTRUCTIONS. The occurrence of canonical mass nouns in STUB-CONSTRUCTIONS in the corpora can be taken as a floor-level baseline distribution.

b. If the nouns of a given noun class are felicitous in the STUB-CONSTRUCTION, then the distribution of the occurrence of these nouns in the STUB-CONSTRUCTION is significantly distinguishable from the floor-level baseline distribution.

c. If a noun of a given noun class is felicitous in the STUB-CONSTRUCTION, then it has objects in its denotation.

We test the following null hypotheses and alternative hypotheses:

| | |
|---|---|
| Null Hypothesis 0a: | The distribution of STUB-CONSTRUCTIONS in the corpora for GRANULAR AND FILAMENT MASS NOUNS is not significantly distinguishable from that of CANONICAL MASS NOUNS. |
| Null Hypothesis 0b: | The distributions of STUB-CONSTRUCTIONS in the corpora for OBJECT MASS NOUNS and CANONICAL COUNT NOUNS is not distinguishable from that of CANONICAL MASS NOUNS |
| Alternative Hypothesis: | The distribution of STUB-CONSTRUCTIONS in the corpora for GRANULAR AND FILAMENT MASS NOUNS is distinguishable from that of CANONICAL MASS NOUNS |

If our observations regarding the modification of stubbornly distributive predicates with *granular and filament* nouns in chapter 2 are robust, we should be able to reject null hypothesis 0a with a sufficient degree of confidence, thus lending support to our alternative hypothesis. If the observations made in the literature with regard to stubbornly distributive predicates, canonical count

Table 2.2: Summary of corpus information

| Corpus | Language | Tokens |
|---|---|---|
| English Web 2020 (enTenTen20) | English | 43,125,207,462 |
| Czech Web 2017 (csTenTen17) | Czech | 12,586,415,546 |

nouns and object mass nouns, we also expect to be able to find evidence to reject null hypothesis 0b.

### 2.2.2 Methodology

#### Corpora

We chose to work with English and Czech based upon our language competencies. Some information about the English and Czech corpora we used is provided in Table 2.2. For both Czech and English, corpus data was extracted via the Sketch Engine platform (full corpus information available at `sketchengine.eu`). These corpora are POS tagged but not dependency parsed. While we also discuss data from Finnish and German in this book, in our corpus study we excluded Finnish, since there are very few attested object mass nouns in Finnish which means that this language is not suitable for this particular study. We plan to further investigate German in the future.

Sketch Engine supports CQL searches via API requests, as well as providing a *Word Sketch* which includes, relative to a POS and lemma, a frequency count for the whole corpus.

#### Data Collection

The nouns we tested for each of the categories in each language are listed in Tables 2.3 and 2.4. The stubbornly distributive predicates we used in English and Czech are given in (2.102) and (2.103).

(2.102) Stubbornly distributive predicates used for testing in English:
big | fat | large | long | round | short | slender | small | square | tiny

(2.103) Stubbornly distributive predicates used for testing in Czech:
čtyřhranný, ‘square’ | dlouhý, ‘long’ | drobný, ‘fine’, ’small’ | krátký, ‘short’ | kulatý, ‘round’, | malý, ‘small’ | rozsáhlý, ‘ample’ | tlustý, ‘fat’, ‘stout’ | tučný, ‘fat(ty)’ | útlý, ‘slender’, ‘thin’ , ‘slight’, ‘trim’ | velký, ‘big’

This selection of stubbornly distributive predicates was based partly on examples cited in the literature on stubbornly distributive predicates in

Table 2.3: Noun list per category (English)

| Canonical count | Canonical mass | Object mass | Granular & filament mass |
|---|---|---|---|
| ball | air | ammunition | asparagus |
| bridge | custard | crockery | bamboo |
| car | gas | cutlery | celery |
| chair | gold | equipment | clover |
| dog | mud | furniture | garlic |
| flat | oil | footwear | gravel |
| pen | shampoo | glassware | hay |
| shirt | steel | jewellery | pasta |
| | | livestock | pollen |
| | | luggage | rice |
| | | poultry | sand |
| | | | wheat |

English (e.g., *round*, *big*, *small*). We then enriched this list with adjectives with similar meanings albeit sometimes encoding a greater or lesser degree (e.g., *tiny*, *large*) and adjectives that are stubs that we felt might be more likely to be evidenced in use with *granular and filament* nouns based on shapes and sizes (*long*, *short*, *fat*, *slender*). All of these are stubbornly distributive predicates as can be seen in the following inference patterns:

(2.104) Alex's fingers are long/short/fat/slender.
$\Rightarrow$ each of Alex's fingers are long/short/fat/slender.
$\not\Rightarrow$ Alex's fingers, taken together, are long/short/fat/slender.

**Frequency of the STUB-CONSTRUCTION (English).** Our initial CQL request for English, provided below,[31] was designed to allow for multiple modifiers in addition to stubbornly distributive predicates (e.g., *big white rice*), and so captures more STUB-CONSTRUCTIONS than a simple 2-gram approach. We also designed it to exclude compounds where the target noun was being used as a modifier (e.g., *big rice container*), as well as cases where this was part of a coordinating conjunction, as in *big rice and grain containers*, where *big* preferably modifies *containers*. This meant we did not count some genuine cases of STUB-CONSTRUCTIONS, such as *round rice and*

[31] This CQL request is for mass nouns, where we excluded plurals. For canonical count nouns, the request included `[tag="NN|NNS" & lemma="NOUN LEMMA"]`.

Table 2.4: Noun list per category (Czech)

| Canonical count | Canonical mass | Object mass | Granular & filament mass |
|---|---|---|---|
| auto 'car' | bláto 'mud' | drůbež 'poultry' | bambus 'bamboo' |
| byt 'apartment' | ocel 'steel' | munice 'ammunition' | chřest 'asparagus' |
| jablko 'apple' | olej 'oil' | nábytek 'furniture' | kukuřice 'corn' |
| košile 'shirt' | plyn 'gas' | nádobí 'kitchenware' | písek 'sand' |
| míč 'ball' | pudink 'pudding' | obuv 'footware' | pšenice 'wheat' |
| most 'bridge' | šampon 'shampoo' | příbor 'silverware' | pyl 'pollen' |
| pero 'feather', 'pen' | tekutina 'fluid' | vybavení 'equipment' | rýže 'rice' |
| pes 'dog' | vzduch 'air' | | sláma 'hay' |
| šperk 'jewel' | zlato 'gold' | | šrot 'scrap', 'grit' |
| židle 'chair ' | | | štěrk 'gravel' |
| | | | suť 'rubble' |
| | | | tráva 'grass' |

*lentils*, which, though not ideal, will mean that our estimated frequencies of STUB-CONSTRUCTIONS will be lower than actually represented in the corpus.

```
  [tag="J.*" & lemma="round|square|long|slender|short|fat|small|
 big|large|tiny"]
[tag="J.*"]*
[tag="NN" & lemma="NOUN LEMMA"]
[tag="(?!CC).*" & tag="(?!NN).*"]
[tag="(?!NN).*"]
```
[32]

However, due in part to POS tagging errors in the corpus, and the variability in English constructions, the data retrieved from the English corpus had many false hits. We concatenated each hits with a window of its left and right contexts, and then dependency parsed this data set using the spaCy Python package and the `en_core_web_trf` pipeline. We then wrote a program to find all STUB-CONSTRUCTIONS in this data set (see Appendix B). The results of this were then manually checked (excluding any remaining false hits as well as incorrect senses of nouns when the noun was polysemous). However in cases where the number of remaining hits was high (>700), we sampled 500 of the remaining hits, and then manually checked these. This allowed us to use standard sampling and estimation techniques to estimate the number of STUB-CONSTRUCTIONS in the whole corpus for each noun.[33]

[32] The tagset reference for the English corpus is available online: `https://www.sketchengine.eu/english-treetagger-pipeline-2/`. This CQL search incudes regex expressions.

[33] For instance, suppose there were $10,000$ hits for a noun with our CQL search and true

These statistics were then used to calculate the Stub Scores for each noun.

**Frequency of STUB-CONSTRUCTIONS (Czech).** Due to differences between Czech and English grammar, the Czech CQL extraction pattern was simpler than in English, because the attributive modifiers have adjectival suffixes that agree in number, gender and case with their head noun. `k1` is the tag for a noun and `k2` is the tag for an adjective.

```
[tag="k2.*"&lemma="kulatý|čtyřhranný|dlouhý|útlý|krátký|tlustý|
 malý|velký|rozsáhlý|drobný|tučný"]
[tag="k2.*"]*
[tag="k1.*"&lemma="NOUN LEMMA"]
```
[34]

The result of the Czech CQL query was in general much more accurate than for the English data. All of the hits for each noun was then manually cleaned (excluding false hits and any incorrect senses of nouns when the noun was polysemous) thus yielding a frequency of STUB-CONSTRUCTIONS for each Czech noun.

**Notes on data cleaning** For the mass noun categories we searched only for nouns used in the singular so as to help avoid cases where these nouns are being coerced into count interpretations, i.e., portions or a plurality-of-subkinds interpretation. We found a lot of noise for canonical mass nouns. For example, for the English *oil*, almost all hits were for the collocation *big oil* and were used in reference to the big corporations in the oil industry. Such examples and others where it was clear that the stubbornly distributive predicate adjective phrase was not referring to concrete entities were thrown out. We also threw out false positive cases where the stubbornly distributive predicate did not modify the target noun, as in the preferred reading of *big rice and grain containers*, mentioned above.

**Total noun lemma counts (Czech and English).** Initial counts of nouns was conducted via the Sketch Engine Word Sketch tool. Based on an initial evaluation of how polysemous an expression was, we randomly sampled either 100 sentences (for less polysemous nouns) or 300 sentences (for more polysemous nouns), and then manually checked each list counting the instances of the relevant noun sense. The proportion of the good hits from this sample were then used to estimate the total occurrences of the noun

100 clean hits from the random sample of 500, this allows one to estimate the number of STUB-CONSTRUCTIONS for the noun as $(100/500) \times 10,000 = 2000$.

[34] The tagset reference for the Czech corpus is available online: https://www.sketchengine.eu/tagset-reference-for-czech/

in its relevant sense for the whole corpus. The results of these counts along with the margin of error can be found in Appendix B.[35]

### 2.2.3 Experiment design

The main goal of our corpus studies is to assess, in English and in Czech, whether the distributions of nouns in different notional classes are sufficiently distinguishable from the baseline for canonical mass nouns when it comes to modification with stubbornly distributive predicates. We grouped nouns together based on their classification in the count/mass literature and based on our hypotheses regarding *granular and filament* mass nouns. These groups are: canonical count nouns (e.g., *chair*, *dog*), canonical mass nouns (e.g., *gold*, *oil*), object mass nouns (e.g., *equipment*, *jewellery*), and *granular and filament* mass nouns (e.g., *bamboo*, *hay*, *rice*, *sand*). These categories constituted our independent variables, as mentioned above.

#### Test measures

In order to be able to assess how compatible a single noun is with the stub-construction, we used two metrics: the relative proportion of occurrences of STUB-CONSTRUCTIONS for a given noun, and the amount of variation that such constructions have.

The relative proportion of occurrences of STUB-CONSTRUCTIONS for a given noun is based on the two corpus counts detailed above: frequency of STUB-CONSTRUCTIONS for a given noun and frequency of occurrence for that noun (in both cases, relative to a particular sense). The use of relative frequencies, expressed as proportions is well established in corpus linguistics (see e.g., Lapata et al. 1999 for an example of its use in the analysis of adjective-noun constructions). Because proportions are expected to be low, purely for ease of reading, we express this measure, $\pi_{\text{stub}}$, as an approximate percentage (approximate since our the results of our data collection contain a margin of error, see Appendix B).

(2.105) $$\pi_{\text{stub}}(\text{N}) = \frac{\text{frequency of STUB-CONSTRUCTION for N} \times 100}{\text{frequency of N}}$$

[35] A reviewer suggested that we should also exclude (some) collocations from these counts. The example they gave was *bamboo flute*. We did not do this for such examples, since this is an example of the use of *bamboo* that does evoke its regular sense. As part of our the data cleaning we did exclude collocations where the noun did not express the relevant sense. As a sanity check, we also looked at frequencies of noun-noun compounds in our samples, and did not find any occurring in sufficient numbers to warrant a worry that this will affect our overall results.

The second factor we chose is a measure of the variety of stubbornly distributive predicates used with a common noun. This is motivated by the fact that there may be fixed expressions involving stubbornly distributive predicates (e.g., *(into the) long grass*), that may artificially inflate the $\pi_{\text{stub}}(\text{N})$ score. To do this, we took the frequency-based probability distribution of stubbornly distributive predicates (in a list of stubbornly distributive predicates), given a common noun, and calculated the entropy of this distribution. For a set of stubbornly distributive predicates, $S$, and a common noun $N$:

(2.106) Entropy of $Pr(S|N)$:
$$\mathbb{H}(S|N) = -\sum_{s \in S} Pr(s|N) \times Ln(s|N)$$

The use of (Shannon) entropy as a measure of variation is established in literature on information theory (see e.g., Campbell 1966). It also has precedent in corpus linguistics and application to adjective-noun constructions, for instance, Sathe et al. 2024[36] See the results section and Appendix B for more details regarding ranges of entropy values.

Our main test statistic, the *Stub Score* is the product of these two measures:

(2.107) **Stub Score:**
$$\mathbb{S}(\text{N}) = \pi_{\text{stub}}(\text{N}) \times \mathbb{H}(S|N)$$

So, if two nouns, N, N' have the same stub percentage score, namely, if $\pi_{\text{stub}}(\text{N}) = \pi_{\text{stub}}(\text{N}')$, but N is used with a larger variety of stubbornly distributive predicates than N', then the stub score for N will be higher than that of N'.

### Statistical Analysis

In the first stage of our study, then we calculated the stub scores for a sample of nouns each of which falls into one of the above categories: *canonical count* (e.g., *cat*, *chair*), *object mass* (e.g., *furniture*, *jewellery*), *granular and filament mass* (e.g., *rice*, *sand*, *bamboo*, *hay*), *canonical mass* (e.g., *air*, *oil*). This gave us, for each noun class, a distribution of Stub Scores. Taking the canonical mass noun score as a baseline, we then compared the other distributions with this, as well as with each other. As we report in section 2.2.4, the relatively small number of nouns in each class made it hard to assess whether these distributions were normal. Therefore, we report the results of two statistical

[36] Sathe et al. (2024) use joint entropy since they are looking at the variability of adjectives across all nouns in a corpus. Since we are only looking at variability of STUB-CONSTRUCTIONS relative to a single noun in any given case, we need only use information entropy.

analyses, one for comparing normal distributions (Welch's t-test), and another for comparing non-normal distributions (the Mann-Whitney U test).

### 2.2.4 Results

The results for the English study are represented in Figure 2.1 and for the Czech study in Figure 2.2.[37] The full results for these studies are given in Appendix B. From these graphical representations, for both languages, it is fairly clear that we have three distinct patterns: very low stub scores for canonical mass nouns, relatively high stub scores for canonical count nouns, and intermediate values for both object mass nouns and *granular and filament* nouns. The average stub scores by noun category given in Tables 2.7 and 2.8 indicate a similar picture.

In order to provide evidence to confirm that there are indeed three distinct patterns, we can treat the results of each noun class as a sample of a distribution and then test for the likelihood that the results for each noun class are drawn from the same distribution. This poses a methodological challenge, however, since the choice of appropriate test depends on whether the distributions for each noun class are normal. The problem this generates is that, due to the relatively high labour intensity of our experiments, the number of nouns we tested in each class in quite small. For English, for instance, the number of nouns for each class were: canonical mass (8), granular and filament mass (15), object mass (11), and canonical count (8). This means that it is difficult to establish with any certainty whether the data is normally distributed. We applied the Shapiro-Wilk test for normality to each distribution[38], the results of which are given in Tables 2.5 and 2.6. For each language, the results are somewhat mixed. In English, the test indicates that *granular and filament* mass nouns and object mass nouns are not normally distributed ($p < 0.05$), with a somewhat unclear result for canonical mass nouns. In Czech, the test indicates that canonical mass and *granular and filament* mass nouns are not normally distributed.

Given this non-decisive result and the small sample size, for full transparency, we provide the results of both the Welch's t-test[39] that is appropriate for comparing two normal distributions[40], and the nonparametric Mann-

[37]The results of this and other studies reported in this volume can be found at `https://github.com/peter-sutton/objects-countability`.

[38]`scipy.stats.shapiro`.

[39]`scipy.stats.ttest_ind(x, equal_var=False, alternative='two-sided')`.

[40]This test was chosen over Student's t-test, since the distributions have different variances canonical mass ($< 0.01$), granular and filament mass ($0.06$), object mass ($0.01$), canonical count ($0.49$).

Figure 2.1: The results of the English study by noun and noun class. Nouns are groups into classes, for each noun is provided the stub score, i.e., the percentage of modification of that noun with a stubbornly distributive predicate, balance by a measure of the diversity of stubbornly distributive predicates modifying that noun.

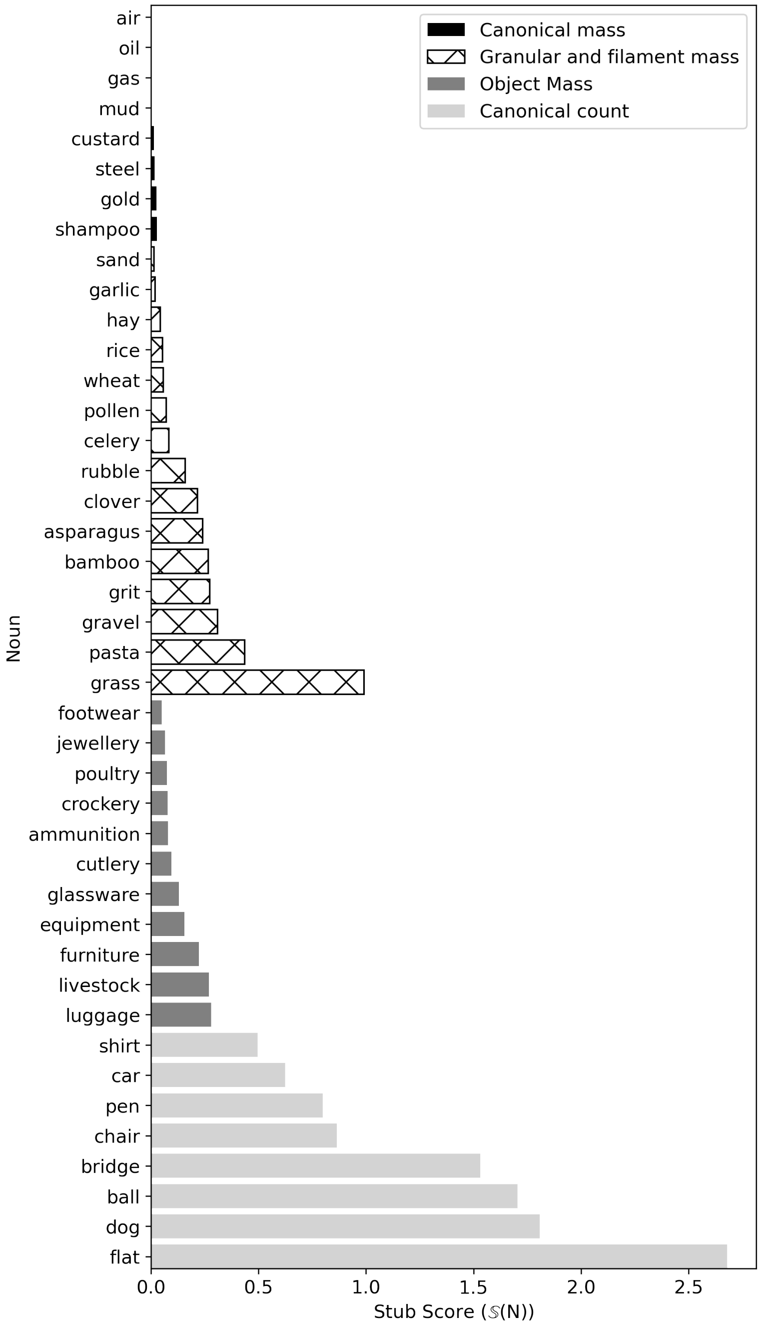


Figure 2.2: The results of the Czech study by noun and noun class. Nouns are groups into classes, for each noun is provided the stub score, i.e., the percentage of modification of that noun with a stubbornly distributive predicate.

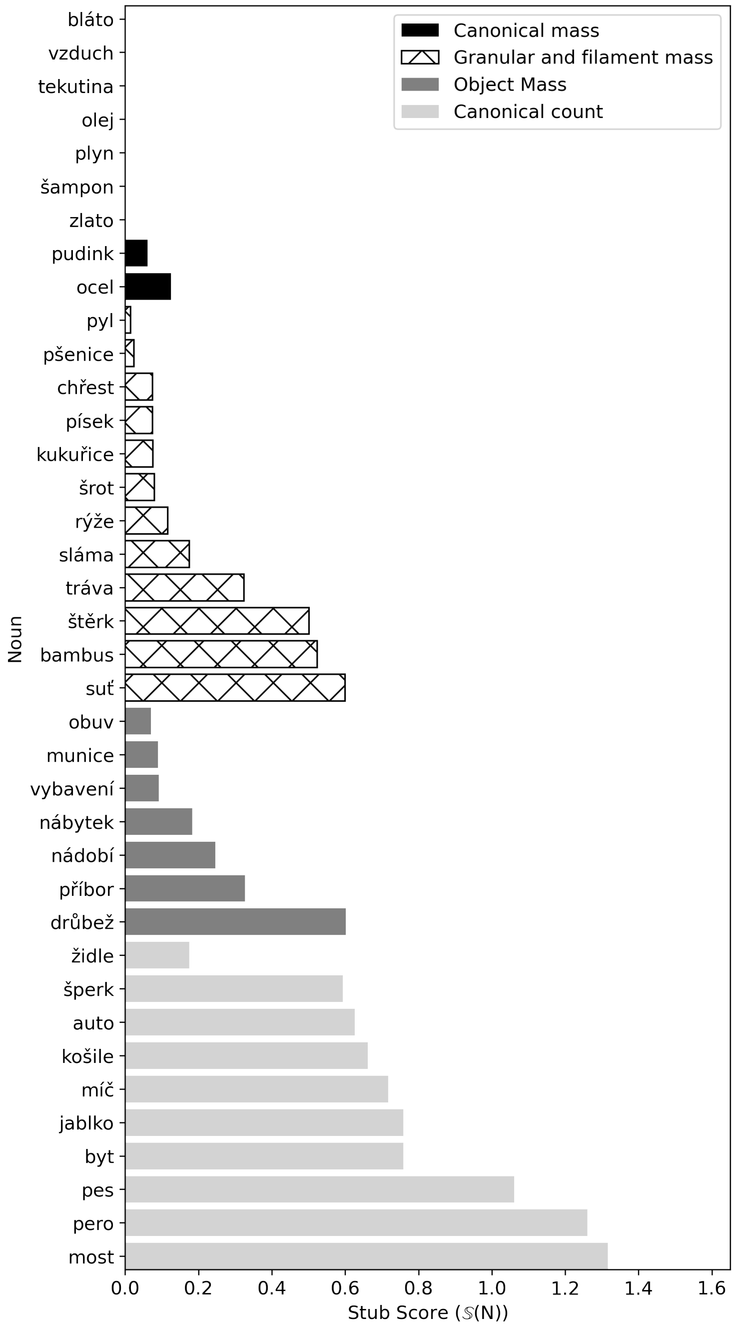


Table 2.5: Results of applying the Shapiro-Wilk test for normality of a distribution for each noun class in English.

| Shapiro-Wilk test | | |
|---|---|---|
| Noun class (English) | W | p-score |
| Canonical Mass | 0.83 | 0.056 |
| Granular and Filament Mass | 0.73 | 0.001 |
| Object Mass | 0.84 | 0.034 |
| Canonical Count | 0.91 | 0.372 |

Table 2.6: Results of applying the Shapiro-Wilk test for normality of a distribution for each noun class in Czech.

| Shapiro-Wilk test | | |
|---|---|---|
| Noun class (Czech) | W | p-score |
| Canonical Mass | 0.56 | <0.001 |
| Granular and Filament Mass | 0.81 | 0.011 |
| Object Mass | 0.84 | 0.102 |
| Canonical Count | 0.93 | 0.411 |

Whitney U test[41] that is appropriate for comparing non-normal distributions. The results of these tests are given in Tables 2.9 and 2.10.

A summary of these results is: (a) there is a significant difference between *granular and filament* mass nouns and canonical mass nouns (Eng: $p < 0.01$, Cz: $p < 0.01$); (b) there is a significant difference between object mass nouns and canonical mass nouns in English, but only marginally so for Czech (Eng: $p < 0.01$, Cz: $p < 0.05$); (c) there is a significant difference between *granular and filament* mass nouns and canonical count nouns, and between object mass nouns and canonical count nouns (Eng: $p < 0.01$, Cz: $p < 0.01$); (d) there is no significant difference between *granular and filament* mass nouns and object mass nouns; (e) there is a significant difference between canonical count and mass nouns. Based on (a), we have evidence to reject null hypothesis 0a, and therefore evidence in favour of the claim that *granular and filament* mass nouns pattern differently from canonical mass nouns with respect to modification with stubbornly distributive predicates. Based on (b) and (e), we we have reason to reject the null hypothesis 0b, and thereby evidence in favour of the reported judgements in the literature regarding the felicitous use of object mass nouns (and canonical count nouns) with stubbornly distributive predicates.

[41] `scipy.stats.mannwhitneyu`

Table 2.7: English: Average stub scores by noun category

| **Noun class** | **Average stub score** |
|---|---|
| Canonical count | 1.314 |
| Granular and filament | 0.215 |
| Object mass | 0.136 |
| Canonical mass | 0.011 |

Table 2.8: Czech: Average stub scores by noun category

| **Noun class** | **Average stub score** |
|---|---|
| Canonical count | 0.792 |
| Mass Granular and filament | 0.215 |
| Object mass | 0.230 |
| Canonical mass | 0.021 |

Table 2.9: English: Comparing the distributions of stub scores for noun categories with Welch's t-test and the Mann-Whitney U test.

**Mann-Whitney U**:

| **Noun class distributions** | U1 | U2 | p-value | Significance |
|---|---|---|---|---|
| Gran-fil mass & Canonical count | 4 | 116 | $4.89e^{-5}$ | $< 0.0001$ |
| Gran-fil mass & Canonical mass | 114 | 6 | $1.22e^{-4}$ | $< 0.001$ |
| Gran-fil mass & Object mass | 86 | 79 | 0.876 | – |
| Object mass & Canonical count | 0 | 88 | $2.65e^{-5}$ | $< 0.0001$ |
| Object mass & Canonical mass | 88 | 0 | $2.65e^{-5}$ | $< 0.0001$ |
| Canonical count & Canonical mass | 64 | 0 | 0.000155 | $< 0.001$ |

**Welch's t**:

| **Noun class distributions** | t | p-value | Significance |
|---|---|---|---|
| Gran-fil mass & Canonical count | $t(-4.03) = 7.8$ | 0.0039 | $< 0.01$ |
| Gran-fil mass & Canonical mass | $t(3.17) = 14.1$ | 0.0067 | $< 0.01$ |
| Gran-fil mass & Object mass | $t(1.15) = 18.1$ | 0.2664 | – |
| Object mass & Canonical count | $t(-4.43) = 7.1$ | 0.0029 | $< 0.01$ |
| Object mass & Canonical mass | $t(4.85) = 10.5$ | 0.0006 | $< 0.001$ |
| Canonical count & Canonical mass | $t(4.920) = 7.0$ | 0.00171 | $< 0.01$ |

Table 2.10: Czech: Comparing the distributions of stub scores for noun categories with Welch's t-test and the Mann-Whitney U test.

**Mann-Whitney U:**

| **Noun class distributions** | U1 | U2 | p-value | Significance |
|---|---|---|---|---|
| Gran-fil mass & Canonical count | 6 | 114 | 0.0004 | $< 0.001$ |
| Gran-fil mass & Canonical mass | 99 | 9 | 0.0014 | $< 0.01$ |
| Gran-fil mass & Object mass | 33 | 51 | 0.4824 | – |
| Object mass & Canonical count | 5 | 65 | 0.0020 | $< 0.01$ |
| Object mass & Canonical mass | 60 | 3 | 0.0023 | $< 0.01$ |
| Canonical count & Canonical mass | 90 | 0 | 0.0002 | $< 0.001$ |

**Welch's t:**

| **Noun class distributions** | t | p-value | Significance |
|---|---|---|---|
| Gran-fil mass & Canonical count | $t(-4.66) = 14.6$ | 0.0003 | $< 0.001$ |
| Gran-fil mass & Canonical mass | $t(3.06) = 12.2$ | 0.0096 | $< 0.01$ |
| Gran-fil mass & Object mass | $t(-0.15) = 14.0$ | 0.88 | – |
| Object mass & Canonical count | $t(-4.36) = 14.5$ | 0.0006 | $< 0.001$ |
| Object mass & Canonical mass | $t(2.86) = 6.5$ | 0.0260 | $< 0.05$ |
| Canonical count & Canonical mass | $t(7.118) = 9.3$ | $4.61e^{-5}$ | $< 0.0001$ |

### 2.2.5 Discussion

The results of our corpus studies show that that we have a robust distributional pattern: *granular and filament* mass nouns are felicitous with stubbornly distributive predicates to just the same extent as object mass nouns are, and they show a significant difference with the pattern we find for canonical mass nouns. In other words, we have good reason to reject the null hypothesis 0a. We also find evidence to reject hypothesis 0b, and so we have reason to believe that judgments reported in the literature that object mass nouns and canonical count nouns, but not canonical mass nouns are felicitous with stubbornly distributive predicates. Put another way, our results suggest that there is at least a sense in which *granular and filament* mass nouns, like object mass nouns, manifest notional/grammatical mismatches, namely mismatches between the object/substance distinction, on the one hand, and the count/mass distinction, on the other hand. They denote entities that we (can easily) conceptualize or think of as objects, and these entities are what facilitates the felicitous use of *granular and filament* mass nouns in the stub-construction, even if these nouns are grammatically mass.

Our results suggest that *granular and filament* mass nouns are more similar in their grammatical reflexes to object mass nouns than they are to canonical mass nouns that denote substances that we view as having no differentiated internal structure. This is significant, given that previous formal mereological analyses align *granular and filament* mass nouns with canonical mass nouns. For example, Landman (2011; 2016; 2021) categorises both granular mass nouns like *rice* and canonical mass nouns like *meat* as MESS MASS, whereas object mass nouns and canonical count nouns are both NEAT. Similarly, in Chierchia's theory (Chierchia, 2010, 2015), granular properties such as `rice` and substance-denoting properties like `mud` are NOT STABLY ATOMIC, but properties underpinning canonical count nouns and object mass nouns are.[42] Not only are *granular and filament* mass nouns similar in their grammatical reflexes to object mass nouns (in English and Czech), but also both exhibit a mismatch between their grammatical mass behavior and notional/conceptual discreteness of objects in their denotation. The meaning of such nouns, as we claim, delimits properties (and a conceptual domain) that are lexicalized by means of count nouns in other languages, i.e., properties subject to variation in count/mass lexicalization patterns.

Turning to the topic of notional/grammatical mismatches, if *granular and filament* properties cannot be assimilated to substance properties, then this implies that these mismatches occur only in one direction: there are mass nouns that denote what are notionally speaking objects, but there do not appear to be any count nouns that denote substances in languages that mark grammatical distinctions between count and mass nouns, at least if we restrict ourselves to lexically simple common nouns. That is to say, that, it does not seem correct to think of *granular and filament count* nouns as instances of notional/grammatical mismatches. Instead, since we have reason to believe that *granular and filament* core properties are instantiated by objects, not undifferentiated stuff, it is *granular and filament mass* nouns that exhibit notional/grammatical mismatches: they have objects in their extensions (grains, strands etc.), but are mass (core properties such as `bean` and `rice` are lexicalized as mass in many languages.

Relatedly, our results are also theoretically significant in that they suggest that there must be some property of the interpretations of object mass nouns and of mass granulars and filaments that they share with the interpretations of count nouns, but not of substance mass nouns, such that stubbornly distributive predicates can be composed with the former, but not with the latter. Obviously, it cannot be the morphological/syntactic category *mass* or *count*, since the pattern cuts across the morphological and syntactic count/mass divide.

[42]See chapter 3 for detailed discussion on the impacts of our results for these theories.

There are, however, two issues that arises in our data that deserves further discussion: that canonical count nouns received higher scores than other nouns classes, and that some *granular and filament* nouns got very low scores.

### Much higher scores for canonical count nouns

One of the notable patterns that we found was that canonical count nouns do not pattern with either object mass nouns or *granular and filament* mass nouns when it comes to modification with stubbornly distributive predicates. Indeed, we found three distinct patterns with very low stub scores for canonical mass nouns, relatively high values for canonical count nouns and values between these extremes for object mass and *granular and filament* mass nouns. A reviewer suggests that we ought to read significance into whether canonical count nouns are more likely to be used in `stub-constructions` than object mass and *granular and filament* mass nouns. They suggest that this probability should be indicative of whether the objects in the extension of a noun are more/less 'accessible'. However, we do not think that this is advisable, since there would be a confound for any such hypothesis.

This confound is introduced, because, for many if not all object mass nouns and *granular and filament* mass nouns, standardised 'object unit' classifier-like expressions exist to access the objects in their denotations, but this is not the case for canonical count nouns. For object mass nouns in English, for instance, *piece* and *item* are commonly used, for granulars, *grain* or *particle*, and for filaments *piece* and *strand*. To see why this would explain the observed patterns (and so introduce a confound into reading other significance into them), let us give a toy example. Consider the common nouns *chair* and *furniture*, the classifier constructions *item of furniture* and *furniture item(s)*, and the stubbornly distributive predicate *small*. It should be clear that speakers have a choice of constructions for referring to small (items of) furniture, but no comparable choice for referring to small chairs. In other words, we should expect at least some uses of stubbornly distributive predicates will be used to modify either the classifier expression or the classifier-noun NP, not just the noun in these classes (i.e., depending on one's analysis, either [[small] [piece of furniture]] or [[small piece] [of furniture]]). I.e., although we found uses of *small furniture*, there are almost certainly uses of *small piece(s) of furniture* in similar contexts. For canonical count nouns, speakers do not have the same choice between multiple forms that they do for object mass nouns and *granular and filament* mass nouns. For example, if one refers to a *small piece of apple*, the reference is not to a small apple and there is no 'object unit' classifier expression in English that can be used to refer to single apples. The same observations also hold for analogous Czech data. This alone can be expected to skew relative frequencies of `stub-constructions` in favour of canonical count nouns in comparison to object mass nouns, and has nothing to do with differences in access to objects, as far as we can see. This is why, in our studies, we focus on whether or not the distribution of stubbornly distributive predicates with common nouns is or is not above the base floor-level that will be established by looking at STUB-CONSTRUCTIONS with canonical mass nouns.

**Low scores of some granular and filament nouns**

In both Czech and English, although as a group in each language *granular and filament* nouns pattern with object mass nouns, some members of this group get scores comparable to the low scoring nouns in the canonical mass category. For instance, the stub score for *sand* in English is around the same as that for *steel* and is lower than the score for *shampoo.* One could object, therefore, that *sand* is perhaps not a *granular and filament* noun at all. In response to this potential objection, let us make two comments. First, some of the canonical mass noun scores were inflated, because they did occur with stubbornly distributive predicates, but in what were clearly packaging readings. This occurred with *shampoo* and *custard*, where, for example, *small shampoo/custard* was used to refer to a small container or portion of shampoo/custard. There were no similar packaging constructions for *sand.* For instance, *small sand* was used to describe sand, the grains of which were small, not a small bag or container of sand. Were we to exclude all packaging cases for *custard* and *shampoo*, there stub scores would be at or close to zero.

Second, the stub scores for *gold* and *steel* in English and for *ocel* ('steel', Czech) were non-zero for an alternative reason. In English for example, *square steel* occurred frequently in the corpus, especially in manufacturing contexts, with the meaning of a piece of steel, square in shape. With *gold*, we had a lot of hits from metal detectorist forums in which people discussed how good a piece of equipment was at detecting small or tiny gold, meaning small or tiny pieces/fragments of gold. Interestingly, therefore, it seems that when a community of speakers interacts with objects made from gold or steel frequently enough or with a certain interest/activity, this licences some uses of stubbornly distributive predicates to predicate e.g., size or shape properties of those objects. Arguably, therefore, nouns such as *gold* and *steel* are not functioning merely like substance mass nouns in those communities.

## 2.3 Summary

In this chapter, we have explored two prima facie unrelated phenomena: variation in count/mass lexicalization patterns across and within languages, and the ways in which nouns can diverge from having the canonical grammatical reflexes of their countability class. Our main claim was that, despite first appearances, these two phenomena are not unrelated. Indeed, we have provided empirical evidence that variation in count/mass lexicalization patterns is a very good predictor of non-canonicity in grammatical reflexes. So, at least for concrete nouns that denote physical objects or stuff, we have, minimally, the following classes of nouns that display variation in their count/mass lexicalization patterns: *interconnected* nouns, *granular and filament* nouns and *functionally combinatorial* nouns. Furthermore, fascinatingly, all of the nouns in these classes have non-canonical grammatical reflexes associated with countability: *interconnected* nouns (specifically when count), and *granular and filament* and *functionally combinatorial* nouns (specifically when mass).

This non-canonicity is evident for some count nouns, specifically those in the class of *interconnected* count nouns such as *fence*, *hedge* and *wall*, which can be used bare and in the singular as the 'downstairs' NPs of pseudopartitive ('measure') constructions as in *three kilometres of fence/wall*.

However, the more widespread divergence from canonical countability patterns can be seen in mass nouns. In particular, we have shown that, for properties that display variation in count/mass lexicalization patterns across and within languages, all mass noun lexicalizations of these properties are felicitous with stubbornly distributive predicates such as *small*, *big* and *square* (modulo specific lexical restrictions). Specifically, We presented new data from Czech, English, Finnish and German showing that it is not the case that only object mass nouns have this status: 'granular mass nouns' such as *rice*, *pollen*, and *gravel*, and 'filament mass nouns' such as *asparagus*, *bamboo* and *grass*, and *interconnected* mass nouns such as *fencing*, *walling* are also felicitous with stubbornly distributive predicates.

In order to bolster this result regarding *granular and filament* mass nouns, we conducted two corpus studies, one in Czech and one in English, and we found that *granular and filament* mass nouns and object mass nouns pattern significantly differently to canonical mass nouns when it comes to their modification with stubbornly distributive predicates. We furthermore found that although these nouns also pattern differently than canonical count nouns, they seem to pattern alike with each other. That is to say that the extent to which the felicitous use of stubbornly distributive predicates with object mass nouns has been seen as an important piece of evidence in the formation of theories of the count/mass distinction is exactly the extent to which we should also focus on the grammatical reflexes of *granular and filament* mass nouns in the formation of such theories.

To our knowledge, the tight connection between variation in count/mass lexicalization patterns and felicitousness with stubbornly distributive predicates as part of a wider pattern of non-canonical grammatical reflexes, has, until now, gone unnoticed. A major goal of the rest of this book is to explain the connection between these phenomena. First, the class of nouns that display non-canonical reflexes of the count/mass distinction cut across the theoretical categories upon which the state-of-the-art theories of the count/mass distinction are based. In particular, in chapter 3, we will show that these data pose challenges for count/mass theories such as those based on disjointness (e.g., Landman 2011, 2016), and stable atomicity (Chierchia 2010, 2015). Second, although we have found a correlation between variation in count/mass lexicalization patterns and felicitousness with stubbornly distributive predicates as part of a wider pattern of non-canonical grammatical reflexes, we so far lack an explanation. Providing such an explanation is the main goal for chapters 4 and 5, and will take the form of a contextualist semantics for the count/mass distinction grounded in objects, an approach we dub *Object-centred contextualism*.

# Chapter 3

# Implications for theories of countability

In chapter 2, we showed that object mass nouns are far from the only class of nouns that have non-canonical reflexes of the count/mass distinction, and, furthermore, that there is a tight connection between these patterns and the patterns we find with respect to the count/mass lexicalization of the properties underpinning these nouns. In sections 3.1–3.4, we argue that these data pose challenges for state-of-the-art mereological theories of the count/mass distinction.[1] In particular, we consider theories based upon disjointness (count nouns specify a non-overlapping set of entities for counting), as in Landman (2011, 2016, 2020, 2021), stable atomicity (count nouns denote stable atoms), as in Chierchia (2010, 2015, 2021), our own previous proposals (e.g., Sutton & Filip 2016b), mereotopological theories (e.g., Grimm 2012; Krifka 2021; Moltmann 1998), and a theory built on semantic atomicity (e.g., Rothstein 2010, 2017).

Thereafter, in section 3.5, we discuss some preliminary issues that will be important in setting the scene for our analysis in chapter 4. In particular, we discuss our assumptions about the structure of the domain, motivate *quantization* (relative to context) as the mereological property underpinning countability, and argue that an adequate account of countability needs to be contextualist.

[1] Please see Appendix A for the core definitions from Classical Extensional Mereology (CEM) assumed here, as well as a summary of the other definitions provided in support of our own account that are given in subsequent chapters.

# 3.1 Implications for theories based on stable atomicity and disjointness

## 3.1.1 Disjointness, Stable Atomicity and Count/Mass Variation

### Stable atomicity

Chierchia (2010, 2015, 2021) proposes that the semantic basis for countability is stable atomicity. A property is stably atomic iff there is a set of entities that instantiate that property that are atoms across all precisifying contexts (Chierchia, 2010) or across all worlds in the common ground (Chierchia, 2015, 2021). Variation in count/mass lexicalization patterns (i.e. why some stably atomic properties are lexicalized as mass and some non-stably atomic properties are lexicalized as count) is explained away by other parts of the theory which we discuss at length below.

*Stably atomic properties lexicalized as mass:* From the perspective of Chierchia's theory, since properties like `furniture` and `chair` are stably atomic, the question then arises is why it should be the case that such properties can be lexicalized as mass nouns when other stably atomic properties such as `chair` are lexicalized as count. Chierchia's answer is that object mass nouns like *furniture* arise as a 'copy cat' effect from the way in which number marking languages treat non-stably atomic nouns. The proposal is that mass nouns in number marking languages express singleton properties, where a singleton property is instantiated by the sum of all entities that instantiate the number neutral property at each world ($\lambda w.\lambda x.x = \sqcup \mathtt{P}_w$, for some number-neutral property $\mathtt{P}$).[2] Furthermore, some stably atomic properties with a 'collective' flavour such as `furniture` can be lexicalized as singleton properties (via copy-catting) and so are also mass.

*Non-stably atomic properties lexicalized as count:* Unlike stably atomic properties such as `furniture` and `chair`, properties like `bean` (granular) and `hair` (filament) are *not stably atomic*, because no set of entities are atoms relative to the property in all contexts. On Chierchia's theory, the lack of stable atomicity is intended to motivate mass lexicalization, as in *fasole* 'bean(s)' in Romanian and the mass uses of *das Haar* 'all the hair on one's head' in German and *hair* in English (*Alex's hair is brown*). However, the

[2] We use $\sqcup$ as the mereological sum relation, e.g., $a \sqcup b$ is the mereological sum of $a$ and $b$. We use the same symbol as an operator on sets. E.g., $\sqcup\{a, b, a \sqcup b, c\}$ is the sum of the members of the set, i.e., $a \sqcup b \sqcup c$. We use $\bigsqcup$ as the supremum operator on a set. For example, $\bigsqcup\{a, b, a \sqcup b, c\}$ is undefined, since the set has no member of which every other member is a part. In contrast, $\bigsqcup\{a, b, a \sqcup b \sqcup c\} = a \sqcup b \sqcup c$.

lack of stable atomicity fails to motivate count lexicalizations of granular and filament properties which are also common, as in *il fagiolo/i fagioli* ('the bean/the beans') and *il capello/i capelli* ('the hair/the hairs') in Italian and so the question that arises for Chierchia's (2010) theory is why properties such as `bean` and `hair` can be lexicalized as count. In order to address this question, he proposes an additional notion of a standardised partition, and suggests that "standardized partitions for the relevant substances are more readily available in such languages/dialects" [such as Italian] (Chierchia, 2010, p.140). Formally speaking, a standardised partition is formed by a semantic operator $\Pi_{\mathrm{ST}}$ that applies to a set X and outputs a set that is a disjoint subset of X, the members of which are the standardized bounded units of X that are most salient in the context (ibid., §5.3).

In short, then, there is no single explanation for the variation we find in count/mass lexicalization patterns (e.g., `furniture`, `jewellery`, `bean` and `hair`), because the stably/non-stably atomic distinction cuts through this class, and so different explanations are needed for why stably atomic properties can be lexicalized as mass (via 'copy-catting'), and why non-stably atomic properties can be lexicalized as count (via standardised partitioning).

#### Disjointness

For Landman (2011, 2016, 2020, 2021), the count/mass distinction is analysed in terms of two sets. The body (the extension of a noun), and the base (a set that generates the body under sum closure). For *base*, we also use Landman's 2011 terminology *generator set*. Count nouns have disjoint base/generator sets and mass nouns do not. Nouns such as *furniture* are mass, since what we would want to count as 'one' (the generator set) overlaps. For instance, take a vanity, which consists of a mirror, table and a chair. While a mirror, table and a chair each count as one piece of furniture, they all are also subsumed under a vanity, which we also count as one item of furniture. But this means that what counts as 'one' for furniture (e.g., a vanity) also includes sums of single items of furniture, which counts as 'one' (e.g., a chair that belongs to a vanity). The idea is that the generator set comprises not only minimal generators, but also their sums, and so if we try to count, we always arrive at multiple inconsistent results. Nouns such as *chair* are count, because their generator (base) sets are disjoint (e.g., the set of single chairs).

*Disjointness and variation in functionally combinatorial nouns:* The theory can also capture what it is that count nouns and object mass nouns (*functionally combinatorial* mass nouns in our terms) have in common: both are ***neat*** insofar as the minimal elements in the base set are disjoint, e.g., the set of single chairs for *chair* (i.e. the generator set and the minimal generator set are identical), and the set of single (minimal) items of furniture for *furniture* (i.e. the minimal generator set is a proper subset of the generator set). So, mass nouns have overlapping generator sets and count nouns have disjoint generator sets. Variation in the lexicalization patterns of what we have dubbed for *functionally combinatorial* nouns is explained as variation in what generator/base set a noun specifies. Count nouns such as the Dutch *meubel* ('item of furniture') straightforwardly denote, for Landman, a disjoint set at every context (Landman, 2011, p. 35) (and so are also neat). Mass nouns such as *furniture* can arise, since what counts as 'one' for furniture also includes sums of single items of furniture, motivated by the idea that sums of items of furniture can still count as 'one'.

*Disjointness and variation in granular and filament nouns:* Mass nouns, such as *rice*, in contrast, are mess mass nouns on Landman's (2020) theory. From this we can infer that other mass granulars such as *fasole* ('bean(s)', Romanian) and *čočka* ('lentil', Czech), for instance, should also be mess mass nouns in Landman's view. But this then raises the question of why properties such as `bean` and `lentil` can be lexicalized as count, as in the English *bean(s)* and *lentil(s)*. Although Landman (ibid.) does not address this question specifically, there is a suggestion of a possible answer within more recent developments of his theory, as in Landman 2021 and Landman 2020. There, he considers why, in certain slightly laboured contexts, granular mass nouns can get cardinality comparison readings. The answer is that "the context has made the grid *grain (of)* available" where "[g]rids are a special kind of portion set" (Landman, 2021, p. 189) and portion sets are contextually disjoint sets (i.e. disjoint subsets of the set of things or stuff the portions are portions of). However, this move means that there is not, within Landman's theory, a single explanation for the count/mass lexicalization patterns of all properties that display count/mass variation (e.g., `furniture`, `jewellery`, `bean` and `lentil`). Count nouns such as *meubel* ('item of furniture', Dutch) are count because their generator sets are disjoint. Mass nouns such as *furniture* are mass, because there is some flexibility in how a base set for a neat noun is specified. Count nouns such as *bean* and *lentil*, we assume, have disjoint generator sets and are count only because we have applied a portioning operation via *grid* to the basic properties `bean` and `lentil`.

### Interim Summary

There is a variation in the count/mass lexicalization patterns of *functionally combinatorial* nouns and *granular and filament* nouns. Since the properties underpinning these nouns cut across both the stably atomic/non-stably atomic and neat/mess divides, both the (non-)stably atomic approach and the

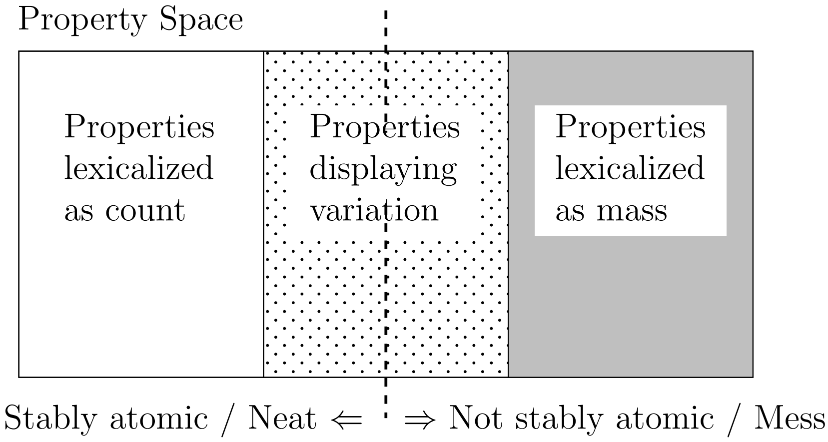



Figure 3.1: Schematic representation of the partition into two groups, 'stably atomic' in Chierchia and 'neat' in Landman, on the one hand, and 'non-stably atomic' in Chierchia and 'mess' in Landman, on the other hand, such that properties that display variation in their count/mass lexicalization patterns cut across both groups. 'Neat' and 'Mess' abbreviate 'Neat if lexicalized as mass' and 'Mess' if lexicalized as mass, respectively.

neat/mess approach (based on disjointness) must posit additional mechanisms to explain this variation. Both Landman and Chierchia, first, seem to adopt the position that granular and filament properties are, in some sense, lexicalized as mass by default, and so both posit a form of partitioning operator to override this default setting. Second, Chierchia, at least, seems to adopt the position that *functionally combinatorial* properties are lexicalized as count by default and so posits an explanation for why some of these properties are lexicalized as mass. (It is less clear to use wha the default is, if any for Landman.) As we will argue, we think the first of these assumptions should be dropped and that doing so facilitates a more unified explanation of variation in count/mass lexicalization patterns.

Figure 3.1 presents a graphical representation of the challenge faced by Landman's and Chierchia's theories for providing a unified picture of these data. On their view, nouns such as *furniture, kitchenware* or *jewelry* (Landman), or properties such as `furniture`, `kitchenware` or `jewellery` (Chierchia), are to the left of the vertical dotted line, while nouns such as *bean, lentil* and *hair*, or properties such as `bean`, `lentil` and `hair` are to the right. That is, these classes of nouns, or the properties underpinning them, fall on the opposite sides of the stably atomic/non-stably atomic (Chierchia) and neat/mess (Landman) divide. For example, on Landman's view *furniture* and *kitchenware* are neat mass nouns, but *rice* and *gravel* are mess mass nouns. On Chierchia's view, `furniture` and `kitchenware` are stably atomic properties, but `rice` and `gravel` are not. Consequently, these assumptions mean that the prevalent amount of count/mass variation we find for lexicalizations of these properties as count or mass *cannot* be treated as a unified phenomenon. Specifically, Chierchia and, arguably also Landman, must explain the count reflexes of granular and filament nouns like `hair` (which are not stably (or non-stably) atomic on Chierchia's view) in a different way from the count reflexes of count nouns such as *cat* or *ball*, which are stably atomic on Chierchia's view, or *meubel* ('a piece of furniture', Dutch) whose base set consists of minimal disjoint elements, on Landman's view. But this means that, as we also observed above, within Landman's and Chierchia's theories, granular and filament nouns require an explanation in terms of an additional semantic operation that, relative to context, derives a disjoint set of entities that are salient in the context: namely, $\sqcap_{\mathrm{ST}}$ for Chierchia and *grid* for Landman.

### 3.1.2 Disjointness, Stable Atomicity and the selectional restrictions of stubbornly distributive predicates

Both Chierchia's and Landman's theories have theory-internal means of distinguishing between different types of mass nouns. In Chierchia's theory, some of the properties that underpin mass nouns are stably atomic (e.g., `furniture` and `kitchenware`), but most are not (e.g., `mud` and `air`). In Landman's theory, some mass nouns are neat (e.g., *furniture* and *kitchenware*), but most are not (e.g., *mud* and *air*). Given this, one might hope that the selectional restrictions of stubbornly distributive predicates can be derived from this partition of mass nouns in each theory. Indeed, this is exactly what Chierchia has in mind (such that 'atomic structure' below should be read as 'stably atomic structure'):

> ... nouns like *furniture* do retain their atomic structure. Such structure can be extracted from their denotation (in fact, it has to be extracted by quantifiers like *some*, *all*, *most*,...). And such structure will be undistinguishable from that of plurals. This would explain why in some cases, fake mass nouns do pattern with count plural nouns and unlike core mass nouns, as with the 'Stubbornly Distributive Predicates', discussed in Schwarzschild (2007). (Chierchia, 2010, p. 139)

However, based on the considerations in section 3.1.1, it should be clear that, for similar reasons as the above, neither stable atomicity (Chierchia, 2010,

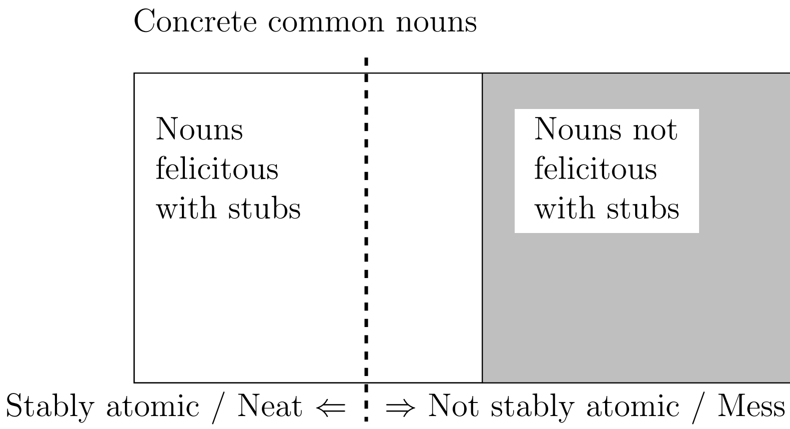



Figure 3.2: Abstract Schematic representation of the correlation between whether a noun can be felicitously combined with a stubbornly distributive predicate, and whether the noun is neat or based on a stably atomic property. ‘Neat’ and ‘Mess’ abbreviate ‘Neat if lexicalized as mass’ and ‘Mess’ if lexicalized as mass, respectively. ‘Stubs’ abbreviates ‘stubbornly distributive predicates’.

2015, 2021) nor neat denotations (Landman, 2011, 2016, 2020, 2021) alone can be used to capture the selectional restrictions for stubbornly distributive predicates, given the granular and filament mass noun, and also *interconnected* mass noun data (like *fencing, walling*) we presented in chapter 2. Put simply, both *functionally combinatorial* mass nouns and *granular and filament* mass nouns are felicitous with stubbornly distributive predicates, but these classes of nouns or the properties underpinning them fall on different sides of the neat/mess and stably atomic/non-stably atomic divide. (See Figure 3.2.) For example, *furniture* and *kitchenware* are neat mass nouns, but *rice* and *gravel* are mess mass nouns. Furthermore, `furniture` and `kitchenware` are stably atomic properties, but `rice` and `gravel` are not. These theories therefore require an alternative or an additional basis upon which to analyse stubbornly distributive predicates.

Landman (2016) suggests that, to the extent that (contextually supported) cardinality comparison readings are available for granular mass nouns, the explanation for them lies in a contextually prompted use of grid. When it comes to explaining the selectional restrictions of stubbornly distributive predicates, therefore, perhaps Landman's grid and Chierchia's standardised partition ($\Pi_{ST}$) could be used.[3] For example, one could encode $\Pi_{ST}$ or *grid*

[3] This is what Landman (2020, §8.3) seems to suggest as an analysis of *lange rijst* (‘long rice’) in Dutch, for which the stubbornly distributive predicate is assumed to necessitate a (grid) portion shift.

into the interpretation of stubbornly distributive predicates. In (3.1)-(3.3), we formulate such a proposal within Chierchia's theory for demonstrative purposes (one could take a similar approach in Landman's formal framework). For Chierchia (2010), mass nouns in number marking languages are interpreted as singleton properties, for example, *rice* is interpreted as a singleton property in (3.1).[4] Based on this, one could propose a semantics for a stubbornly distributive predicate such as *round* along the lines in (3.2): stubbornly distributive predicates quantify over entities in a standardized partition.

(3.1) $[\![\text{rice}]\!] = \lambda w \lambda x[x = \sqcup \mathtt{rice}_w]$

(3.2) $[\![\text{round}]\!] =$
$\lambda \mathtt{P} \lambda w \lambda x \exists \mathtt{Q}[x = \sqcup \mathtt{Q}_w \wedge {}^{\cup}\mathtt{Q}_w \subseteq {}^{\cup}\mathtt{P}_w \wedge \forall y[y \in \Pi_{ST}(\mathtt{Q}_w) \rightarrow \mathit{round}(y)]]$

(3.3) $[\![\text{round rice}]\!] =$
$\lambda w \lambda x \exists \mathtt{Q}[x = \sqcup \mathtt{Q}_w \wedge {}^{\cup}\mathtt{Q}_w \subseteq {}^{\cup}\mathtt{rice}_w \wedge \forall y[y \in \Pi_{ST}(\mathtt{Q}_w) \rightarrow \mathit{round}(y)]]$

In words, (3.3) is a function from worlds to a singleton set, the member of which is the sum of some rice stuff such that every grain made up of that rice stuff is round.

There are reasons not to accept this analysis, however, since (a) it does not apply to count nouns, because count nouns do not express singleton properties (and so ${}^{\cup}\mathtt{P}_w$ is not defined); (b) it does not straightforwardly apply to object mass nouns, since the stubbornly distributive predicates are supposed to distribute down to the stable atoms of these nouns, not to, say, a standardised partition of furniture/kitchenware etc. (unless one were to posit that the standardized partitions of object mass nouns are the stable atoms). Point (a) alone generates a prediction for this hypothetical extension of Chierchia's theory, namely, that stubbornly distributive predicates are polysemous/ambiguous, i.e, that a lexical entry along the lines in (3.4) (where $AT_{st}(P_w)$ is the set of stable atoms of $P_w$) is required.

(3.4) $[\![\text{round}]\!] =$

$$\begin{cases} \lambda \mathtt{P} \lambda w \lambda x \exists \mathtt{Q}[x = \sqcup \mathtt{Q}_w \wedge \\ {}^{\cup}\mathtt{Q}_w \subseteq {}^{\cup}\mathtt{P}_w \wedge \forall y[y \in \Pi_{ST}(\mathtt{Q}_w) \rightarrow \mathit{round}(y)]] & \text{if } \mathtt{P} \text{ is not stably atomic} \\ \lambda \mathtt{P} \lambda w \lambda x[P_w(x) \wedge \forall y[y \in AT_{st}(P_w) \rightarrow \mathit{round}(y)]] & \text{if } \mathtt{P} \text{ is stably atomic} \end{cases}$$

Although a possible analysis, we worry that it is not well motivated, since we have no data-based reason to assume that stubbornly distributive predicates

[4] In words, a property that is instantiated by only one entity at each world, namely, the sum of all rice stuff.

are polysemous. Furthermore, ideally, one should want the semantics of stubbornly distributive predicates to specify what it is that the nouns they select for have in common, something the proposal in (3.4) does not do. Indeed, a further unwelcome consequence of the analysis in (3.4), is that we once again do not have a single unified explanation of the phenomenon.

Landman (2020) provides an analysis of the use of stubbornly distributive predicates with mass nouns, since he wants to account for data from Dutch in which, in some contexts at least, *grote vlees* ('big meat', Dutch) can be felicitously used to mean something like 'big chunks of meat'. He also considers *lange rijst* ('long rice', Dutch). Landman's solution is to let stubbornly distributive predicates force a portion shifted interpretation on the noun. For mass granulars like *rice*, grains are accessed via a special kind of portion shift that picks out the natural units. We disagree with Landman that accessing e.g., grains of rice in the denotation of *rice* is a kind of portion shift. For one, our data in chapter 2 appear to show that the use of stubbornly distributive predicates with mass granulars is no more rare than with object mass nouns, which suggests that, even if *grote vlees* ('big meat', Dutch) is derived via some kind of contextually supported coercion, we do not have reason to think this for mass granular constructions like *lange rijst* ('long rice', Dutch). Second, we worry that if stubbornly distributive predicates can prompt a reinterpretation of a mass granular noun into the special kind of grain-based portion reading, it no longer becomes clear why numerals cannot do the same. However, at least in English, while *two rices* can mean 'two portions of rice' such as bowls of rice, it cannot ever mean 'two grains of rice'.

With count/mass lexicalization patterns, we argued that Chierchia's and Landman's theories do not provide a unified explanation. Here too, with the selectional restrictions of stubbornly distributive predicates, the same problem arises. We want to be able to explain why stubbornly distributive predicates are straightforwardly felicitous with count nouns, and with *functionally combinatorial* mass, and *granular and filament* mass nouns, but not with canonical mass nouns. We have shown a way for such an explanation to be given within Chierchia's and Landman's theories. However, this treats *functionally combinatorial* mass nouns, on the one hand, and *granular and filament* mass nouns, on the other, as of a fundamentally different sort. We think a unified theory is possible, i.e., that there is one factor that decides whether stubbornly distributive can be felicitously applied to a noun, be it count or mass.

## 3.2 Challenges for our previous work

In addition to being a challenge for Chierchia's and Landman's theories, the data presented in chapter 2 also constitute a challenge for analyses we have provided in our previous work. We briefly set out some of these challenges here, and so why we need to motivate a different analysis that we put forward here.

### 3.2.1 Two-dimensionalism

Our analysis in Sutton & Filip 2016b, which was already then motivated by some of the count/mass variation data described in chapter 2, rests on a synthesis of elements of Landman's account of object mass nouns, Chierchia's of granular mass nouns, and Rothstein's of interconnected count nouns. We proposed that nouns are evaluated relative to two contextual dimensions. One contextual dimension, following Rothstein, we called *counting contexts*. Single counting contexts, we proposed, select a disjoint set of entities from an overlapping set. However, nouns can also be indexed to a union over all such contextual interpretations, meaning that overlap is not resolved. We used this to explain how, for example, *koru-t* ('piece-s of jewellery', Finnish) can be count in Finnish: because at each context, for instance, only either single earrings count as 'one' or only pairs do. But also how *jewellery* can be mass in English, because the set of entities that count as 'one' evaluated at the union of these contexts includes both, say, earrings and pairs of earrings.

The other contextual dimension we proposed is based upon Chierchia's supervaluations we called *precisifying contexts*. In order to define the set of what counts as 'one' (the counting base set), these contexts each cut off what counts as an instance of the property at some level of granularity (e.g., at bowlfuls of beans, single beans or parts of single beans). We then allowed nouns either to be evaluated at the precisifying context of utterance or else at the intersection of all such contexts. In the latter case, we get a mass noun (because the counting base set is empty). In the former case, at some specific contexts, the resulting counting base set just contains the set of e.g., single beans, and yields a count interpretation.

We showed how the interactions between these contextual parameters can make the right predictions when it comes to count/mass lexicalization pattern variation. To this extent, our approach in Sutton & Filip (ibid.) could account for one half of the data we are concerned with here. However, it has no clear way of accounting for the different grammatical reflexes of count and mass nouns that lexicalize properties that display such variation that we observe with felicitous modification with stubbornly distributive predicates. The reason for this is that, for instance, once a granular property is indexed to the intersection of all precisifying contexts (giving rise to a mass interpretation), the set of grains is lost from the counting base set, and hence the semantics of a stubbornly distributive predicate cannot pick up on.

In some subsequent work (Sutton & Filip, 2016a, 2017c), we dropped our two-dimensional approach for one that was closer to Landman's account. In this work, we focused primarily on restrictions on mass-to-count coercion which required only counting contexts and not precisifying contexts.

### 3.2.2 Incorporating richer lexical structures

A second strand of our work again returned to the phenomenon of variation in mass/count lexicalization patterns (Filip & Sutton, 2017; Sutton & Filip, 2017a,b, 2021b). This work can be seen, to some extent, as a forerunner to the approach we present here. Although, at that time, unaware of the full set of the non-canonical grammatical reflexes of the classes of nouns we were looking at, we were nonetheless driven by the intuition that, even for *granular* nouns, the set of 'objects' (i.e., the grains) in their denotations had some kind of privileged place conceptually, such that the question we should be asking is why these properties should be lexicalized as mass. Recall that for Chierchia, and also for Landman, granulars like rice or gravel or filaments like hair are puzzling, because they treat them as, in some sense att least, 'notionally mass', and therefore raise the question about just why they should be also lexicalized as count. For instance, in Sutton & Filip 2017b, using a probabilistic frame semantics (pTTR (Cooper et al., 2015)) enriched with mereology, we connected count/mass variation to the result of different learning strategies: one which maximises individuation (that we linked to informativeness), the other, reliability. One can 'view' grains of rice as sets of individual grains (maximally informative, but unreliable, since parts of e.g., rice grains can count as *rice*), or one can class rice as any unbounded portion of stuff which has the relevant properties (less informative, but more reliable). In Sutton & Filip 2021b, we further extended our use of frame semantics to analyse granular nouns. There, we assumed that the lexical entries for granular nouns, be they count or mass, record information about the granular entities (the single grains) in their denotations. But only count nouns pass this set up to the counting base. It was in part a result of making this proposal that we started looking for grammatical reflexes of granular mass nouns that evidence access to this set of single grains. It was this investigation, combined with our work on the grammatical reflexes of nouns like *fence* (Filip & Sutton, 2017) that led us towards the current work.

## 3.3 Mereotopological theories

In pioneering work on the semantics of different notional and grammatical countability classes of common nouns, a mereotopological semantics for common nouns was developed in Grimm 2012, 2018 amongst others. (See also Moltmann 1997, 1998 for work on *integrated wholes*, Lima 2014a; Wągiel 2021 for subsequent developments, and also Krifka 2021 for a semantics with an alternative foundation *haptomereology*.) Mereotopological semantics enriches mereological semantics with an additional primitive, namely where two entities are connected. Hence, one is able to describe not only when entities constitute a mereological sum, but also the ways in which these entities are arranged relative to each other in physical space. This enrichment allows one to formulate, in large part, what we have described above as a *Spelke object*, namely a Maximally Strongly Self-Connected (MSSC) entity:

> 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)

In simple terms, the definition requires that an entity is an integrated whole (Moltmann 1997, 1998; Simons 1987), that is to say that that all of its parts are genuinely connected to at least one other part, as opposed to, say, merely touching/resting against them. This notion and others within Grimm's theory also allow him to distinguish predicates denoting objects as opposed to substances and also as opposed to cluster entities.

The centrality of MSSC objects in Grimm's approach has some advantages with respect to our data regarding the distribution of stubbornly distributive predicates, namely, many of the mass nouns that are felicitous with stubbornly distributive predicates denote MSSC objects. For instance, grains of sand and single lentils etc. are MSSC objects. However, MSSC objects cannot, alone, account for these data. First, as a caveat, it is worth stressing that the work in Grimm 2012 was not intended to apply to artefacts, but rather to natural kinds terms. Indeed, the kinds of nouns we mentioned in chapter 1 such as *multi-mixer* as well as nouns such as *apartment* do not denote MSSC entities, since, parts of a multi-mixer do not form an integrated whole, and apartments in a block of flats overlap (e.g., share walls). Grimm & Levin (2017) develop an account of artefact denoting expressions in terms of function, the details of which we return to in chapter 4. Furthermore, as observed in Sutton 2024b, other non-artefact-denoting count nouns do not denote MSSC entities. For instance, *mountain* denotes entities with edges that are not well defined.

The notion of an integrated whole in Moltmann 1997 is more flexible, since it allows for a wider range of relations to underpin integrity. These so called $R$-*integrated wholes* from Simons 1987 are such that $R$ is a relation under which entities are integrated. $R$ can be, for instance, a function. As we will argue in chapter 4, we think that we do need to incorporate function as part of an account of what counts as an *object*. However, it is less clear to us that the way that Moltmann (1997) conceives of the role of integrated wholes in the count/mass distinction can account for our data:

> Moreover, there are mass nouns, for example *furniture* or *clothing*, which seem to apply to entities that consist of integrated wholes. When such mass nouns are used to refer to an entity $x$, however, it is implied that the integrity of the parts of x is not relevant or not perceived as integrity. For the picture one has in mind when applying furniture or clothing to an entity seems to be a more or less homogeneous mass. (ibid., p.21)

The problem is that nouns like *furniture* and *clothing*, as well as mass granulars like *rice* have denotations made up of integrated wholes, *and* these integrated wholes are accessible to some parts of the grammar, e.g., stubbornly distributive predicates. An explanation is needed why the interpretations of stubbornly distributive predicates can access integrated wholes in the extensions of mass nouns, but the interpretations of, say, numerals cannot. Moltmann's account does not seem to offer such an explanation.

For now, therefore, we can at least conclude that an account of the distribution of stubbornly distributive predicates based upon MSSC entities is not sufficient to account for all of the data regarding what nouns are felicitous with stubbornly distributive predicates. Insofar as mereotopology helps us better define notions such as *Spelke object*, MSSC entities are, in our view, only part of the story for explaining the phenomena of non-canonical count/mass reflexes and variation in count/mass lexicalization patterns. However, in order to account for the full array of patterns we see in the reflexes of countability across different classes of nouns, many of which do not denote MSSC objects, a theory of these data must include, but importantly, go beyond MSSC entities. Adopting a broader notion such as an integrated whole may be helpful for developing a broader conception of *object* than that of Spelke objects, but this alone is not sufficient to account for the data we presented in chapter 2, namely, why some nouns are compatible with e.g., stubbornly distributive predicates, but are nonetheless mass.

## 3.4 Contextualism and semantic atoms

While the theory that we espouse in the next two chapters shares some properties with Rothstein's (2010; 2017) contextualist account, we also think that the data from chapter 2 poses some challenges for this approach. In Rothstein's analysis, counting is counting *semantic atoms*, which contrast with natural atoms. Natural atoms seem to approximate Spelke objects, "bodies that are cohesive, bounded, spatiotemporally continuous, and solid or substantial; they move as connected wholes, independently of one another, on connected paths through unoccupied space." (Soja et al. 1991, p. 183). Semantic atoms, in contrast, are semantic entities, namely context indexed entities of the domain of physical entities (of Rothstein's type $d$, we will use type $e$ for the domain of physical entities). So where as natural atoms may be entities of type $e$, semantic atoms are entities of type $e \times k$, with a type $k$ for contexts.[5]

Contexts, in this approach are (in default cases) disjoint subsets of the domain if type $e$. So for a count nouns such as *fence*, we have a lexical entry as in (3.5) in which *fence* denotes a set of semantic atoms. The predicate of semantic atoms $\mathit{fence}$ is derived from a root predicate $\mathit{FENCE}$ of type $\langle e, t\rangle$, via the context indexed $\mathsf{COUNT}_k$ function given in (3.6).

(3.5) $\lambda \mathbf{x}_{:e \times k}.\mathit{fence}_{\langle e\,\times\,k,\,t\rangle}(\mathbf{x})$

(3.6) $\mathit{COUNT}_k(\mathit{FENCE}) = \{\langle x, k\rangle : x \in \mathit{FENCE} \cap k\}$

Mass noun interpretations, in contrast, are of type $\langle e, t\rangle$ and do not involve the application of the $\mathsf{COUNT}_k$ function. For instance for *mud* as in (3.7). Thereby count noun and mass noun interpretations in this theory are of different types.

(3.7) $\lambda x_{:e}.\mathit{MUD}_{\langle e,\,t\rangle}(x)$

We will detail in section 3.5.5 precisely how our proposal diverges from Rothstein's, not least in terms of how we define contexts and differences in semantic types across countability classes. Here let us briefly discuss how this approach can deal with variation in count/mass lexicalization patterns and our data regarding stubbornly distributive predicates.

[5]This assumes that entities can be of *product types*. See chapter 4 for a full discussion of product types and our use of them in our analysis.

### 3.4.1 Semantic atomicity and count/mass variation

One of the features of Rothstein's analysis is that all of the explanatory work is done by the grammar and the application of the $\mathsf{COUNT}_k$ function. As far as were are aware, no constraints were ever placed on the application of this function, and so, in principle, there are no constrains on count/mass variation. Put another way, the theory itself does not, and we suspect was not intended, to make predictions about constraints on variation in count/mass lexicalization patterns. Therefore, we cannot assess this account in terms of these data.

### 3.4.2 Semantic atomicity and stubbornly distributive predicates

We are also not aware of any proposals within Rothstein's work regarding the semantics of stubbornly distributive predicates applied to mass nouns. What we say here is highly speculative, therefore.

There are two obvious candidates within the theory that could be used to characterise selectional restrictions on stubbornly distributive predicates. (i) Stubbornly distributive predicates only apply to predicates of semantic atoms, and the semantics of stubbornly distributive predicates distributes down to these semantic atoms; (ii) Stubbornly distributive predicates only apply to naturally atomic predicates, and the semantics of stubbornly distributive predicates distributes down to these natural atoms. Neither option is without problems, however. Regarding (i), this would make the wrong predictions for object mass nouns. Object mass nouns do not, as mass nouns, denote semantic atoms, and so (i) would falsely predict object mass nouns not to be felicitous with stubbornly distributive predicates.

Regarding (ii), the problem arises that not even all count nouns are naturally atomic, the exemplar case being *fence*. However *fence*, and indeed its mass counterpart in English *fencing*, are felicitous with stubbornly distributive predicates.

In chapter 4, we detail our object centred contextualist approach to countability. As we will make clear, we have taken much inspiration from the work of Rothstein in the development of our ideas. We will introduce a notion of *object* and a context sensitive semantics that can account straightforwardly for the stubbornly distributive predicate data. In chapter 5, we will furthermore propose a system of perceptual-interactive constraints to get a handle on variation in count/mass lexicalization patterns.

## 3.5 Preliminary issues

In this section, we lay out some of the basic assumptions that will support our analysis in chapter 4. We characterise our basic assumptions regarding the mereological structure of the domain, and explain why the notion of vagueness is unsatisfactory to ground countability in natural languages, in departure to the proposal of Sutton & Filip 2016c, and also Chierchia 2010. We then argue in favour of a theory of countability based on quantization relative to context: namely, count nouns specify a quantized set of entities for counting relative to context (for a related idea in the denotation domain of verbal predicates that concerns the semantic analysis of telicity and perfectivity see Filip 2000)[6]. We also outline how the form of context sensitivity can be integrated with the kind of context sensitivity that all common nouns have, namely that which governs contextual domain restrictions in e.g., quantified noun phrases.

### 3.5.1 The structure of the domain

We assume a truth-conditional, model theoretic semantics with the addition of classical extensional mereology such that the domain of type $e$ is structured as a Boolean join semi-lattice. Following Krifka (1986, 1989) and much subsequent work, we assume a single domain of type $e$ upon which the semantics of both concrete count and concrete mass nouns will be defined (contra Link, 1983).

A question that arises is what kinds of things populate this domain of type $e$. One issue in particular that divides recent single-domain analyses of the mass/count distinction is whether this domain should be atomic or non-atomic (i.e., non-committal as to whether the domain is atomic or atomless) To address this issue, let us first set the scene in terms of a distinction between ontological assumptions and semantic assumptions. For us, questions about the domain (e.g., what exists) are, broadly, ontological questions. For instance, the question 'What is the smallest entity we must assume to exist in our model in order to provide a semantic analysis of this fragment of natural language?' is an ontological question. Questions about properties of the denotations of linguistic expressions are semantic questions. For instance, the question like 'Are the denotations of singular count nouns disjoint or merely quantized?'

[6]Filip 2000 argues that telic predicate denotations have a quantized set of events relative to context, updating a context-free definition of quantization of Krifka 1989. This also solves the problem of perfective verbs in Slavic languages that fail to be quantized on their own, but behave like quantized/telic predicates with respect to the requisite adverbials and other co-constituents in a sentence just like other perfective verbs that clearly specify a quantized set of events.

is a semantic question. Now, while we do not rule out that someone might provide solid ONTOLOGICAL reasons for a non-atomistic mereology, we worry that some of the reasons given for non-atomicity are really semantic, and so not a good basis for making an ontological theoretical choice. For this reason, we will now try to draw a clear line between an atomicity assumption (an ontological assumption), on the one hand, and an assumption that singular count nouns denote *absolute atoms* (a semantic assumption, which we will address shortly), call this latter assumption *semantic count atomicity*.

The positions we argue for have the following two consequences: (i) The atoms in one's domain have no essential connection to the denotations of count nouns. As a result, some proper parts of concrete objects in the denotations of count nouns may in turn also fall under denotations of count nouns (e.g., a cat's ear is a mereological part of the cat). (ii) Ontological questions are clearly demarcated from semantic questions. I.e., we do not motivate semantic decisions based upon issues that are fundamentally ontological. For instance, we do not think that ambivalence about whether the domain is atomic should be used to address issues surrounding the denotations of mass nouns.

**Domain Atomicity vs Semantic count atomicity.** The assumption of an atomic domain, *domain atomicity*, is usually paired with the further, and in our view, dispensable assumption that the extensions of count nouns such as *cat*, *paw* and *ear* are subsets of the domain of *absolute atoms* (entities that are atoms relative to the whole domain, rather than atoms defined relative to a property P), i.e., the thesis of *semantic count atomicity*[7]. The combination of domain atomicity and semantic count atomicity found in, for example, Link 1983, 1998 and Chierchia 1998a has the undesirable consequence that, for example, the ear of a cat is not a mereological part of a cat. This is because if *cat*, as a singular count noun, denotes a set of atoms in the domain, then so does *ear*. By definition, atoms have no parts, and so, the ear of a cat cannot be a part of the cat (nor can the ear drum in the ear be a part of the ear, etc.).

To overcome this wrinkle, one must, in addition to a standard (unstructured) mereological 'part-of' relation, define other relations between objects and their parts. For instance, Chierchia (2010) proposes a *spatiotemporal inclusion* relation which establishes a kind of 'material' relation between an individual and its parts. However, such a fix comes at a cost of not being theoretically parsimonious, and it also raises a principled question about the nature and number of 'part-of' relations for an adequate mereological

[7]Note that what we mean by 'semantic count atomicity' is different to, and independent of Rothstein's (2010) *semantic atomicity*.

semantics for natural language. In this connection, Wągiel (2019) argues that a single 'part-of' relation is preferable, since 'part' words in German, for instance, can receive both a part-of a-single-object and a part-of-a-plurality interpretation as we see in (3.8) and (3.9), which also both occur in coordinated structures as we see in (3.10):

(3.8) German (p. 21 Wągiel, 2021, citing Nina Haslinger, p.c.)

a. ein Teil des Apfels
   a part the.GEN apple.GEN
   '(a) part of the apple'

b. ein Teil der Äpfel
   a part the.gen apples.gen
   'some of the apples'

(3.9) German (p. 21 ibid., citing Nina Haslinger, p.c.)

a. ein Teil vom Apfel
   a part of.the.DAT apple.DAT
   '(a) part of the apple'

b. ein Teil von den Äpfeln
   a part of the.DAT apples.DAT
   'some of the apples'

(3.10) Ein Teil des Apfels und der Birnen sind
a part the.GEN apple.GEN and the.GEN pears.GEN are
verfault.
rotten
'Part of the apple and some of the pears got spoiled.' German (p. 24 ibid., citing Viola Schmitt, Martin Prinzhorn, p.c.)

**Non-atomicity.** On the other hand, we could assume a non-atomic domain instead of an atomic domain by not including an atomicity condition in our algebra[8] (i.e., not including the assumption that the domain is atomic). Non-atomicity has been criticised as being obscure (see Chierchia 2010). However, the reason why we do not adopt a non-atomic domain, and instead prefer to make the atomicity assumption, is as follows. A reasonable methodology for developing a theory is that it should be *as strong as possible* and *as weak as necessary*. Based on this methodology, in terms of being *as strong as possible*, an atomicity condition in one's mereology is preferable to its absence. One difference between our position and that of e.g., Krifka (1989) and Landman (2016) who assume a non-atomic domain is as follows. Krifka

[8] Atomicity Assumption: $\forall x \in \mathcal{D}_e[\exists y[\forall z[(y \sqsubseteq x \wedge z \sqsubseteq y) \rightarrow y = z]]]$.

(1989) and Landman (2016) do not need to make the domain atomicity condition in order to explicate their theories of countability, and so do not do so. We, in contrast, prefer to hold the logically stronger domain atomicity position, precisely because it does not prevent us from explicating our theory of countability. Therefore, the preferable position according to our strong-as-possible methodology is to assume domain atomicity.

Turning to the question whether adopting the domain atomicity condition makes the theory *as weak as necessary*, we may ask whether it makes false predictions as a result of adopting the domain atomicity assumption. We briefly consider a few reasons why one might think this, but ultimately reject them.

*Problems with semantic count atomicity do not motivate non-atomicity.* The criticisms of atomicity mentioned above could be seen as a reason to endorse non-atomicity. However, as we hope is now clear, this would be to confuse semantic count atomicity (on which the extensions of count nouns such as *cat* and *ear* are subsets of the domain of *absolute atoms*) with domain atomicity (i.e., atomicity relative to the whole domain). The former generates the problem mentioned above, that, for instance, an ear of a cat is not a part of a cat, given that *cat* denotes a set of absolute atoms in the domain and, by definition, atoms have no parts. The latter, domain atomicity, does not on its own lead to this problem, since it merely amounts to the assumption that there are atoms in the domain, but it does not link the denotations of singular count nouns to the absolute atoms in the domain.

*Divisibility (aka Divisiveness) does not motivate non-atomicity.* Another reason why one might embrace non-atomicity is because it appears to allow one to circumvent the controversial issue of whether mass nouns have divisive reference, and related to it the minimal parts problem, whether there are any mass nouns that have no minimal parts, i.e., whether mass noun extensions are atomless. Definitions for divisibility vary. Krifka's (1989, p. 78) is below in (3.11) and Rothstein's (2010, p. 351) is below in (3.12) (Rothstein uses *divisiveness* and *homogeneity* interchangeably). We adjust their notation to fit with our own and drop types that are specified on mereological operators and relations. For Krifka, for instance, a predicate is divisive iff for anything in $P$, there is a proper part of that thing that is also in the in $P$. For Rothstein, a predicate $P$ is divisive (homogeneous) iff for every $x$ in $P$, there is a way of splitting $x$ into two non-overlapping parts, both of which are also in $P$.

(3.11) $\forall P[\mathbf{DIV}(P) \leftrightarrow P(x) \wedge \exists y[y \sqsubset x \wedge P(y)]]$

(3.12) $\forall P[\mathbf{DIV}(P) \leftrightarrow \forall x[P(x) \rightarrow \exists y \exists z[y \sqsubseteq x \wedge z \sqsubseteq x \wedge \neg y \circ z \wedge P(y) \wedge P(z)]]$

That divisibility is the property that characterises mass noun extensions is attributed to Cheng (1973), and was later discussed by Pelletier (1975) who observes that it arguably has its earliest formulation in Frege (1884). A precondition to countability, for Frege, is that a concept (*Begriff* in German) "keine beliebige Zertheilung gestattet" ('does not permit any arbitrary division'). Notice that, as defined above, if any non-empty predicate is divisible, then this implies that at least part of the domain is atomless.

Cheng's and Frege's intuition seems to be that mass terms, unlike count terms, are divisive in their reference: stuff in the extensions of mass nouns can be endlessly subdivided such that if $x$ is in $P$, then every part of $x$ is in $P$, and every part of every part of $x$ is in $P$, etc. For example, if some stuff counts as *water*, then every part of it counts as *water* and every part of those parts counts as *water* etc. Such a conception of divisibility, however, poses the question whether there there any words at all that are divisive in this sense, i.e., whether there are any words that have referents with no smallest parts, and therefore are truly atomless. This is the notorious *minimal parts problem*. It arises for homogeneous mass nouns like *water*, and also for heterogeneous mass nouns like *fruitcake*, 'heterogeneous' in the sense of Taylor (1977). For instance, a proper part of what is in the denotation of *fruitcake*, which consists of heterogeneous ingredients, namely, flour, raisins, nuts, dry fruit and the like, is a raisin, but a raisin is not fruitcake, so *fruitcake* does not have divisive reference (ibid.). What *water* refers to in the external world is not divisive, given that it refers to stuff water ($H_2O$) which consists of molecules each of which is made up of two hydrogen and one oxygen atoms, but a single atom of hydrogen, for instance, is not water.

As Pelletier (2012) observes, a standard defence of the divisiveness property of mass nouns in the face of these facts is to distinguish between "empirical facts", on the one hand, and "facts of language" or "natural language metaphysics", on the other hand. It is an empirical fact that the stuff water is made of has smallest parts that do not count as water (i.e., individual hydrogen and oxygen atoms). This, however, English does not recognise, because what the word *water* describes is taken or is conceived of as having the property of infinite divisibility. But if the word *water* has divisive reference, and the water stuff in the world does not, then the stuff water, on any externalist view of truth, cannot be the semantic value of *water*, it cannot be what makes the predicate *water* true. This is a problem, since it entails a (truth-conditional) semantics that is separate from "the world", and hence a semantics that is not a theory of the relation between language and the world. At the same time, this suggests a semantics that would not be a relation between natural language expressions and a speaker's mental construct/state, given that many speakers know that water has smallest parts, namely hydrogen and oxygen atoms. This in turn introduces a problem for natural language metaphysics, tied to "facts of language".

Now, one might think that the above problems with divisibility motivate non-atomicity, because if one assumes a non-atomic domain, then it is possible to circumvent the whole issue of divisiveness, the minimal parts problem, and the thorny issues of the relation between words and the (external) world, or words and speakers' mental constructs/states. Put another way, non-atomicity side-steps the problem of whether any mass nouns have divisive reference, because one can simply be agnostic about whether they do.

We, however, do not think that this is a good argument for non-atomicity, because, again, this would be to confuse a semantic question with an ontological one. For instance, we may not know what the minimal parts of the referent of the word *mud* are (a semantic question), but this has no bearing on whether our semantic model should be agnostic about what the smallest entities in the domain are (an ontological question). For example, assuming a doxastic or an epistemic conception of vagueness based upon uncertainty, one could take the view that it is vague whether the extensions of mass nouns like *mud* are atomic, because it is vague, i.e., unknown, whether the domain is atomic, whether it has minimal entities. However, not knowing whether the extension of *mud* is atomic is compatible with an atomic mereology. There is no reason to explain why we do not know what the minimal parts of mass nouns like *mud* are in terms of not knowing whether there are minimal entities in the domain. One can consistently assume the first and deny the second.

For example, if our absolute atoms were, say, hydrogen and oxygen atoms (making it up water molecules) and clay minerals with silica atoms composed with other stuff (whatever it is), then, based on one's favourite theory of vagueness, one could treat the denotation of *mud* as vague, as it might be vague how many water molecules need to be mixed with how many clay ingredients to make mud. Now, provided that a necessary, even if not sufficient, condition for being mud would be to contain some clay and some water, the minimal entities in the denotation of *mud* would never be identical with the absolute atoms of the domain.

In summary, neither problems with semantic count atomicity, nor puzzles relating to the extensions of mass nouns are reasons for assuming a non-atomic domain, nor are they reasons for not making an atomicity condition in one's mereology.

**Domain atomicity without semantic count atomicity.** We propose that a plausible response to the above issues is to deny that the extensions of singular count nouns are absolute atoms. To be agnostic as to whether there are any absolute atoms achieves this effect indirectly (it is not coherent to assume that the extensions of singular count nouns are absolute atoms if one is agnostic about the existence of absolute atoms), however it is not necessary to be agnostic in this way since there are other grounds for denying that the extensions of singular count nouns are absolute atoms. Furthermore, there are methodological reasons for strengthening one's theory to being an atomic one if there are no good grounds for not doing so.

In short, the problem with atomicity is not the assumption that there are absolute atoms, but rather it is the extra, dispensable assumption that the extensions of singular count nouns are absolute atoms. Non-atomicity, to some extent, throws the baby out with the bath water by remaining agnostic on whether there are absolute atoms. We therefore assume an atomic domain, but we drop entirely the additional assumption that all relative atoms in the extensions of count nouns (i.e., relative atoms are atoms which are relative to predicates denoted by count nouns, or relative P-atoms) correspond to absolute atoms (i.e., atoms relative to the whole domain). The reason for this is that, in our view, it is correct to capture our common sense knowledge about part relations, such as paws and ears being parts of cats, and also hairs and claws parts of paws and tails, etc. We furthermore think, based on parsimony considerations, that it is correct to assume only a single part-relation. These two assumptions entail, however, that individuals like cats, ears, paws, claws, tails and hairs *cannot* all be absolute atoms, and, consequently, that semantic count atomicity is false: the denotations of singular count nouns are not necessarily absolute atoms in the domain.

A further consequence of this position is that, lacking any other motivation, absolute atoms need not play any role in our semantic theory of countability. We will make no assumptions about what the set of absolute atoms are beyond the intuitive idea that they are whatever the mereological smallest entities are in one's ontology. Put bluntly, it is our view that the question of what absolute atoms there are is an ontological question (what is in one's ontology), not a semantic question (what is potentially 'one' in the denotation of a noun for the purposes of counting).

Adopting this position has the following two welcome consequences: (i) Proper parts of concrete objects (whose proper parts are organised in a structured coherent whole) in the denotations of count nouns are mereological proper parts of those objects, and may in turn also fall under denotations of count nouns (e.g., a cat's ear is a mereological part of the cat, and so what *cat* denotes has the denotation of *ear* as its proper part). (ii) Ontological questions are clearly demarcated from semantic questions. Implicit in our considerations is the idea that the problem with an atomic mereology is not that it relies on absolute atoms, but rather it is the assumption that absolute atoms (including things in the denotation of count nouns) are key for theories of countability and the semantics of counting operations. We suspect that those who have proposed a non-atomic mereology (Krifka, 1989; Landman, 2016) are motivated by similar assumptions. We think that the insights of Krifka and Landman, which inform our theory, can be captured in a way that is consistent with an atomicity assumption in one's mereology.

### 3.5.2 A role for vagueness?

In one of our previous analyses of the count/mass distinction (Sutton & Filip, 2016c), we used vagueness as part of the explanation for why, say, granular properties such as `rice` can be lexicalized as mass. However, we no longer think that vagueness is a central notion for the analysis of the count/mass distinction. Indeed, we have come to realise that vagueness is orthogonal to the count/mass distinction. The main evidence for this is twofold. First, many granular properties are vertically vague, but are lexicalized as count (e.g., *bean*, *lentil*). 'Vertical vagueness' here is meant in the sense of Chierchia (2010). A predicate is vertically vague if it is vague what its atoms are. For instance, it is vague whether the smallest entity in the extension of *rice* is a whole grain, a part of a grain or a fragment of a grain as with rice flour. Chierchia (ibid.) claims, for instance, that a proper part of a (whole natural) grain of rice and its fragments are not in the extension of *rice* in all contexts.[9]

Second, as the cross-linguistic data with stubbornly distributive predicate show, even if granular properties are vague and lexicalized as mass, the objects that instantiate granular properties are accessible to the modification with stubbornly distributive predicates. Below, (2.48) and (2.75) are repeated as (3.13) and (3.14):

(3.13) ARBORIO A medium-grain Italian variety used for making the classic dish risotto. This **small, round rice** cooks to a soft, creamy consistency while maintaining a slightly firm center. [COCA]

(3.14) Context: Arborio-Reis wird gerne für die italienische Küche und besonders für Risotto verwendet.
'Arborio rice is the preferred rice to use in Italian cuisine, especially for risotto.'
Dieser sehr feine **runde Reis** kann viel Flüssigkeit aufnehmen
this very fine **round rice** can much liquid absorb

[9]This contrasts with *horizontal vagueness*. For instance it is vague what the boundary is between kittens and adult cats.

ohne aufzuweichen.
without to.soften
'This very fine round rice can absorb a lot of liquid without getting mushy. [DeTenTen13]

These facts together imply that (a lack of) vagueness with respect to what is the smallest entity in the extension of a noun is neither sufficient to predict mass/count lexicalization patterns, nor can it explain why the grains and granules in the denotations of granular mass nouns are accessible to modification via stubbornly distributive predicates. In this monograph, we identify the semantic properties that can predict when properties will be lexicalized as mass or count, and display variation patterns in their count and mass lexicalization, as well as motivate data with stubbornly distributive predicates, including those in the above examples. Our 2016 proposal (Sutton & Filip, 2016b) cannot do both of these things, nor, as we argued in section 3.1, does Chierchia's (2010; 2015) vagueness-based theory.

### 3.5.3 Quantization: The mereological property underpinning countability

Quantized sets, see (3.15), have featured centrally in Krifka's work on countability (see, especially, Krifka, 1986, 1989). A *quantized predicate/set* is a set in which no two members are in a proper-part relation (Krifka, 1989):[10]

(3.15) $QUA(P) \leftrightarrow \forall x.\forall y.P(x) \wedge P(y) \rightarrow \neg x \sqsubset y$

However, due in part to the work of Rothstein (2010) and Landman (2011) the logically stronger property of disjointness[11], given in (3.16), has become more prominent in countability theories (see, e.g., Khrizman et al., 2015; Sutton & Filip, 2016b; Vries & Tsoulas, 2018).

(3.16) $DIS(P) \leftrightarrow \forall x.\forall y.P(x) \wedge P(y) \wedge x \neq y \rightarrow \neg x \circ y$

The reason for the displacement of quantization with disjointness was arguably due to a problem that Krifka (1989, and elsewhere) himself observes, but does not provide any formal solution to, namely, expressions such as *twig* and *sequence* do not denote quantized sets, because what *(a) sequence*, for example, denotes, has proper parts that also fall under the same predicate

[10] We use the following notation: $\sqcup$ for *sum*; $\sqsubseteq$ for *part*; $\sqsubset$ for *proper part*.

[11] $DIS(P) \models QUA(P)$ but the inverse inference is not valid, since, for example, a set of two entities that overlap but do not stand in the proper part relation is quantized but not disjoint.

*(a) sequence*). However, this problem can be addressed by enriching one's countability theory with context-sensitivity à la Rothstein (2010), who in turn is in this respect inspired by Zucchi & White (1996, 2001). This is also a strategy that we pursue here, however, there are significant differences between our account and Rothstein's. One of them is that we do not assume a difference in semantic type between count and mass nouns. (See also the discussion of 'individuating contexts' below.)

It is important to emphasise, however, that incorporating context-sensitivity into one's theory does not require that we replace quantization with disjointness, as it may appear in Landman (2011, 2020) and Rothstein (2010, 2017). In fact, one might argue, as we do, that incorporating context-sensitivity into one's theory makes the replacement of quantization with disjointness unnecessary. Indeed, disjointness is a less desirable mereological property than quantization for capturing the semantics of count nouns. The reason for this is that many entities in the denotation of singular count nouns can be, and are, counted in a single given context even though they overlap. Take, for example, fences that overlap when they share corner posts, or flats in a block of flats that overlap because they share walls, and the same also applies to rooms in a flat or house, all considered from the perspective of a single particular context. Disjointness here fails to motivate the count property of the nouns *fence(s)*, *flat(s)* and *rooms(s)* precisely because of the overlap of the entities in their denotation. In contrast, quantization can, because sets of entities can qualify as quantized in the same contexts, even if the relevant entities may overlap.

We therefore defend the view that the sets of entities in the denotation of count nouns that are suitable for grammatical counting operations must merely be quantized, albeit contextually restricted, not disjoint.[12] That is,

[12]We assume that more extreme cases of overlap are ruled out on pragmatic and/or practical grounds. For example, typically, if $a \sqcup b \sqcup c \sqcup d \sqcup e$ counts as two fences with $c$ as the corner post, then the partition $\{a \sqcup b \sqcup c, c \sqcup d \sqcup e\}$ is more plausible than $\{a \sqcup b \sqcup c \sqcup d, b \sqcup c \sqcup d \sqcup e\}$ even though both of these sets are quantized and both have a cardinality of 2. We posit that the sense in which disjointness is important, then, is the practical principle that says if two competing partitions of an entity are quantized and have the same cardinality, one should adopt that which contains the least overlap. All else being equal, this principle would favour disjointness over a small amount of overlap and a small amount of overlap over a larger amount of overlap without ruling out the counting of entities which overlap such as two fences sharing a corner post.

However, quantization, even relative to context is not wholly unproblematic. See Sutton 2024b for a detailed discussion of the challenges for different mereological properties in relation to the *Problem of the Many* (Geach, 1962/1980; Unger, 1980) and count nouns such as *cloud*, which arguably have neither disjoint nor quantized reference. There, Sutton presents a weakened version of quantization and an account of the semantics of count nouns based upon it.

as in Rothstein (2010), and also Landman (2011, 2016, 2020) and Chierchia (2010, 2015, 2021), the role of context in restricting the what counts as an instance of a property will be central to our theory of count nouns, and implemented with our *context-indexed individuation schemas* (see chapter 4).

The mechanism behind such contextual restrictions is the *maximally quantized subset* relation, which is the quantization-based equivalent of Landman's (2011) maximally disjoint subset relation. If $P$ is a maximally quantized subset of $Q$, then $P$ is a subset of $Q$, and is quantized, and no other member of $Q$ could be an additional member of $P$ while $P$ remains quantized (the maximality condition). In chapter 4, we use the maximally quantized subset relation to define a *quantizing contextual parameter*, a function that applies to a set and returns a maximally quantized subset thereof. We provide the full details of how we use maximally quantizing functions in section 4.1.4. To anticipate, and in simple terms, when a property is not inherently instantiated by a quantized set of objects, but nonetheless is lexicalized as a noun that exhibits grammatical countability, this is because it is associated with a derived contextually restricted quantized set, i.e., we will use a contextual parameter, modelled as a maximally quantizing function, to derive a quantized subset of that property which is a set that is suitable for grammatical counting operations.

### 3.5.4 Context sensitivity in common nouns

Kaplan (1989) made a convincing case for the need for context-indexing of some expressions, specifically pronouns such as *I* and *you*, and indexical expressions such as *here* and *now*. Kaplan proposes that there are two sides to the meaning of expressions: character and content. Character is described as a function from contexts to content, and content, which, for present purposes can be viewed as synonymous with *intension*, is a function from worlds to extensions. Context-sensitive expressions such as *I*, *you*, *here* and *now* have a character that outputs different contents across contexts. For example, relative to one context *I am here* may be interpreted as the proposition that PETER IS IN BARCELONA and relative to another context as the proposition that HANA IS IN DÜSSELDORF. As Kaplan argues, any utterance of this sentence will be true in every context and world of utterance, even if the proposition expressed may be false relative to non-actual worlds. Non-context sensitive expressions, which, for Kaplan, include common nouns such as *person* also have a character and a content, however, their character is *fixed*, i.e., is a constant function from contexts to an intension (i.e. the same intension at every context). (See also Cooper 2023 for a broadly Kaplanian approach to semantics in a richly typed situation theoretic model, Type Theory with

Records, TTR.)

There have been many proposals in both the philosophical and linguistics literature for nouns and other expressions being context sensitive. See Recanati 2002; Travis 1978, 1997 for versions of so-called *radical context/occasion sensitivity*, as well as Musan 1999; Tonhauser 2007b for a proposal for temporally indexing common nouns *student*. Partee (1995) observes that "[p]robably almost every predicate is both vague and context-dependent to some degree" (p.332). In her view, vagueness and context-dependence are in principle independent properties, but often co-occur, and are nearly omnipresent in natural language. They enter into the interpretation of not only indexicals and demonstratives, but also of a sizeable number of open-class lexical items such as nouns, verbs, and adjectives exhibit 'mixed properties': namely, their meanings involve a combination of ordinary properties with indexical or demonstrative-like elements.

As many others, Partee assumes a Kaplanian analysis of the meanings of demonstratives and indexicals in terms of functions from contexts to intensions, whereby the latter are functions from possible situations to referents. Partee credits Fillmore (1971, 1975) with initiating the study of open-class lexical items from this 'mixed properties' perspective with his studies of the verbs *come* and *go*, *take* and *bring*, by showing that their interpretation requires an interaction of contextual factors like the location and orientation of the speaker and the hearer, and possibly also the direction of motion. Now, there are adjectives like *left* and *right* which are context-dependent but not (very) vague, and many other adjectives which are both context-dependent and vague like *nearby, far, ahead, behind, close, closest, local, foreign*. For words like *foreign*, context-dependence and perspective are not limited to spatio-temporal parameters of the context, but also include matters like political boundaries, citizenship and the like. Finally, when it comes to the context-dependence (and vagueness) of nouns, Partee mentions *giant* among others. To add to this list, we can add e.g., *neighbour*, *foreigner*, *pedestrian*, *boss*, *colleague*, *player*, *batter*, and *fielder*. For example, in a game of rounders, a person counts as a *player* only in the context of the game. Furthermore, at any one time, only one member of the batting team counts as *the batters*, and around half way through, every player that counts as *a fielder* ceases to do so, since they then are merely waiting to bat (and vice versa with the batting team).

In fact, a case can be made for context sensitivity of all common nouns, as has been also argued by Stanley & Gendler Szabó (2000) and Stanley (2002). All common nouns undergo contextual domain restriction when combined with quantifiers. For instance, *every book*, in context, is almost always restricted to some contextually relevant/salient set of books. Stanley argues, also inspired by Graff (p.c.) that this quantifier domain restriction cannot be part of the semantics of the quantifier (as in e.g., von Fintel 1994, pp. 29–30), but must be located in the nominal restrictor of a quantified DP to the context of utterance, i.e., each nominal restrictor co-occurs with a domain index. Hence, we should not speak of 'quantifier domain restriction', but rather of 'nominal restriction'. This is the essence of Stanley's Nominal Restriction Theory (NRT)

(3.17) The tallest person is nice.

If context (or domain) indexing occurs on the determiner in (3.17), rather than on *person*, its denotation will be the set of all people in the universe/world, and the set that results from applying 'tallest' to 'person' is the singleton set, namely, whoever is the tallest person in the world. However, in evaluating *tallest person* in (3.17), one does not select the tallest person in the world, but the tallest person in the contextually relevant domain, e.g., the tallest person in the room, at Cornell University. Stanley concludes, that the semantics of nominals must be associated with a *domain index*.

These data have been challenged, however, by Schwarz (2009), who argues that the locus of contextual domain restriction should be in the DP. Even so, Schwarz (ibid.) assumes that common nouns are context sensitive insofar as, for him, all nouns are interpreted relative to situations, and situations play the dual role in his account of both (partial) worlds of evaluation, and local contexts of interpretation.

Such intuitions concerning the context-dependence of common nouns (as reflected in observations and proposals by Partee (1995), Stanley (2002), and others) can, we propose, be interpreted in Kaplanian terms as follows: All common nouns express Kaplanian functions from contexts to intensions, where some contextually provided property is intersected with the extension of the common noun. For instance, if $\mathit{MAX\_HEIGHT}$ applies to a set and returns the singleton set containing only the member with the greatest height, then, given some value for the contextually salient intersection property $\mathtt{f}(c)$ in the lexical entry for *person* will make the correct prediction that *tallest person* denotes singleton set containing the person tallest relative to some contextually salient domain restriction:[13]

(3.18) $[\![\text{person}]\!] = \lambda c.\lambda w.\lambda x.\mathtt{person}(w)(x) \wedge \mathtt{f}(c)(w)(x)$

(3.19) $[\![\text{tallest}]\!] = \lambda \mathcal{P}.\lambda c.\lambda w.\lambda x.\mathit{MAX\_HEIGHT}(\mathcal{P}(c)(w))(x)$

(3.20) $[\![\text{tallest person}]\!] =$

[13]This proposal is not inconsistent with allowing for the fixing of the value for $\mathtt{f}$ in $c$ to be done at the DP level.

$$\lambda c.\lambda w.\lambda x.MAX\_HEIGHT(\texttt{person}(w)(x) \wedge \texttt{f}_{c,w}(x))$$

Crucially, such an argument applies equally to mass nouns. DPs such as *the heaviest furniture* and *the cleanest water* can denote furniture that is the heaviest and water that is cleanest in the local context.

### 3.5.5 Kaplanian contexts and the semantics of countability

Context sensitivity also plays a central role in the theories of countability. It is now widely recognised that an adequate theory of count nouns requires the incorporation of some kind of parameter that allows for more fine-grained variation in the interpretations of (at least some) count nouns than interpretation relative to possible worlds affords us, and specifically that this parameter be expressed via indexing to context. It is one of the key contributions of Susan Rothstein to integrate context directly into the lexical semantics of nouns (e.g., Rothstein, 2010, 2017) by means of *counting contexts* that encode counting perspectives (Rothstein, 2010). Chierchia (2010) relies on *ground contexts*, Landman (2011) on *contexts* determining contextually minimal parts, and Sutton & Filip (2016b) on a two-dimensional conception of context.

The main motivation for such a contextual parameter is that, for at least a subset of count nouns, what counts as 'one' can vary across contexts. As discussed above, a good example is *fence*, which is also one of Rothstein's paradigm examples: fencing around a rectangular field can count as one fence from one perspective and as four fences from others. Other English count nouns that display similar variation include *sequence* and *twig* (see Krifka 1989 and Partee p.c., mentioned therein, as well as Zucchi & White 1996, 2001), *wall*, *hedge*, *road*, and *fence*, among many others (see chapter 2).

The idea of how the requisite notion of 'counting perspective' (in Rothstein's terms) or context ought to be best thought of is clearly articulated in Rothstein (2010, p. 362):

> As our discussion of nouns like *fence* and *wall* showed, count nouns do not necessarily presuppose a specific set of salient atomic entities; instead, the model needs to specify a context-dependent choice of atomic elements relative to which the count noun is derived, and count noun denotations must specify the context in relation to which they are to be interpreted. In general, along with specifying contextual parameters such as those that provide values for indexicals, time and location, part of specifying a context is specifying what are the set of 'things which count as one for the purposes of counting'. The choice of this counting parameter is determined by discourse considerations and

is updated ceteris paribus in the standard way (see e.g., discussion in Partee et al. (1990/1993, §15).

In the above quote, Rothstein (2010) points to Partee et al. (1990/1993, §15.5) for a discussion of how the above suggestions can be implemented. There the notion of context is modelled as a tuple of parameters. For example, for a context $c$, the utterer, addressee and time of utterance in the context can be modelled as $c = \langle c_{utt}, c_{add}, c_{time} \rangle$ such that $c_{utt}$ and $c_{add}$ are entities in the domain of type $e$ and $c_{time}$ is a time (interval). The interpretations of context sensitive expressions can then be modelled in terms of specific parameters of the context (accessed, e.g., by projection functions).

Although neither Rothstein nor Partee et al. explicitly mention the work of Kaplan (1989), this conception of context is essentially Kaplanian, and some confirmation for this idea can also be seen in the observations of Partee (1995) regarding context-dependence and vagueness (see above). As Partee et al. (1990/1993, §15.5) point out, the set of contextual parameters can be extended as needed (i.e., beyond those highlighted by Kaplan). Informally, at least, this is precisely Rothstein's proposal: we should extend the set of contextual parameters to include *counting contexts* relative to which count nouns are interpreted. In this sense, Rothstein's theory of (at least some) count nouns is an indexical one, as also her quote above suggests.

### Comparison with Rothstein's Theory

However, despite being Kaplanian in spirit, perhaps in order to simplify her formal theory, Rothstein (2010) implements this idea in a non-Kaplanian way. As we outlined in section 3.4, for Rothstein, count nouns denote *semantic atoms* of type $e \times k$ "entities that in the given context $k$ count as atoms and thus can be counted" (ibid., p. 364). Mass nouns denote regular entities of type $e$. This guarantees that the interpretation of singular count predicates is a set of contextually discrete, mutually non-overlapping (or disjoint) atoms. The result of this analysis is that (i) count nouns and mass nouns are interpreted as expressions of different types ($\langle e \times k, t \rangle$ and $\langle e, t \rangle$, respectively; and so (ii) effectively only count nouns, but not mass nouns are treated as having a Kaplanian character.

Our proposal, however, differs from Rothstein's in respect to both (i) and (ii), even if we agree with her strategy of integrating context directly into the lexical entries of nouns. Prior to providing our formal model, we will, therefore, briefly discuss why we reject (i) and (ii), and also further distinction between our approach and that of Rothstein (ibid.).

Our proposal is to embrace the Kaplanian intuitions of Rothstein and to model (at least some, but not all) count nouns as indexical-like expressions with non-fixed (i.e., variable) characters. However, we will implement these ideas in a way that is closer to Kaplan's proposal. This, as we will show, does not lead to a type-distinction between count and mass nouns, a key difference between our and Rothstein's theory. In addition, we argue for a different analysis of the contextual parameter that is relevant for countability. To terminologically distinguish this parameter from Rothstein's *counting contexts*, we call this the *quantizing contextual parameter*.

**Semantic type distinctions.** In contrast to Rothstein, our proposal is that all common nouns, be they mass or count, are interpreted with a Kaplanian character (a function from contexts to intensions). Thus count and mass nouns are of the same semantic type. The difference between count and mass nouns, on our analysis, is that only the intensions of count nouns specify a quantized set of entities at each context. Mass nouns do not.

Let us briefly elaborate on some theory independent reasons for not adopting a type distinction between count and mass nouns. They concern the distributions of adjectives, determiners, and classifier-like expressions. Many adjectival expressions do not select between count and mass nouns. For example:

(3.21) a. I picked up and carried a {grey | heavy} {cat | chair}.
b. I picked up and carried some {grey | heavy} {furniture | gravel}.

If count and mass nouns are interpreted as expressions of distinct types, then we would need to analyse all such adjectives as polysemous between modifiers of count-noun-type expressions and modifiers of mass-noun-type expressions.

Similarly, not all determiners or articles select for countability:

(3.22) a. the {cat(s) | chair(s) | furniture | gravel}
b. no {cat(s) | chair(s) | furniture | gravel}
c. all {cats | chair(s) | furniture | gravel}

Finally, there are many classifier-like pseudo-partitive constructions that select for expressions that denote cumulative predicates (mass or plural), but not for only count or only mass nouns:

(3.23) a. piles of {kittens | chairs | furniture}
b. {buckets | bags | boxes} of {apples | beans | rice | sand}

Put in the simplest terms, provided one has a semantic means of distinguishing count from mass nouns one can account for the distribution of e.g., numeral expressions without requiring adjectives, determiners or classifier-like expressions to be interpreted as type-polysemous expressions. It is therefore not clear what advantage a type distinction between count and mass nouns offers us.

**Quantizing contextual parameter versus counting contexts.** In lieu of Rothstein's (2010) counting contexts $k$, we propose a *quantizing contextual parameter* that differs from counting contexts in two ways. Rothstein's counting contexts $k$ are subsets of the domain that are disjoint in default cases. Our quantizing contextual parameter will be modelled as a maximally quantizing function, namely a function from subsets of the domain to maximally quantized subsets thereof. The first difference, then, is that we use quantization, a logically weaker property than disjointness (or contextually discreteness/non-overlap, see above), and we have already provided reasons for favouring quantization over disjointness in §3.5.3.

The second difference is that our quantizing contextual parameter is typed as a function on sets of entities of type $\langle\langle e,t\rangle,\langle e,t\rangle\rangle$, not, like counting contexts, as sets of entities. Because Rothstein's counting contexts are subsets of the domain of entities, a distinction between default and non-default context is needed in order to deal with examples such as *I can move my hand and my five fingers* which are assumed to be interpreted relative to non-default contexts that do not enforce disjointness (non-overlap). Disjointness (non-overlap) is a constraint on default contextual interpretations. The reason this is required is because, otherwise, hands and fingers could not be counted relative to the same context (Rothstein, 2010, p. 364). Concretely, if $[\![\text{my hand}]\!] = h$ and $[\![\text{my five fingers}]\!] = f_1 \sqcup f_2 \sqcup f_3 \sqcup f_4 \sqcup f_5$ such that $f_1 \sqcup f_2 \sqcup f_3 \sqcup f_4 \sqcup f_5 \sqsubset h$, then there is no default (i.e., disjoint) counting context $k$ in which both $f_1 \sqcup f_2 \sqcup f_3 \sqcup f_4 \sqcup f_5$ and $h$ are members of the domain intersected with $k$, so no $k$ at which *my hand and my five fingers* would be interpretable.

We do not require the default/non-default context distinction, since our individuating contexts are functions from predicates to (maximally) quantized predicates. For example, the same individuating context $c$ applies to the interpretation of *hand* and to the interpretation of *fingers*, yielding a quantized set of hands and a quantized set of fingers. Assuming a mereological sum based interpretation of DP conjunction, a conjunctive construction such *my hand and my five fingers* will just be $[\![\text{my hand}]\!]^c \sqcup [\![\text{my five fingers}]\!]^c = h \sqcup f_1 \sqcup f_2 \sqcup f_3 \sqcup f_4 \sqcup f_5$, which simplifies to $h$, the correct result.

## 3.6 Summary

The above observations suffice to illustrate some obstacles that state of the art theories of the count/mass distinction face, when applied to a wider range of data that concern the variation with respect to count/mass lexicalization patterns in a particular language and cross-linguistically, and the distribution of stubbornly distributive predicates. Chierchia's and Landman's theories represent two among the most sophisticated ones today, and yet a unified account of this variation seems outside of their scope. This is because *ex hypothesi* they treat object mass nouns as puzzling, given that they are, for want of a better term, 'notionally count', while count granular and filament nouns are problematic, given that they are treated as, for want of a better term, 'notionally mass'. Put differently, properties like `furniture` or `jewellery`, which in English are lexicalized as object mass nouns, on the one hand, are assumed to be a fundamentally different sort than granular properties like `bean` or `lentil` and filament properties like `hair`, on the other. We propose that this is not the case. All of these properties are instantiated by objects and so the pertinent question to answer is whey any of them can be lexicalized as mass.

We have also argued in favour of a theory of countability that is context sensitive, and have suggested that this can be incorporated naturally into a Kaplanian model of context to which all common nouns (count or mass) are sensitive. We have proposed that count nouns should specify a quantized set relative to such a context.

In the next chapter, we combine these ideas into our *object-centred, contextualist account.*

# Chapter 4

# An object-centred, contextualist theory of countability

In this chapter, we provide theoretical tools for our object-centred contextualist theory of countability, which relies on a context-indexed version of the mereological property of quantization, which was originally defined by Krifka 1986.

Recall, in chapter one, our main overarching question:

> Main Question
>
> **What underpins the connection between variation in count/mass lexicalization patterns and the non-canonical reflexes of the count/mass distinction that we find across and within languages?**

In this chapter, we show how our approach to countability provides an answer to the above main question. In pursuit of this answer, we pose more specific questions:

QUESTION 1 **What are the necessary conditions for a core property to be lexicalized as count?**

QUESTION 2 **What are the necessary conditions for a concrete noun to be felicitous with stubbornly distributive predicates?**

QUESTION 3 **Why are the non-canonical reflexes of countability restricted to felicitous use with stubbornly distributive predicates, for instance, and not use in numeral constructions and with strong universal quantifiers such as *each* and *every*?**

The first two questions are motivated by our empirical observations summarised in chapter 2, and repeated here below for convenience:

**Observation 1: stubbornly distributive predicates and the canonical reflexes of count nouns**

Canonical count nouns, but not canonical mass nouns, are felicitous with stubbornly distributive predicates.

**Observation 2: count/mass variation and stubbornly distributive predicates**

If a core property displays variation in its count/mass lexicalization patterns, then mass nouns that lexicalize this core property are felicitous with stubbornly distributive predicates.

Our account provides answers to all the three questions in a unified way, while also dealing with challenges to some previous influential accounts that we laid out in chapter 3. The remaining questions, (4a) and (4b), will be addressed in chapter 5).

QUESTION 4A **Why can properties that are instantiated by objects be lexicalized as mass nouns at all?**

QUESTION 4B **Why are some of these properties more frequently lexicalized as count and others more frequently lexicalized as mass?**

Questions 1 and 2 arose based upon our, perhaps surprising, empirical observations in chapter 2: there is a strong correlation between core properties that display variation in their count/mass lexicalization patterns, on the one hand, and core properties that underpin nouns that display non-canonical reflexes of the count/mass distinction, on the other hand. Specifically, regarding non-canonical reflexes of the count/mass distinction in chapter 2, we observed that stubbornly distributive predicates are felicitous not only with all count nouns, precisely because they have objects in their extension, but also with some classes of mass nouns. While it is well known that object mass nouns (e.g., *furniture*, *kitchenware*) can be modified with stubbornly distributive predicates, we showed that stubbornly distributive predicates are also felicitous with all granular and filament mass nouns (e.g. *rice*, *gravel*), as well as with mass nouns that we refer to as *Interconnected* mass nouns (e.g., *fencing*, *hedging*).

As we also showed in chapter 2, the vast majority of the properties underpinning object mass nouns, granular and filament mass nouns, and *Interconnected* mass nouns also display variation in their count/mass lexicalization patterns. E.g., *furniture*, and *asparagus* are mass nouns in English, and all are felicitous with stubbornly distributive predicates, and the relevant properties (e.g., `furniture` and `asparagus`) are lexicalized as count in other languages (e.g., in Finnish *huonekalu-t* 'item-s of furniture, and in French *asperge-s* 'asparagus (spear-s)'), or either as count or mass in the same language (e.g., in Dutch *meubel-s*/*meubilaire* 'item-s of furniture/furniture', see Landman 2011).

Our theoretical claim is that the answers to both Question 1 and Question 2 are based upon ***objects***. In answer to Question 1, we propose that, at least for concrete nouns, only core properties that are instantiated by objects can be lexicalized as count. In answer to Question 2, we claim that, at least for concrete nouns, to be felicitous with stubbornly distributive predicates requires that they denote objects. Notice, importantly, that the group of nouns with objects in their extensions cuts across the count/mass divide. In short, and put in the simplest terms, such considerations motivate that objects, and whether they are instantiations of a core property, are central to the theory that we propose in this book, and introduce in detail in this chapter.

Our theory is ***contextualist***, which is essential to our answers to Question 3. Since the group of nouns with objects in their extensions cuts across the count/mass divide, objects alone are insufficient to explain, e.g., when a noun can be used in a numeral construction. Our contextualist approach is in turn largely motivated by the mereological property of quantization that, on our view, underpins countability (see chapter 3), albeit in an updated form that improves on the original proposal by Krifka (1989): namely, here quantization is recast in context-dependent terms (see also an independent proposal along these lines in Filip 2000). The reason why we need contextualism is because what counts as 'one' for many count nouns varies from occasion to occasion. For instance, contextualism allows us to address the well-known problem posed by count nouns like *fence* that fail to be quantized on the original context-independent sense as defined by Krifka (1989) (see Krifka 1989; Rothstein 2010; Zucchi & White 1996, 2001 and Partee p.c.).

We, therefore, propose that not only do concrete count nouns denote objects, but also they specify a quantized set of objects for counting relative to context. We formalise the contextualist elements of our theory within a version of the contextualist semantics in Kaplan 1989. Our inspiration also comes from some previous work emphasising that all common nouns are context sensitive, albeit for reasons that are independent of those that drive our analyses (see chapter 3).[1]

We show that the context sensitivity of common nouns, and specifically context sensitivity with respect to what counts as one individuated ***object*** which matters for our theory, can be formalised as one parameter in a Kaplanian-style context. It amounts to fixing a quantized set of objects for the purposes of counting, which is just another such parameter. We argued in chapter 3 that common nouns have a Kaplanian character, i.e., they are interpreted as functions from contexts to intensions. In this section 4.1, we formalise this idea from Kaplan (1989) in a system based upon TY2 (Gallin, 1975). This allows us to specify the two ways in which core properties underpinning common nouns can be lexicalized: as either in an object-centred way, resulting in a count noun, or in an object neutral way, resulting in a mass noun.

In section 4.2, we argue for a combination of this model with a theory of the lexicon that presupposes that common nouns have lexical entries consisting of two parts (originally proposed by Landman, 2011): one that specifies an 'extension set' (what the noun denotes) and the other a 'counting base set' (what counts as 'one' in the extension of the noun). We argue that this lexical bi-partite structure is needed to motivate the existence of co-extensional pairs of singular mass nouns and plural count nouns, such as *change* and *coins*, within a particular language, or *furniture* and *huonekalu-t* ('items of furniture', Finnish) across different languages.

Finally, in section 4.3, we apply our model to the analysis of the combinations of stubbornly distributive predicates with count nouns, and crucially also with mass nouns, specifically with granular and filament mass nouns. We propose that stubbornly distributive predicates select for nouns with objects in their extensions (i.e., nouns that lexicalize an object-instantiated core property). Crucially, the class of nouns that have objects in their extensions

[1] To recapitulate the main points in chapter 3, Stanley & Gendler Szabó (2000) and Stanley (2002) argue that all common nouns are context sensitive insofar as their domains are systematically restricted in DPs by their common nouns. Furthermore, that common nouns can be directly associated with domain indices or other devices like context parameters that restrict their interpretation relative to extra-linguistic context has been also suggested under different guises elsewhere. For instance, Tonhauser (2007a), inspired by DRT (Kamp, 2001a,b; van der Sandt, 1992), proposes that common nouns like student have a bi-partite lexical structure, where the first element represents the context-dependent meaning, which must be resolved in the context (i.e., specifically interpreted at the verbal predication time unless there exists contextual justification to the contrary) and the second represents the context-independent meaning.

cuts across the lexical count/mass divide.

## 4.1 The object-centred, contextualist model

Our contextualist theory of the count/mass distinction analyses all common nouns (count or mass) as context sensitive, because all common nouns display contextual domain restriction (see, e.g., Stanley 2002). However, the ways in which common nouns are context sensitive can be distinguished. For mass nouns the question of what counts as one object in their extensions does not arise. Many count nouns (e.g., *cat*, *chair*) denote objects and what counts as 'one' for them is stable across contexts. However some count nouns (e.g., *fence*), have an additional layer of context sensitivity. For them, what counts as *one object* in their extensions can vary.[2]

Formally, our contextualist theory of count nouns presupposes that common nouns are interpreted relative to Kaplanian contexts of utterance. We analyse count nouns such as *fence* as having a context-indexed, OBJECT-CENTRED quantizing function in their lexical entries which sets them apart from canonical count nouns.

We provide the formal model for this theory in section 4.1.1. We define a modified $\mathbf{TY_2}$ functional logic that enables us to model the 'two-dimensional' aspect of Kaplan's approach to indexicals simply as functions from contexts to intensions.[3] In section 4.1.2, we argue for a conception of objects that goes well beyond Spelke objects, which are taken to play a role in the cognitive grounding of the count/mass distinction. On our account, what is 'one' object also includes functional units, such as a house in a row of terraced houses, which are not Spelke objects, as they were originally understood. In section 4.1.3, we define an extended version of Kaplanian contexts in our semantics. An central ingredient in our theory will be our quantizing contextual parameter which we subsequently use to define *Object-centred quantizing functions*: namely, functions which apply to core properties (e.g., `ball`, `fence` etc.) and output a property that, at each context, is instantiated by a quantized set of objects. Importantly, we restrict the application of context-indexed quantizing functions to properties that are instantiated by objects. Then, in section 4.1.4, we use this model to outline a theory which

[2]This proposal is, in part, inspired by some implicit assumptions in the work of Susan Rothstein.

[3]One could also develop a richly typed semantic model. Indeed, Type Theory with Records (TTR, see e.g., Cooper 2012) is a richly typed semantics theory that has recently been enriched in Cooper 2023 with a model of context that is broadly Kaplanian, but also develops and enriches the notion of context in e.g., Ranta 1994.

has the following three core characteristics:

(i) count nouns and mass nouns are interpreted as expressions of the same type, as functions from contexts to intensions;

(ii) some count nouns have a variable Kaplanian character;

(iii) however both mass nouns and some 'naturally atomic' count nouns have a constant character with respect to their individuation criteria (even if they are context sensitive in other ways, namely, as allowing for contextual domain restriction in DPs).

Moreover, we account for the possibility of variation in count/mass lexicalization patterns, given the necessary condition that a core property is instantiated by objects. We put forward an account of the two ways core properties can be lexicalized as common nouns: in an object-centred way, resulting in a count noun, or in an object neutral way, resulting in a mass noun, thus giving us the mechanism behind accounting for variation in crosslingustic mass/count lexicalization patterns.

### 4.1.1 Semantic model: A Kaplanian contextualist semantics in a modified $\mathbf{TY_2}$

Our semantic model is based on an enrichment of the functional, two-sorted, type logic, $\mathbf{TY_2}$ (Gallin 1975, see also Muskens 1995, ch. 2). We make two adjustments to $\mathbf{TY_2}$: first, we make use of product types and, second, we assume a set of four basic types, $e$, $t$, and two distinct basic types for worlds and times, $w$ and $i$. Thus we are technically using a $\mathbf{TY_3}$ logic enriched with a product type constructor, which, as we will show, allows us to provide a functional type logic rendering of a Kaplanian two-dimensional semantics (Kaplan, 1989) in which certain expressions (e.g. nouns and pronouns) are interpreted as functions from contexts to intensions. This is motivated by our goal to analyse count nouns as those expressions that specify a quantized set of entities relative to a context, and mass nouns as those expressions that fail to do so.

First, we will detail how we modify $\mathbf{TY_2}$ and we provide a model of Kaplanian contexts within this system.

#### Adjustments to $\mathbf{TY_2}$

Gallin and Muskens assume three basic types: $e, t, s$, for individuals, truth values and world-time pairs, respectively. Since contexts will include time indices, we assume that type $s$ is the type for possible worlds, and we reserve a separate type ($i$) for time intervals. We thus have four basic types $e, t, s, i$. As is standard, functional types are defined recursively from basic types, such that if $\tau, \sigma$ are types, then $\langle \tau, \sigma \rangle$ is a type of functions from expressions of type $\tau$ to type $\sigma$. As can be seen in (4.1c), we further enrich $\mathbf{TY_2}$ by also allowing the construction of product types (see, e.g., Carpenter, 1997).[4] The product type constructor will be essential for our bi-partite view of the lexicon discussed in section 4.2.3 in which common nouns will denote a pair of sets, one that specifies the extension, the other which determines what counts as 'one'.

(4.1) **Type**, the set of types, is the smallest set such that:

a. $e, t, s, i \in \mathbf{Type}$
b. If $\tau, \sigma \in \mathbf{Type}$, then $\langle \tau, \sigma \rangle \in \mathbf{Type}$
c. If $\tau, \sigma \in \mathbf{Type}$, then $\tau \times \sigma \in \mathbf{Type}$

The product type constructor is recursive and associates to the right. We introduce the following notational convention:

(4.2) **Notational convention (product types):**
$\tau_1 \times (\tau_2 \times (... \times (\tau_{n-1} \times \tau_n))) \mapsto \tau_1 \times \tau_2 \times ... \times \tau_{n-1} \times \tau_n$

Product types, like functional types, have domains defined in terms of the types out of which they are constructed:

(4.3) **Domains of functional and product types.**
For any types $\tau, \sigma$, $D_\tau$ is the domain of type $\tau$ such that

a. For any types $\tau, \sigma$, $D_{\langle \tau, \sigma \rangle} = D_\sigma^{D_\tau} = \{f | f : D_\tau \to D_\sigma\}$;
b. For any types $\tau, \sigma$, $D_{\tau \times \sigma} = D_\tau \times D_\sigma$;

In addition to the standard definitions of well formed expressions of type $\tau$ ($WFE_\tau$), following ibid., p. 65, ordered pairs of well formed expressions are also well formed expressions and projection functions applied to a well formed expression is a well formed expression when the latter is is of a product type:

(4.4) **Well formed expressions for product types.**

a. If $\alpha \in WFE_\tau$ and $\beta \in WFE_\sigma$, then $\langle \alpha, \beta \rangle \in WFE_{\tau \times \sigma}$
b. If $\alpha \in WFE_{\tau \times \sigma}$, then $\pi_1(\alpha) \in WFE_\tau$
c. If $\alpha \in WFE_{\tau \times \sigma}$, then $\pi_2(\alpha) \in WFE_\sigma$

[4]We could reconstruct Gallin's type $s$ in terms of product types (for Gallin, such pairs are characterised in the meta-theory).

This yields a model that differs from $\mathbf{TY_2}$ only with respect to basic types (4.1a) and the addition of a type constructor (4.3b). We will call this logic $\mathbf{TY_{3\times}}$. The model we assume is given in (5), which, following Carpenter 1997, p. 66 is a conservative extension to a predicate logic based upon the simply typed $\lambda$-calculus with the addition of a product type constructor, where the interpretation of product types is given in clause (i).

(4.5) A Model $\mathbb{M} = \langle D, \mathcal{I} \rangle$ such that $\mathcal{I}$ the interpretation function and $D$, a frame, is a set of entities of basic types. For example, $D_e$ is the set of entities (including objects and stuff), $D_t = \{0, 1\}$, $D_s$ is the set of worlds, and $D_i$ is set of times. The value of $[\![\mathrm{X}]\!]^{M,g}$ on $\mathbb{M}$ under a variable assignment $g$ is defined as:

(a) For any constant $a$ of type $\tau$, $[\![\mathrm{a}]\!]^{M,g} = \mathcal{I}(a)$

(b) For any variable $v$ of type $\tau$, $[\![\mathrm{v}]\!]^{M,g} = g(v)$

(c) $[\![\beta(\alpha)]\!]^{M,g} = [\![\beta]\!]^{M,g}([\![\alpha]\!]^{M,g})$

(d) $[\![\neg\phi]\!]^{M,g} = 1$ iff $[\![\phi]\!]^{M,g} = 0$

(e) $[\![\phi \wedge \psi]\!]^{M,g} = 1$ iff $[\![\phi]\!]^{M,g} = 1$ and $[\![\psi]\!]^{M,g} = 1$

(f) $[\![\forall x_\tau.\phi]\!]^{M,g} = 1$ iff for all $a \in D_\tau$, $[\![\phi]\!]^{M,g[x:=a]} = 1$

(g) $[\![\lambda x_\tau \alpha_\sigma]\!] = f \in D_\sigma^{D_\tau}$ such that for all $a \in D_\tau$, $f(a) = [\![\alpha]\!]^{M,g[x:=a]}$

(h) $[\![A = B]\!]^{M,g} = 1$ iff $[\![A]\!]^{M,g} = [\![B]\!]^{M,g}$

(i) i. $[\![\langle\alpha, \beta\rangle]\!]^{M,g} = \langle[\![\alpha]\!]^{M,g}, [\![\beta]\!]^{M,g}\rangle$
 ii. $[\![\pi_1(\alpha)]\!]^{M,g} = a$ and $[\![\pi_2(\alpha)]\!]^{M,g} = b$ iff $[\![\alpha]\!]^{M,g} = \langle a, b\rangle$

Clause (i) states that, the interpretation of an ordered pair of expressions $\langle\alpha, \beta\rangle$ is a pair of the interpretations of $\alpha$ and $\beta$. This clause also defines the projection functions $\pi_1$ and $\pi_2$ that map a pair to the first and second members of that pair, respectively.

For a linguistic expression $\alpha$ of syntactic category $C$, where $[_C\ \alpha]$ and a mapping from $[_C\ \alpha]$ to an $\lambda$-calculus expression $o$, if the interpretation of $o$ in the model is $p$, then, as is common practice, we will slightly overload the use of $[\![\cdot]\!]$.:

(4.6) $$[\![[_C\ \alpha]]\!]^{M,g} = [\![o]\!]^{M,g} = p$$

Furthermore, where we are more interested in the mapping to an expression of the $\lambda$-calculus, we will sometimes drop the interpretation brackets around this expression, and simply write:

(4.7) $$[\![[_C\ \alpha]]\!]^{M,g} = o$$

### 4.1.2 Objects

Objects, understood pre-theoretically, are characterized by Soja et al. (1991, p. 183) as "bodies that are cohesive, bounded, spatiotemporally continuous, and solid or substantial; they move as connected wholes, independently of one another, on connected paths through unoccupied space". The set of such *Spelke objects*, as they are commonly known, subsumes both natural units such as apples and cats as well as some artefacts, including chairs, doors and children's building blocks since all of these objects are cohesive and bounded etc.

A notion of 'object' based on the definition of a Spelke object, has influenced much valuable work in the theories of the count/mass distinction in recent years. Some examples of such theories are those that centre on integrated wholes (Moltmann, 1997), maximally strongly self-connected entities (mereotopology in Grimm 2012; Wągiel 2019, based upon Casati & Varzi 1999), and it can also be detected in spatiotemporal haptomereology of Krifka 2021, which emphasises the persistence of bounded objects through space and time. This notion of object could be roughly captured as:

(4.8) **Objects (first pass):**
$\mathsf{O}(\mathsf{w}) \subseteq \mathsf{D}_e : \forall \mathsf{x}.\mathsf{O}(\mathsf{w})(\mathsf{x}) \leftrightarrow \mathsf{x}$ *is a Spelke object.*

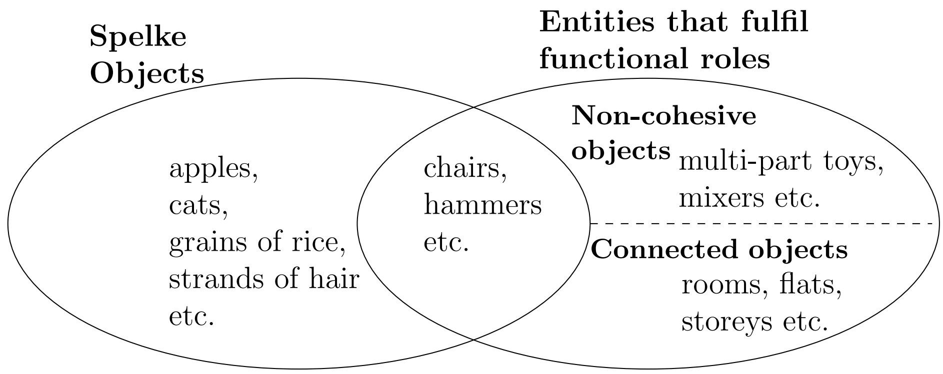
Notice that the above quoted passage that defines Spelke objects applies equally well to entities with a smaller granularity, such as grains of rice and pieces of thread, as they are also cohesive, bounded, spatiotemporally continuous, and solid or substantial; they move as connected wholes, independently of one another, on connected paths through unoccupied space. Therefore, taking this definition at face value, we claim that such granular and filament entities are as much objects as apples or boulders, although not usually considered to be Spelke objects.

However, the notion of 'Spelke object' is not broad enough to capture many things that intuitively count as objects. Those entities not included in the definition of Spelke objects fall into two groups, both of which are subsets of the set of entities that fulfil functional roles, many of which are artefacts (we do not assume that all entities that fulfil functional roles are artefacts, see chapter 5). The first group are entities that that fulfil some functional role but are not cohesive or bounded in the requisite fashion. We call these *non-cohesive objects*. For example, a multi-mixer that comes with many different cutting and slicing attachments is a device and intuitively also an object that has a certain function, but it is not straightforwardly cohesive or bounded, since it is not the case that all of the parts of such devices can be fitted together simultaneously (one cannot typically slot in the chopping and grating blades simultaneously, for instance). Another similar example would be multi-part toys like *Potato Head*. The toy, all its parts taken together, intuitively can count as an object, but it is not the case that all can be slotted together at once at any single time. Despite the fact that these objects are not cohesive objects, there is an important sense in which we learn, albeit through latter stages of linguistic development, to be able to class them as single items. Brooks et al. (2011) find that younger infants count broken pieces of some entities each as one (e.g., a fork broken in half as *two*. In this sense, counting Spelke objects is more deeply encoded in our conceptual make-up. Nonetheless, by a relatively young age, we seem to learn to count also in terms of function.

The second group of objects we focus on are a subset of entities that fulfil some functional role. Entities in this group do not fit into the definition of a Spelke object because they do not 'move as connected wholes, independently of one another'. Call these *connected objects*. Examples include the houses in a terrace (i.e., a row of houses), the storeys of each house and the rooms on each storey. The houses and rooms share walls with other houses and rooms and the floors of some storeys are the ceilings of others. These objects cannot move independently of one another precisely because they are connected. They are also not the kinds of things that can be picked up or moved around. The findings of Brooks et al. (ibid.) seem to suggest that at some stage of linguistic development, children are nonetheless able to treat these objects as discrete entities. We hypothesise that this is the case because that they form units in virtue of having a certain purpose or function, even if they are connected to (and overlap with) other objects. Objects like connected fences also fall into this category since two fences can each count as an object even if they share a corner post (even if the corner post is a part of both of them).

Objects in both of these groups, whose boundaries are determined, at least in part, by their function, are therefore problematic for a solely (mereo-)topological conception of 'object' based on Spelke objects. Indeed, in recognition of this problem, Grimm & Levin (2017) extend the mereotopological account of Grimm (2012) to artefact nouns, such as *furniture*, via the inclusion of *minimal events* in the lexical entries of artefact nouns (see chapter 5.1.3 for further discussion of this proposal). It is important to mention, however, that there are entities, such as hammers and chairs, which have both stable spatiotemporally boundaries (and hence are Spelke objects) and also have boundaries that are determined by some function or role they assume. This means that the set of Spelke objects and the set of such 'functional' objects do not have an empty intersection. The connection between Spelke objects and the different kinds entities that fulfil functional roles is outlined in figure 4.1.

Figure 4.1: Types of objects, both Spelke objects and objects that fulfil functional roles.




In order to include in the domain of objects also entities that are viewed as objects in virtue of fulfilling some intended role or function at a given context, we define a set of objects at each world $O^+$, as in (4.9). For any world, $w$:

(4.9) **Objects (final version):**
$O^+(w) \subseteq D_e$ such that:
$\forall x. x \in O^+(w) \leftrightarrow$ $x$ *is a Spelke object or*
$x$ *is a physical entity that fulfils some functional role.*

We will not, in this work, provide what would undoubtedly be a complex theory of functional roles and how entities fulfil these functional roles. but instead assume these notions as basic.[5]

It is important to note that the set $O^+(w)$, at least in the actual world, is not quantized. For example, single fences can count as objects (in virtue of their perceptual and functional properties, but, if they are connected, their sum can also count as an object). Furthermore, a mortar and pestle can plausibly count as an object since the parts of this entity have a joint function (that of grinding spices etc.), and the two wings on an aeroplane can count equally as one object or two (think of a biplane for example, the wings could be thought of as two objects, four objects, or perhaps even three objects[6]).

The distinction between objects which rely on a notion of functional role

[5] An additional restriction on the definition of *object* may also be required, namely that the physical entity is not undifferentiated stuff.

[6] The top wing on a biplane is one piece, but sometimes two pieces comprise the lower wing(s), each of which is attached to the fuselage.

and those that do not can be seen in *used as* constructions[7] and in *makeshift* constructions in which the use of a functionally characterised entities is felicitous, as the argument of *as* in the PP or of *makeshift* in the VP.[8]

(4.10) a. These boxes/This log can be used as a coffee table.
b. The planks/stones were used to form a makeshift wall.
c. Before the development of modern prostheses, wooden poles were used as legs by those who had had theirs amputated.
d. We could use the kitchen as a dining room during the renovation.

(4.11) a.??This coffee table could be used as a log.[9]
b.??The hill can be used as a mountain.
c.??We used a large bush as a makeshift tree.
d.??This pear/ball can be used as a makeshift apple.

As we will shortly elaborate in the remains of this section and also in section 4.1.4, the distinctions between Spelke objects and objects that fulfil functional roles will play an important role in our account of countability. Specifically, there are some core properties, namely those which are instantiated by connected objects, such that these objects form a non-quantized set of entities e.g., `fence` and `wall`. This semantic feature of these properties, we claim, explains why there are mass lexicalizations of these properties and why, for count lexicalizations of these properties, these count nouns non-canonical reflexes with regard to tests for countability (see chapter 2).

### Objects, MSSC entities, and integrated wholes

Let us briefly consider whether our use of object can be subsumed by or equated with the previously developed conceptions of objects and wholes in the literature. We will consider two of these. The first is an *integrated whole* as defined formally by Simons (1987), and applied to numerous linguistic phenomena, including the count/mass distinction, by Moltmann (e.g., Moltmann 1997, 1998). The second is a *maximally strongly self-connected* (MSSC) entity as formally defined by Casati & Varzi (1999) and applied to the count/mass distinction by Grimm (2014) (see also Wągiel 2021).

Let us first consider a *maximally strongly self-connected* (MSSC) entity. It is defined in terms of classical extensional mereology (CEM) enriched with

[7]For a similar point, see Grimm & Levin (2017, §2.2).

[8]An exception is in certain dramatic or make-believe contexts. For example, an actor could use a painted tennis ball as an apple on stage if they thought the audience would not notice.

[9]Contrast this with ..*used as fuel/firewood*, both of which convey function.

one other primitive relation, namely *connected*, a symmetric and reflexive relation, yielding a classical extensional mereotopology (CEMt):

> An [entity] 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, 2014, p. 135)

It should be noted that Grimm (ibid.) does not use MSSC to characterise the denotations of all count nouns. For instance, he does not think that all artefact count nouns denote MSSC entities. We think that Grimm's definition of a MSSC entity formalises what is akin to the concept of a Spelke object. To this extent, the notion of a MSSC entity characterises only some entities that fall under our notion of an *object*, and the reasons we give why our class of objects includes but is larger than the class of Spelke objects (see above), also apply to MSSC entities.

An *integrated whole* was formally defined by Simons (1987) in terms of a second order logic enriched with mereology. Unlike Casati & Varzi (1999), Simons (1987) does not opt for mereotopology by adding a requisite single relation to his mereology, but instead leaves the additional relation(s) underspecified via a variable $\mathcal{R}$ in his definitions. Mereological part is used by Simons to define what integrated wholes are. If this is assumed to be $\sqsubseteq$ from CEM, the result is a relatively broad version of CEMt. Integrated wholes are defined relative to some relation $\mathcal{R}$, an $\mathcal{R}$-INTEGRATED WHOLE, and therefore we have a (classical extensional) mereotopology based upon $\mathcal{R}$.

A number of technical concepts are used to define integrated wholes, that we briefly summarise below (we use notation consistent with that used in this volume instead of Simons' original). All of the following definitions are notationally adapted from ibid., pp. 327-330.

(4.12) $Div(P, a) \leftrightarrow \forall x \in P[x \sqsubseteq a] \wedge \forall x[x \sqsubseteq a \rightarrow \exists y \in P[x \circ y]]$

A set $P$ divides $a$, iff every member of $P$ is a part of $a$ and for every part of $a$, there is a member of $P$ that overlaps it.

(4.13) $Cl_{\mathcal{R}}(P) \leftrightarrow \forall x, y[(x \in P \wedge (\mathcal{R}(x, y) \vee \mathcal{R}(y, x))) \rightarrow y \in P]$

A set, $P$, is closed under a relation $\mathcal{R}$ iff everything that is in some way related by $\mathcal{R}$ to a member of $P$ is also a member of $P$.

(4.14) $Con_{\mathcal{R}}(P) \leftrightarrow \forall x, y[(x \in P \wedge y \in P) \rightarrow (\mathcal{R}(x, y) \vee \mathcal{R}(y, x))]$

A set, $P$, is connected under a relation $\mathcal{R}$ iff every member of $P$ is pairwise in some way related by $\mathcal{R}$.

The above two definitions are conjoined to give a *closure system under* $\mathcal{R}$:

(4.15) $\mathit{Cs}_{\mathcal{R}}(P) \leftrightarrow \mathit{Cl}_{\mathcal{R}}(P) \wedge \mathit{Con}_{\mathcal{R}}(P)$

Where $\mathcal{R}_{+}$ is the transitive closure of $\mathcal{R}$:

(4.16) $\mathit{Fam}_{\mathcal{R}}(P) \leftrightarrow \mathit{Cs}_{\lambda x \lambda y[\mathcal{R}(x,y) \vee \mathcal{R}(y,x)]_{+}}(P)$

A set $P$ is an $\mathcal{R}$ family iff $P$ is closed and connected with respect to the transitive closure of the disjunction of $\mathcal{R}$ with its inverse.

For example, and to keep things simple, if we take a relation that is symmetrical such as *touching* (the relation that underpins the spatiotemporal haptomereology of Krifka (2021)), then, the set of entities that form a pile of bricks could count as a family under the touching relation, since there is some chain of touchings such that every brick in the pile can be linked to every other (assuming that no bricks in the pile touch anything else).

An *integrated whole* with respect to a relation $\mathcal{R}$ (an $\mathcal{R}$-integrated whole) is then defined in terms of $\mathit{Div}$, a classical extensional mereological property, and $\mathit{Fam}$:

(4.17) $\mathit{Wh}_{\mathcal{R}}(a) \leftrightarrow \exists P[\mathit{Div}(P, a) \wedge \mathit{Fam}_{\mathcal{R}}(P)]$

As should now be clear, if $\sqsubseteq$ in (4.12) is the part relation from CEM, then (4.17) is defined in terms of a CEMt underspecified by $\mathcal{R}$. To take the previous example, if $a$ is the mereological sum of the pile of bricks, $P$ is the set of bricks in the pile, and $\mathcal{R}$ is touching, then $a$ forms an integrated whole under the touching relation, because every brick in $P$ is a part of $a$ and every part of $a$ overlaps with at least one brick, and, as above, there is a chain of touchings that link the bricks together. Again, however, this only applies if no brick in $P$ touches anything that is not in $P$.

Now, arguably, $\mathit{Wh}_{\mathcal{R}}(a)$ could subsume the *Maximally Strongly Self-Connected* (MSSC) entities of Casati & Varzi (1999). However, in order to prove this, one would need to define an $\mathcal{R}$ that replicates all and only the effects of the definition of MSSC. We are not aware that anyone has demonstrated this subsumption relation in terms of providing a formal proof. The previous example, for instance, demonstrates that simple relations such as *touching* or *connected* on their own are both too weak and too strong to characterise MSSC entities as $\mathcal{R}$-integrated wholes. A pile of bricks (in isolation) can count as an integrated whole under the touching or connected relation, but a pile of bricks is not an MSSC entity. However, a ball on the floor is an MSSC entity, but would not be an integrated whole under the connected or touching relation, because it touches and is connected to the floor. Therefore, to define MSSC entities in terms of $\mathcal{R}$-integrated wholes, one would have to incorporate maximality and strong self-connectedness. In simple terms, whereas *$\mathcal{R}$-integrated whole* is a very general and underspecified property defined in a very general version of CEMt, *MSSC-entity* is a very specific property defined in terms of a very specific CEMt based upon *connectedness*.

Moltmann (1997) adopts Simons' definition of *integrated whole* in her own work:

> The notion of integrated whole is a difficult one, and it is hard to give a unified definition of it – should that be possible at all. Hence it may not be possible to state what is common among all count nouns.
>
> But fortunately, for most of the analyses of natural language constructions given in this book, a rather simple notion of an integrated whole of a particular kind suffices. This is the notion of R-integrated whole. This notion comes from Simons (1987) (ibid., p. 24)

Moltmann (ibid.) then uses $Wh_{\mathcal{R}}$ to define an alternative part relation that is more restricted than the one in CEM. For instance, it is relativised to situations and is not unrestrictedly transitive or extensional. She also uses $Wh_{\mathcal{R}}$ to characterise some necessary properties of count and mass nouns, again relativised to situations.[10]

[10]It is unclear to us whether $\sqsubseteq$ in (4.12), and thereby the notion of $\sqsubseteq$ that is used to define $Wh_{\mathcal{R}}$ is that of CEM for Moltmann. Moltmann 1997, p. 11, fn. 10 refers to a part relation that is not reflexive, and this is formalised later (p. 33), as the *general part relation* which is transitive and antireflexive. If $\sqsubseteq$ in (4.12) is antireflexive, one has to give up at least one of idempotency for $\sqcup$ ($\forall x.x \sqcup x = x$), and inter-definability between $\sqcup$ and $\sqsubseteq$ ($\forall x, y.x \sqsubseteq y \leftrightarrow x \sqcup y = y$). If $\sqsubseteq$ is not reflexive, then, for all $a$, $\neg a \sqsubseteq a$. Via inter-definability, we may then infer $\neg(a \sqcup a = a)$, which contradicts idempotence of $\sqcup$. Additionally, if $\sqsubseteq$ is antireflexive (or even not reflexive), then one can no longer prove that $\forall x, y[(x \sqsubset y \vee x = y) \rightarrow x \sqsubseteq y]$, so we lose a rather intuitive characterisation of a sufficient condition on parthood. It also follows that this part relation is trivially antisymmetric, since there is no $a, b$ such that $a$ and $b$ are parts of each other. Now, it is worth noting that CEM already has a relation that is transitive, anti-reflexive and trivially antisymmetric, namely the proper part relation, $\sqsubset$. As noted by e.g., Simons (1987, p. 11), it is merely a matter of convenience that CEM defines proper part in terms of part. Indeed, part is easily definable in terms of proper part and identity:

(i) $\forall x, y[x \sqsubseteq y \leftrightarrow (x \sqsubset y \vee x = y)]$

This part relation, so defined, is provably reflexive (given an axiom of self identity), provably

*The information-based account of the mass-count distinction*

a. If $f$ is a mass noun, then for any minimal situation $s$ and entity $x$ such that $[f]^s(x) = 1$, $x$ is not an integrated whole in $s$.

b. If $f$ is a singular count noun, then for any situation $s$ and entity $x$, if $[f]^s(x) = 1$, then $x$ is an integrated whole in $s$.

(Moltmann, 1997, p. 21)

We wish to briefly address two points with respect to our conception of *object* and its role in characterising the count/mass distinction, and the (uses of) integrated wholes. First, do integrated wholes as defined by Simons (1987) subsume the class of entities that we are characterising as objects? Our answer to this is a resounding *maybe*. For instance, a pestle and mortar could, potentially, form an integrated whole under a relation such as *designed to grind spices etc. with the aid of*. However, this is a highly specific relation. The challenge therefore would be to define, presumably many, relations that allow all and only the set of objects to count as integrated wholes. In the above quoted passage, Moltmann concludes that it may not be possible to state what is common among all count nouns in terms of $\mathcal{R}$-integrated wholes. We are inclined to say something similar, albeit in relation to objects, NOT in relation to count nouns: it may not be possible to state what is common among all objects (in our sense of *object*) in terms of $\mathcal{R}$-integrated wholes.

Second, in relation to the use of integrated wholes as part of a theory of the count/mass distinction, and our use of objects, we differ substantially from Moltmann (1997). For us, denoting objects is perfectly compatible with a noun being mass. For Moltmann's situation-relativised conception of integrated wholes, it is not possible for a mass noun to denote integrated wholes. We have provided evidence, primarily from the stubbornly distributive predicates data, that objects play a role in the grammatical reflexes of both concrete count nouns and mass nouns that have objects in their extensions.[11]

### Object-instantiated properties

We assign core properties the standard type $\langle s, \langle e, t \rangle\rangle$. The core properties that underpin the semantics of common nouns, we further assume, are number

transitive (given the transitivity of proper part and identity), and provably non-trivially anti-symmetric (given the anti-reflexivity of proper part). Therefore, as far as we can see, Moltmann's general part relation simply is the proper-part relation from CEM.

[11]Moltmann (1997), in fact, mentions that there is a distributive reading of *All of the furniture was light*. It is unclear to us how this is consistent with the claim that an entity referred to as *furniture* "seems to be a more or less homogeneous mass". (p.21).

neutral. (We share the assumption that core properties are number neutral with, for example, Krifka (1989), Chierchia (2010) and Rothstein (2010). For Rothstein (ibid.), for example, the set in the range of such properties at a world is referred to as $\mathrm{N}_{\mathrm{root}}$.) That is to say that, for example, the core property $\lambda w \lambda x.\mathtt{cat}(w)(x)$ is instantiated by both single cats and any sums of single cats. However, in our contextualist setting, we assume that, at least as a first pass, the interpretations of common nouns are of type $\langle c, \langle s, \langle e, t\rangle\rangle\rangle$, a function from contexts to intensions (i.e. Kaplanian characters).[12] We define precisely how we model contexts in section 4.1.3.

We define properties that are instantiated by objects in (4.18). As a reminder, we sometimes abbreviate 'properties that are instantiated by objects' as *object-instantiated properties*. We also henceforth use the notational abbreviation of $et$ for $\langle e, t\rangle$:

(4.18) **Object-instantiated core property.**
A core property $\mathtt{P} : \langle s, et\rangle$ *is object-instantiated iff:*
$\exists w.\exists X.X \subseteq O^{+}_{w} \wedge X \subseteq \mathtt{P}_{w}$

In words: $\mathtt{P}$ is object-instantiated if and only if, at least one world, some $\mathtt{P}$s are objects.

This notion will be crucial in answering our main questions 1 and 2:

QUESTION 1 **What are the necessary conditions for a core property to be lexicalized as count?**

Answer: For concrete core properties at least, the property must be object-instantiated.

QUESTION 2 **What are the necessary conditions for a concrete noun to be felicitous with stubbornly distributive predicates?**

Answer: The noun must be lexicalized from an object-instantiated core property.

Finally, it will be convenient later to introduce the following abbreviation:

(4.19) $\mathtt{P}_{obj} =_{def} \lambda w.\lambda x.\mathtt{P}(w)(x) \wedge O^{+}(w)(x)$

I.e., $\mathtt{P}_{obj}(w)$ is the set of objects in $\mathtt{P}$ relative to a world, $w$ (which will be the empty set if $\mathtt{P}$ is not object-instantiated).

[12] In section 4.2, we argue that this view is overly simplistic, and that lexical entries should be bi-partite (specify two sets), thus making them of type $\langle c, \langle s, \langle e, t \times et\rangle\rangle\rangle$.

Importantly, depending on $\mathtt{P}$, and for at least some $w$, $\mathtt{P}_{obj}(w)$ will not always be quantized. I.e., not all properties are instantiated by a quantized set of objects. Examples of properties that do not include `fence` and `wall`. These properties, we claim, can still be lexicalized as count (because they are object-instantiated), but are also, in some sense mass-like, because this set of objects is not quantized. This, we will argue has implications for the grammatical reflexes of count nouns that lexicalized such properties, specifically, why singular count nouns such as *fence* can be used bare as the 'downstairs' NPs in pseudopartitive (measure) constructions.

### 4.1.3 Kaplanian contexts in $\mathbf{TY}_{3\times}$ and the individuating contextual parameter

In order to make our $\mathbf{TY}_{3\times}$ model Kaplanian, we will now add to it the Kaplanian two-dimensional view of meaning (where expressions are interpreted as functions from contexts to intensions). We will do this via explicit $\lambda$-abstractions (over contexts and worlds) in the lexicon, not as part of the definition of the interpretation function as in Montague semantics. Therefore, we still need to define what contexts are.

We propose to implement, in our Kaplanian semantics for common nouns, additions to the standard set of contextual parameters. One additional parameter we propose is crucial when it comes to countability: the QUANTIZING CONTEXTUAL PARAMETER. This parameter is formalised as a maximally quantizing function which relative to a context ensures that a context-sensitive count noun such as *fence* denotes a quantized set of entities. We have argued that, modulo some important theoretical differences between our approach and that defended in Rothstein (2010) (not least that we do not assume a type distinction between count and mass nouns), our approach is Rothsteinian in spirit, as we hope will be clear in the further elaborations of our proposal.

Bennett (1978) formalises Kaplan's two-dimensional semantics in Montague's **IL**. In Kaplan 1989 and Bennett 1978, contexts are treated as tuples. For example, simplifying the context set, $\langle c_{utt}, c_{add}, c_{time}\rangle$ would be the ordered set of the utterer, and addressee, both members of $D_e$, and a time (modelled as an integer in a set $T$). So, the members of the context tuples *are* elements of the domain. In Montague's Intensional Logic (**IL**) setting, this treatment of contexts is required to ensure that indexicals are rigid designators. In Montague's **IL**, constants $a$ are interpreted relative to a world $[\![a]\!]^{M,w,g} = \mathcal{I}(a)(w)$, and so the extension of these constants can vary with worlds. Thus, to ensure rigidity, Bennett (ibid.) differentiates between run-of-the-mill constants, interpreted relative to worlds, and indexical constants that have their own interpretation rule in the model. For example, the pronoun *I* is translated as the constant $c_0$ which is interpreted in the model as follows: $[\![c_0]\!]^{M,w,c,g} = c_{utt}$. This treatment of contexts does not make sense in $\mathbf{TY}_2$ or $\mathbf{TY}_{3\times}$. Instead, we have variables over and constants for contexts each of which must be properly typed and have an interpretation. In $\mathbf{TY}_2$ and in $\mathbf{TY}_{3\times}$, furthermore, we do not need any bespoke interpretation rule for constants or variables since (4.5a) and (4.5b) are sufficient. In other words, we cannot treat contexts *as* tuples of members of the domain (as Bennett (ibid.) does). Instead, we must treat contexts as tuples of run-of-the-mill constants (or variables) that are interpreted as tuples of members of the domain. Now an advantage of $\mathbf{TY}_2$ (and so also $\mathbf{TY}_{3\times}$) is that we do not need to worry about rigidity. Our interpretation function is not relative to worlds, and so provided that these constants do not have types involving basic type $s$, their interpretation will be rigid.

### Simplified Kaplanian Contexts

Minimally, Kaplanian contexts include information about the utterer, the addressee, and the time of utterance. A simplified version of Kaplanian contexts includes constants for the utterer, the addressee and the time of utterance (we ignore locations and contextual indices for demonstrata here):[13]

(4.20) **(Simplified) Kaplanian contexts** including constants for an utterer, addressee and time are tuples of type $e \times e \times i$ and are of the form $\langle c_{utt}, c_{add}, c_{time} \rangle$.

For instance, the pronoun *I* will be interpreted as the value of the contextual parameter $c_{utt}$. (E.g., as $a$ in contexts where $a$ is the speaker, and as $b$ in contexts where $b$ is the speaker, etc.)

It is worth discussing briefly the impact of couching our approach in terms of $\mathbf{TY}_{3\times}$ as opposed to an intensional logic of Montague-style semantics $\mathbf{IL}$. With an intensional logic analysis, we do not have variables for worlds/world-time pairs and worlds are featured in the definition of the interpretation function. This approach necessitates, for example, operators such as $^\vee$ and $^\wedge$ to shift between intensions and extensions. Similarly, on an $\mathbf{IL}$ implementation of Kaplan, the different contextual indices must feature as part of the definition

[13] We could have treated such Kaplanian contextual tuples as being of a basic type, however, this would have certain unwelcome consequences. Given that contexts are tuples of e.g., entities like utterers, addressees and things like times/time intervals, we would then have a basic type for contexts that would be itself constructed out of other basic types. Instead, therefore, we treat contexts as tuples of a product type and indices of evaluation as worlds.

of the interpretation function such that the set of constants is partitioned into groups each of which is interpreted differently (see Bennett, 1978, p. 63). $\mathbf{TY_2}$ and $\mathbf{TY_{3\times}}$ logics make the definition of the interpretation function uniform (all constants are interpreted via the same function), and so we reduce complexity in our model. However, as we shall see, this necessitates a bit more complexity within our lexical entries, since, we will have to specify, for example, for each common noun, the precise sense in which its intension is or is not sensitive to contextual variation.

### Adding a contextual domain restriction parameter

The first parameter we add to this basic picture is one that can model contextual domain restrictions, as discussed in chapter 3. We will do this in a somewhat simplified way that abstracts over the selection of relevant constraining properties.

(4.21) **Kaplanian contexts enriched with a contextual domain restriction parameter** including constants for an utterer, addressee, time and are tuples of type $e \times e \times i \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle$ and are of the form $\langle c_{utt}, c_{add}, c_{time}, c_{dom}\rangle$.

(4.22) $c_{dom} := \lambda P_{\langle s,et\rangle}.\lambda w.\lambda x.\mathtt{P}(w)(x) \wedge \mathtt{Q}(w)(x)$ such that:

a. There is a $w' \in \mathcal{D}_s$ where $\mathtt{P}(w') \cap \mathtt{Q}(w') \neq \varnothing$ and

b. $\mathtt{Q}$ is salient/relevant to $\mathtt{P}$.

The idea here is that if, in context, *book*, as in *The book is inspiring*, for instance, is naturally interpreted as *book on the shelf* (that is, the relevant nominal domain restriction is to things on the shelf), then there should be at least one world in which the things on the shelf and the set of books have members in common, and the property of being on the shelf should be relevant/salient (or whatever is required for capturing the selection process of the relevant property). In which case, *book* is interpreted as the set of books intersected with the set of things on the shelf.

For instance, abstracting away for a moment on how we select $c_{dom}$ from a context $c$, a first-pass lexical entry for *book* would be:

(4.23) $\lambda c.\lambda w.\lambda x.c_{dom}(\mathtt{book})(w)(x)$

If the relevant property is `on_shelf` (the property of being an entity on some relevant shelf entities on the shelf) in $c$, this will yield the following property:[14]

[14]To reiterate, we need not be committed to the selection of the relevant domain

(4.24) $\lambda w.\lambda x.\texttt{book}(w)(x) \wedge \texttt{on\_shelf}(w)(x)$

Adding the contextual restriction parameter to contexts already will lead to a view in which all common nouns (count and mass) express functions from contexts to intensions. This is therefore a departure, strictly speaking, from Rothstein's framework.

### Adding a quantizing contextual parameter

The second, and perhaps the most crucial parameter that we add to our Kaplanian contexts is the *quantizing contextual parameter*. In ways to be set out shortly, this parameter will only be in effect for count nouns that do not denote a quantized set of objects and thus are open to multiple ways of counting e.g., *fence*, *sequence*, *branch* etc. In other words, this parameter allows us to formally characterise what 'counts as one' relative to a predicate. Put another way, it is this parameter that models different *counting perspectives* on the same entities. We will sometimes just refer to the *quantizing contextual parameter* simply as the *quantizing context*.

(4.25) **Kaplanian contexts enriched with a contextual domain restriction parameter and a quantizing contextual parameter** are tuples of type $e \times e \times i \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle$ of the form $\langle c_{utt}, c_{add}, c_{time}, c_{dom}, c_{qua}\rangle$.

In terms of type, $c_{qua}$ is a property modifier. It applies to a core property, $\mathcal{P}$, and outputs a property that, at each world $w$, denotes a maximally quantized subset of the entities in $\mathcal{P}(w)$ (cf. maximally disjoint subsets in Landman 2011).[15] $P$ is a maximally quantized subset of $Q$, then $P$ is a subset of $Q$, and is quantized, and no other member of $Q$ could be an additional member of $P$ while $P$ remains quantized (the maximality condition):

(4.26) $$P \subseteq_{max.QUA} Q \leftrightarrow \begin{array}{l} P \subseteq Q \wedge QUA(P) \wedge \\ \forall X \subseteq Q[X \supseteq P \wedge QUA(X) \rightarrow X = P] \end{array}$$

We can now use the $\subseteq_{max.QUA}$ relation to define a *maximally quantizing function* of type $\langle\langle s, et\rangle, \langle s, et\rangle\rangle$:

restricting property to be resolved at the NP level, since the context argument is in any case 'passed up' to the DP level.

[15] Landman's (2011) use of (variants of) maximally disjoint subsets differs from our use of maximally quantized subsets. Landman defines a counting condition in terms of such variants to explain why e.g., *furniture* is mass. We use the multiplicity of possible maximally quantized subsets to motivate how what counts as e.g., *one fence* can vary depending on the context.

(4.27) $f_{qua} : \langle\langle s, et\rangle, \langle s, et\rangle\rangle$ is a maximally quantizing function iff: for all $\mathtt{P} : \langle s, et\rangle$, and for all $w$, $f_{qua}(\mathtt{P})(w) \subseteq_{max.QUA} \mathtt{P}(w)$

This now allows us to give the semantics for the $c_{qua}$ parameter.

(4.28) $c_{qua} := \lambda P_{\langle s,et\rangle}.\lambda w.\lambda x.f_{qua}(\mathtt{P})(w)(x)$ such that $f_{qua}$ is a maximally quantizing function

For instance, abstracting away for a moment on how we select $c_{dom}$ and $c_{qua}$ from a context $c$, a first-pass lexical entry for a context-sensitive count noun such as *fence* would be:

(4.29) $\lambda c.\lambda w.\lambda x.c_{qua}(c_{dom}(\mathtt{fence}_{obj}))(w)(x)$

As an example, suppose that there is fencing around Alex's garden: $f_1 \sqcup f_2 \sqcup f_3$. After a storm, Alex reports *Two of my fences were damaged* in a context where the relevant contextual domain restriction is to fences in Alex's garden (`in_garden`). This contextual domain restriction does not yet give us a counting perspective on the fences. Indeed, the domain restriction only limits us to a set such as $^*\{f_1, f_2, f_3\}$ (the set of fence objects in Alex's garden). This is not a quantized set. In order to count the fences, therefore, we need, in addition, a counting perspective. This is modelled by the quantizing contextual parameter. Suppose that, in this case, the relevant individuation criteria for these fences is that each of $f_1$, $f_2$ and $f_3$ count as one fence. Suppose further that $f'_{qua}$ is a maximally quantizing function that outputs this result. The two contextual domain parameters can therefore stack. If the above context is $c_0$ and the relevant world is $w_0$, then:

(4.30) $$\begin{aligned}&\lambda c.\lambda w.\lambda x.c_{qua}(c_{dom}(\mathtt{fence}_{obj}))(w)(x)\ \ (c_0)(w_0)\\ &\quad= \lambda w.\lambda x.f'_{qua}(\mathtt{fence}_{obj}(w)(x) \wedge \mathtt{in\_garden}(w)(x))\ \ (w_0)\\ &\quad= \{f_1, f_2, f_3\}\end{aligned}$$

I.e., given some restriction to what fence/fences we might be referring to (contextual domain restriction), we can further restrict the range of `fence` via the quantizing contextual parameter, yielding a quantized set of entities for counting. I.e., in the relevant world, the set $\{f_1, f_2, f_3\}$. The truth conditions of Alex's storm report will therefore require (at least) two of $f_1$, $f_2$ and $f_3$ to have been damaged.

In summary, our semantics developed thus integrates two types of context-sensitivity for common nouns implemented it within a Kaplanian contextualist semantics. Our approach not only can we capture contextual domain restrictions for common nouns, but also captures e.g., Rothstein's (2010) insights into the context sensitivity of common nouns regarding their individuation criteria. Our analysis differs from Rothstein's in one key respect, however: we do not assume count and mass nouns to be of different semantic types. As we will soon show in section 4.1.4, we also do not assume that contextual resolution of non-quantized sets is required in the semantics of all count nouns, unlike Rothstein. In particular, if the set of entities that instantiate a core property is anyway quantized, the lexical entry of the relevant count noun need not be indexed to the $c_{qua}$ parameter.

### Accessing contextual parameters

Given that types of basic expressions are now a little lengthy, will will use the following type abbreviation convention:

(4.31) **Type abbreviation convention (contexts):**
$e \times e \times i \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle \mapsto c$

For example, simplifying slightly, a lexical entry for a common noun, given this abbreviation convention, will be of type $\langle c, \langle s, et\rangle\rangle$, i.e., a function from contexts to intensions.[16] In other words, with our extension of $\mathbf{TY_2}$, $\mathbf{TY_{3\times}}$, we have now been able to rather literally interpret the Kaplanian maxim that expressions are interpreted as characters: functions from contexts to intensions, where intensions are functions from worlds to extensions.

Finally, we need a means of accessing members of contextual tuples which can be done via the standard projection functions $\pi_1$, $\pi_2$. Following Carpenter (1997), product types associate to the right, and so the type for contexts is: $e \times (e \times (i \times \langle et, et\rangle)$. However, to keep notation more transparent, we use the definitions in (4.32) to access contextual parameters, for example as in (4.33).

(4.32) **Context projection functions.**
For a context $c$ of type $e \times e \times i \times \langle\langle s, et\rangle, \langle s, \langle et\rangle\rangle\rangle \times \langle\langle s, et\rangle, \langle s, \langle et\rangle\rangle\rangle$:

a. $\mathbf{utt}_c =_{def} \pi_1(c)$
b. $\mathbf{add}_c =_{def} \pi_1(\pi_2(c))$
c. $\mathbf{time}_c =_{def} \pi_1(\pi_2(\pi_2(c)))$
d. $\mathbf{dom}_c =_{def} \pi_1(\pi_2(\pi_2(\pi_2(c))))$

[16] It may seem obtuse to go to lengths to keep the components Kaplanian contexts separated out as expressions of a relatively complex product type only to then introduce an abbreviation convention that makes contexts seem as though they have a basic type. However, while this convention makes our notation more concise, it is important to note that contexts are, for us, merely interpreted as tuples of entities each of which has a type defined in terms of our four basic types.

e. $\mathbf{qua}_c =_{def} \pi_2(\pi_2(\pi_2(\pi_2(c))))$

(4.33) If $c = \langle a, b, t_1, \mathfrak{F}, \mathfrak{G} \rangle$:

a. $\mathbf{utt}_c = a$
b. $\mathbf{add}_c = b$
c. $\mathbf{time}_c = t_1$
d. $\mathbf{dom}_c = \mathfrak{F}$
e. $\mathbf{qua}_c = \mathfrak{G}$

### 4.1.4 Facilitating count/mass variation

In this section, we combine object-centredness and context sensitivity in order to provide an account of how properties can be lexicalized as count or mass, given our claim that a necessary condition for a core property to be lexicalized as count is that it has objects in its denotation. We will furthermore explain some of the data from chapter 2 on the basis of whether this set of objects is quantized. Properties that do not denote a quantized set of objects can still be lexicalized as count (via the quantizing contextual parameter). However, because these properties are not instantiated by a quantized set of objects, we can use this feature to explain why some count nouns can be used bare as the 'downstairs NPs' in pseudopartitive (measure) constructions. (An elaboration on the proposal in Filip & Sutton 2017.)

First, to differentiate the lexicalization of count nouns from mass nouns, we define two ways in which a number neutral core property can be lexicalized: object-centred lexicalization, which results in a lexical entry for a count noun, and object-neutral lexicalization, which results in a lexical entry for a mass noun. First, we give a brief, informal overview of these two lexicalization processes, and then provide the formal details.

Importantly, there are some aspects of variation in count/mass lexicalization patterns that we will not address in this section. We defer until chapter 5 the discussion of perceptual-interactive constraints on when a core property that is instantiated by objects can be lexicalized as mass and how likely it is to be so lexicalized. For example, a core property such as `ball` is never lexicalized as mass, and object-instantiated properties such as `gravel` and `pollen` are never, to our knowledge lexicalized as count. In this section we focus on the mechanism via which one can map object-instantiated properties to count or mass denotations, and why these mechanisms prevent properties of substances from being lexicalized as count.

*Object-centred lexicalization* makes a quantized set of objects that instantiate a core property the privileged set of entities for grammatical counting operations relative to a context. We formalise this as the application of the *object-centred quantizing function* to the core property as part of a lexical entry. This function applies to a number-neutral, object-instantiated core property (of type $\langle s, et \rangle$) and outputs a function from contexts to intensions (a function from contexts to an object-instantiated property) that, at each context and world outputs a quantized set of objects. The result of the object-centred lexicalization of a core property is therefore a lexical entry for a count noun. As we will show, this means of lexicalizing a core property can result in a count noun such as *fence* that has a variable character (what counts as 'one' can vary across contexts), or in a count noun such as *cat* that has a fixed character (what counts as 'one' does not vary across contexts).

*Object-neutral lexicalization* does not make any set of entities that instantiate a core property privileged. So, even if a core property e.g., `furniture` is instantiated by objects, if this core property undergoes object-neutral lexicalization, this set of objects is not made available to grammatical counting operations. We formalise this as the application of the *object-neutral function* to the core property as part of a lexical entry. This function applies to a number-neutral core property and outputs a function from contexts to intensions. Crucially, we claim that although mass nouns *per se* (barring coercion and meaning shifts) are sensitive to contextual domain restrictions (the $c_{dom}$ parameter), they are not sensitive to contextually determined variation in individuation conditions (the $c_{qua}$ parameter). Also, importantly, object-neutral function does not encode intersection with the set of objects ($\mathcal{O}^+$) in the lexical entries of mass nouns. I.e., a core property underpinning a mass noun may be instantiated by objects, but the set of single objects is not given a privileged status in the lexical entries of that mass noun. The result of the object-neutral lexicalization of a number neutral core property is a lexical entry for a mass noun: an expression that does not determine a quantized set of objects as an input to grammatical counting operations.

The components of both object-centred and object-neutral lexicalization are summarised in Table 4.1.

### Count Nouns and Object-centredness

Our analysis of count nouns using our Kaplanian, contextualist framework is grounded in the idea that count noun extensions are quantized (sub)sets of objects that instantiate number-neutral core properties relative to context. To model this, we use the quantizing context parameter, combined with our conception of objects as entities that form either natural or functional units. For us, limiting ourselves to 'concrete' properties, a number neutral core property can be lexicalized as count only if it is object-instantiated.

| Countability class | Examples | Intersected with $O^+$ | Apply $\mathbf{qua}_c$ | Apply $\mathbf{dom}_c$ |
|---|---|---|---|---|
| Count | *ball*, *cat* | ✓ | ✗ | ✓ |
| | *fence*, *hedge* | ✓ | ✓ | ✓ |
| Mass | *furniture*, *mud* | ✗ | ✗ | ✓ |

Table 4.1: Summary of semantic operations that apply to core properties and output the lexical entries for count or mass nouns depending on which operations are applied: (i) all resulting common noun lexical entries are sensitive to contextual domain restriction (Apply $\mathbf{dom}_c$); (ii) only properties within count noun lexical entries are intersected with the set of objects (Intersected with $O^+$); (iii) only some count noun lexical entries are additionally indexed to the quantizing contextual parameter (Apply $\mathbf{qua}_c$). These nouns (e.g., *fence*, and *hedge*) are count, but what counts as 'one' may vary depending on one's counting perspective.

**Object-centred quantizing functions** So far, we have introduced four key elements of our theory: the contextual domain restriction parameter, accessed via $\mathbf{dom}_c$; the quantizing contextual parameter accessed via $\mathbf{qua}_c$; whether core properties are object-instantiated; a means of accessing the set of objects that instantiate a core property at each world $\mathtt{P}_{obj}$ (a property of objects), such that, for any world $w$, $O^+_w$ is of type $et$. We now define the *object-centred quantizing function*. This function combines these four elements and maps object-instantiated properties onto functions from contexts to properties that, at each world, output a quantized set of objects.

The object-centred quantizing function, $\mathcal{Q}_c$, can apply to any object-instantiated core properties. It applies therefore, to properties such as `ball`, `lentil` and `fence` but not to properties such as `air` and `oil`.[17] We model this as a presupposition on $\mathcal{Q}_c$, namely that $\mathtt{P}(w) \cap O^+(w) \neq \varnothing$. For any core properties that pass the presupposition that they are instantiated by objects, $\mathcal{Q}_c$ applies the contextual parameter selected by $\mathbf{dom}_c$ to this property. Via this, we capture nominal domain restriction.

Furthermore, of those properties that pass the object-instantiated presupposition, the function $\mathcal{Q}_c$ is defined to also be sensitive to whether the specified set of objects is quantized. I.e., whether or not $QUA(\mathtt{P}_{obj}(w))$.[18] In

[17]For portion readings of measure constructions such as *barrels of oil*, we assume a different analysis. See, e.g., Sutton & Filip 2021a.

[18]Is is worth stressing that we could simplify the definition of $\mathcal{Q}_c$ without affecting the outcome. This is because, were we to apply $\mathbf{qua}_c$ to all object instantiated properties, the output would be vacuously quantized for all properties that are instantiated by a quantized set of objects. I.e., we could have used:

(i) Object-centred Quantizing Function (simplified first version):

short, the object-centred quantizing function, $\mathcal{Q}_c$, is sensitive to whether a core property is object instantiated and whether these objects form a quantized set at each world. All object-instantiated core properties are indexed to the context via $\mathbf{dom}_c$ (e.g., `ball`, `fence`), but only those that specify a non-quantized set of objects at least some worlds (e.g., `fence`, but not `ball`) have the contextual parameter selected by $\mathbf{qua}_c$ applied to them. Properties that are not object-instantiated e.g., `air` are undefined for this function.

The first pass of the object-centred quantizing function is given in (4.34). (This definition will be amended when we move from monopartite to a bipartite approach to lexical entries in section 4.2.)

(4.34) Object-centred Quantizing Function (monopartite lexical entries):

$$\mathcal{Q}_c = \begin{cases} \lambda \mathtt{P}\lambda c\lambda w\lambda x[\mathbf{dom}_c(\mathtt{P}_{obj})(w)(x)] & \text{if } \mathtt{P}(w) \cap O^+(w) \neq \varnothing, \\ & \text{and } QUA(\mathtt{P}_{obj}(w)) \\ \lambda \mathtt{P}\lambda c\lambda w\lambda x[\mathbf{qua}_c(\mathbf{dom}_c(\mathtt{P}_{obj}))(w)(x)] & \text{if } \mathtt{P}(w) \cap O^+(w) \neq \varnothing, \\ & \text{and } \neg QUA(\mathtt{P}_{obj}(w)) \\ \bot & \text{otherwise.} \end{cases}$$

The application of the object-centred quantizing function $\mathcal{Q}_c$ to an object-instantiated core property `P` has the following form, namely a function from contexts to a property that is instantiated by a quantized set of objects at each world at which it is defined:

(4.35) $\lambda c\lambda w\lambda x[\mathcal{Q}_c(\mathtt{P})(w)(x)]$

For convenience, we shall sometimes say that:

(4.36) If common noun N expresses $\mathcal{Q}_c(\mathtt{P})$ then N is the object-centred lexicalization of `P`.

The definition in (4.34) enables us to provide a first pass at characterising the

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$$\mathcal{Q}_c = \begin{cases} \lambda \mathtt{P}\lambda c\lambda w\lambda x[\mathbf{qua}_c(\mathbf{dom}_c(\mathtt{P}_o bj))(w)(x)] & \text{if } \mathtt{P}(w) \cap O^+(w) \neq \varnothing, \\ \bot & \text{otherwise.} \end{cases}$$

The reason why we have opted for the more complex, but more explicit formulation, stems from our experience with objections raised against our account. The simplified version may give the misleading impression that we analyse all count nouns by generalising to the worst case scenario. Given the formal equivalence between the simplified version and the one in (4.34), it should be clear that such objections are not well founded.

interpretations of two kinds of count nouns: those with variable characters such as *fence*, and those with fixed characters such as *cat*.

**Count expressions with a fixed character with respect to $\mathbf{qua}_c$.** The object-centred quantizing function $\mathcal{Q}_c$ is such that if a core property is anyway instantiated by a quantized set of objects at each world, as is arguably the case for 'naturally atomic', object-denoting expressions such as *cat*, then the output of applying $\mathcal{Q}_c$ to such a core property will be a function from contexts to the property that outputs just this set of objects at that world. In other words, we have an expression with a *fixed character*: every context yields the same intension. A first-pass at a lexical entry for *cat* is given below.

(4.37)
$$[\![ [_{\text{CN}}\ \text{cat}] ]\!]^{M,g} = \lambda c \lambda w \lambda x[\mathcal{Q}_c(\texttt{cat})(w)(x)]$$
$$= \lambda c \lambda w \lambda x[\mathbf{dom}_c(\texttt{cat}_{obj})(w)(x)]$$

So, at least with respect to its individuation criteria, *cat* has a fixed Kaplanian character, because the set of objects that instantiate `cat` at each world is quantized (it is still however context sensitive with respect to nominal domain restriction).

**Count expressions with a variable character with respect to $\mathbf{qua}_c$.** In our analysis of objects, we observed that some entities are objects in virtue of fulfilling some functional role. Of these, some were what we called 'connected objects'. Now, some count expressions that denote connected objects (e.g., rooms in a flat) form a quantized set. They overlap (they share walls, for instance), but do not stand in proper part relations. However, now consider all of the entities that could count as forming some partition or enclosure, such as those that instantiate a core property like `fence`. As is well known, count nouns like *fence*, in English for instance, do not denote a quantized set across all contexts.

A simple case for the count nouns *fence* and its associated core property `fence` is as follows. Suppose the objects that instantiate the number neutral core property `fence` at world $w$ is the set $\{a, b, a \sqcup b\}$. Then there are two contexts $c'$, $c''$ such that at $c'$, $[\![\text{fence}]\!](c')(w) = \{a, b\}$, meaning that there are two fences, and at $c'$, $[\![\text{fence}]\!](c'')(w) = \{a \sqcup b\}$, meaning that there is one fence. In other words, even though the set of objects that instantiate `fence` is not quantized, $[\![\text{fence}]\!](c)(w)$ is quantized for all $c$. Via $\mathcal{Q}_c$, therefore, we have a means of analysing count nouns such as *fence* as context-sensitive expressions with a variable Kaplanian character. A first-pass at a lexical entry for *fence* is given below.

(4.38) $$[\![[_{\text{CN}}\ \text{fence}]]\!]^{M,g} = \lambda c\lambda w\lambda x[\mathcal{Q}_c(\texttt{fence})(w)(x)]$$
$$= \lambda c\lambda w\lambda x[\mathbf{qua}_c(\mathbf{dom}_c(\texttt{fence}_{obj}))(w)(x)]$$

So, *fence* has a variable Kaplanian character, because the set of objects that instantiate `fence` is not quantized.

This also helps explain, perhaps, why *Interconnected* count nouns like *fence* have some of the grammatical reflexes of mass nouns, as we observed in chapter 2 (see also Filip & Sutton 2017). Unless we fix a counting perspective for *fence*, the set of entities that we may wish to count is not quantized. This in turn may motivate why we can felicitously use such nouns as bare 'downstairs' NPs in measure constructions such as *two kilometres of fence*. For instance, we could propose the following sketch for the semantics of measure expressions such as *kilometre*:

(4.39) $$[\![[_{\text{N}_{meas}}\ \text{kilometer}]]\!]^{M,g} = \begin{cases} \lambda n\lambda \mathtt{P}\lambda c\lambda w\lambda x\,[\mu_{km}(x) = n \wedge \mathtt{P}(c)(w)(x)] & \text{if } \mathtt{P}_{obj}(w) = \varnothing \\ & \text{or } \neg QUA(\mathtt{P}_{obj}(w)); \\ \bot & \text{otherwise} \end{cases}$$

This would allow for constructions such as *two kilometres of open water*, since `water` is not object-instantiated. It would also allow *two kilometres of fence/fencing*, since the set of objects that instantiate `fence` is not quantized, but would not allow for e.g., *two kilometres of ball*, since the set of objects that instantiate `ball` is quantized.

### Mass Nouns and Object-neutrality

Our analysis of mass nouns using our Kaplanian, contextualist framework is grounded in the idea that although mass nouns may be context sensitive with respect to contextual domain restrictions, they have a fixed character with respect to their individuation criteria, i.e., they have the same intension in every context with respect to the quantizing contextual parameter. Furthermore, they do not make the set of objects that instantiate a core property privileged. As a result of these two factors, mass nouns do not specify a quantized set of entities as an input to grammatical counting operations.

**Object-neutral functions.** On our proposal, all common nouns have a Kaplanian character (are interpreted as functions from contexts to intensions). We have also sketched how object-instantiated properties can be lexicalized as count nouns via the object-centred quantizing function. For mass nouns, we propose that lexical entries include an *object neutral function*, $\mathcal{N}_c$, which is contextually restricted, as indicated by the subscript. This function is also of type $\langle\langle s, et\rangle, \langle c, \langle s, et\rangle\rangle\rangle$: applied to a core property, it outputs a function from contexts to properties. In this case, however, this function only introduces the contextual parameter governing contextual domain restriction via $\mathbf{dom}_c$. Furthermore, importantly, unlike $\mathcal{Q}_c$. the relevant property is not intersected with the set of objects. Therefore, the object-neutral lexicalization of any core property results in a mass noun, regardless of whether the property is instantiated by objects:

(4.40) Object-neutral Function (monopartite lexical entries):

$$\mathcal{N}_c = \lambda \mathtt{P}.\lambda c \lambda w \lambda x[\mathbf{dom}_c(\mathtt{P})(w)(x)]$$

We shall, also for convenience, sometimes say that:

(4.41) If common noun N expresses expresses $\mathcal{N}_c(\mathtt{P})$, then N is the object-neutral lexicalization of $\mathtt{P}$.

The object-neutral function gives us all we need to characterise the interpretations of two types of mass nouns, namely granulars like *rice* and canonical mass nouns like *oil*, both of which have a fixed Kaplanian character with respect to their individuation criteria. In what follows, let us provide a first pass at their analysis.

**Mass expressions have fixed characters with respect to $\mathbf{qua}_c$.** The object-neutral function $\mathcal{N}_c$ is such that whether or not a core property is object-instantiated, given an input of a number neutral core property, the output is only restricted by any contextual domain restrictions. Importantly, the object-neutral function does not encode intersection with the set of objects, and so even if the core property is instantiated by a quantized set of objects, this set is nevertheless not made available to grammatical counting operations. In other words, we have a lexical entry that does not specify a quantized set of entities for grammatical counting and so is the lexical entry of a mass noun. A first-pass at the lexical entries for *rice* and *oil* are given below.

(4.42)

$$\begin{aligned}
[\![[_{\text{CN}}\ \text{rice}]]\!]^{M,g} &= \lambda c \lambda w \lambda x[\mathcal{N}_c(\mathtt{rice})(w)(x)] \\
&= \lambda c \lambda w \lambda x[\mathbf{dom}_c(\mathtt{rice})(w)(x)] \\
[\![[_{\text{CN}}\ \text{oil}]]\!]^{M,g} &= \lambda c \lambda w \lambda x[\mathcal{N}_c(\mathtt{oil})(w)(x)] \\
&= \lambda c \lambda w \lambda x[\mathbf{dom}_c(\mathtt{oil})(w)(x)]
\end{aligned}$$

So, neither *rice* nor *oil* have $\textbf{qua}_c$ as part of their lexical entries and so neither are sensitive to $\textbf{qua}_c$. Similarly for other mass nouns including object mass nouns such as *furniture*.

We note that even if $\textbf{qua}_c$ is part of the interpretation of a count construction in a sentence, e.g., *two tables and a chair*, this does not license shifting the mass noun *furniture* into a count interpretation:

(4.43) I bought two tables and a chair, and ??these three furnitures were expensive.

In our approach, this is explained as follows. Although $\textbf{qua}_c$ is part of the logical representation of *two tables*, this has no effect on the counting base set in the lexical entry for *furniture*, even if the denotation of *furniture* is partially comprised of tables. This is because the lexical entry of *furniture* is not indexed to $\textbf{qua}_c$, and so $\textbf{qua}_c$ cannot affect the counting base set for *furniture*.

Furthermore, if applied to a number-neutral core property like `fence`, the object neutral function provides a lexical entry that plausibly is that of a mass noun such as *fencing*:

(4.44)
$$
\begin{aligned}
[\![[_{\text{CN}}\ \text{fencing}]]\!]^{M,g} &= \lambda c \lambda w \lambda x[\mathcal{N}_c(\texttt{fence})(w)(x)] \\
&= \lambda c \lambda w \lambda x[\textbf{dom}_c(\texttt{fence})(w)(x)]
\end{aligned}
$$

I.e., *fencing* expresses a property of any fence objects or sums thereof, even if some of these sums do not count as fence objects themselves. For instance, the sum of a fence in Germany and a fence in Spain, taken together count as *fencing*, but not as one *fence* object.

To reiterate, number-neutral core properties like `fence` are instantiated by objects, however, the intersection of `fence` (at a world) with the set of objects, $\texttt{fence}_{obj}$, is not quantized in (most[19]) worlds at which it is defined. We hypothesise that this is why we find so many cases of mass noun lexicalizations of core properties like `fence`. These properties can be lexicalized as count, because they are object-instantiated, but the non-quantized nature of these objects motivates why they can also be lexicalized as mass. That is, if the set of objects that instantiate a core property is not quantized, this sanctions the lexicalization of that object-instantiated core property as mass.

The *fence*/*fencing* example also helps to clarify our position on the relationship between countability (the count-mass distinction) and the structure

[19]There may be worlds with, for example, so few fences that the set of fence objects is quantized. These are not however words that we typically experience in learning what fences are.

of matter (the object-substance distinction). Clearly, these two pairs of categories are not entirely independent of one another, given that there is substantial alignment between them. (See chapter 2 in relation to the rough alignment between canonical count nouns and objects (*ball*) and canonical mass nouns and substances (*air*).) However, as we discussed in chapter 2 and as has been widely noted (e.g., Chierchia 2010; Rothstein 2010 amongst many others), the structure of matter does not DETERMINE lexicalization as count or mass. Part of the undertaking of this volume is to more closely examine the nature of the non-determining dependence that holds between these categories. Here, with nouns denoting connected objects, we find one extra detail: if the set of objects that instantiate a core property is not quantized, then this facilitates the lexicalization of that object-instantiated core property as mass. In chapter 5, we will add much more detail to this picture when we propose three perceptual-interactive constraints that can help predict mass/count lexicalization patterns on the basis of the perceptual and functional properties of objects and the way we interact with them.

**Interim summary**

The key points of our object centred semantics for mass and count nouns introduced so far can be summarised as follows: (i) we motivated our conception of the notion of objects that extends that of Spelke objects. (ii) As a result, we may identify which number-neutral core properties are instantiated by a non-quantized set of objects (e.g., `fence`). (iii) We have provided two ways in which such core properties may be lexicalized: object-centred and object neutral. (iv) The same number-neutral core property can be lexicalized as either count or mass, provided it is object-instantiated. For instance, `fence` underpins a count noun with a variable character in the Kaplanian sense (e.g., *fence*), or a mass noun with a fixed character across all contexts with respect to the quantizing contextual parameter (e.g., *fencing*); (v) all core properties that are instantiated by a quantized set of objects (e.g., *ball*), or else are not instantiated by objects (e.g., *mud*) will be lexicalized with a fixed character with respect to the quantizing contextual parameter.

One of the main innovations of our object centred semantics is that it predicts which count nouns will have variable characters across different contexts with respect to the quantizing contextual parameter (i.e., which nouns will be context sensitive with respect to what counts as 'one'). All concrete count nouns have objects in their extensions, but not all are context sensitive like *fence*. What separates nouns that are context sensitive like *fence* from those that are not is that the former have a non-quantized set of objects in their extensions.

## 4.2 The structure of the lexicon

In this section, we refine the simple first-pass lexical entries just given. We argue for an analysis of common nouns in terms of lexical entries that are *bi-partite* in the sense that they determine two sets of entities for every noun: the standard *extension* of the noun and a *counting base set*. The counting base set is either quantized, in which case the lexical entry is that of a count noun, or not quantized in which case the lexical entry is that of a mass noun.

The use of bi-partite lexical entries as a means of articulating countability distinctions was pioneered by Landman (2011), and developed and refined into his *Iceberg Semantics* over subsequent years (Landman 2016, 2020, 2021). As we hope has been clear over our past work, the core tenet of Landman's work, that a more structure lexicon can solve a number of puzzles in relation to countability, has been of great influence to us (see, e.g., Erbach et al. 2019; Filip & Sutton 2017; Sutton & Filip 2016c, 2017b among many others). Indeed, in this section, we argue that a bi-partite implementation of object-centred, contextualist semantics is likely the most promising option for solving some puzzles relating to count/mass variation. That said, as should be clear from the discussion in chapter 3, as well as the earlier sections of this chapter, we diverge substantially from Landman in several respects. Higher-level differences include that we use quantization over disjointness, and we ground our theory in objects relative to a context instead of the *neat-mess* distinction (see chapter 3). These differences carry through into the Landman-style bi-partite lexical semantics we give in this section. We also depart from Landman in some more fine-grained ways (e.g., that we do not think that the counting base set always generates the extension set). We summarise these points at the end of section 4.2.1.

In section 4.2.1, we provide the details of a bi-partite version of our object-centred contextualist semantics. Then we provide two arguments for a bi-partite semantics. In section 4.2.2, we raise a problem for mono-partite lexical entries of common nouns, namely, that they make the wrong predictions for countability in contexts in which the set of entities in the contextually restricted domain are quantized/disjoint etc. In section 4.2.3, we argue that a bi-partite theory of the lexicon is the best response to the puzzle that arises due to co-extensional pairs of plural count nouns (e.g., *coins, leaves*) and object mass nouns (e.g., *small change, foliage*) that we dub the *co-extensionality puzzle*: put in the simplest terms, on a bi-partite analysis, object mass nouns and plural count nouns can be semantically distinguished in terms of whether their counting base set is quantized.

### 4.2.1 Bi-partite, object-centred contextualist semantics

The principal contention behind a bi-partite approach to the lexical entries of common nouns is the claim that there is more to the lexical semantics of common nouns than specifying a single extension set at each possible world. Specifically, nouns specify, in addition, a set (typically a subset of the extension) that either is or is not suitable as an input to grammatical counting operations. This crucial idea originates in Landman 2011, 2016, and has influenced and inspired others, including ourselves, e.g., (Sutton & Filip, 2016b, 2017b; Vries & Tsoulas, 2018) to name but a few. In other words, the lexical entries of common nouns specify not only the extension of the noun at each possible world, but also the individuation conditions of that noun: a property of objects that count as 'one' for that noun. At each possible world, let us call the set of entities that count as 'one', the *counting base set* (cf. *generator set* in Landman 2011 and *base* in Landman 2016). One can use the counting base set to distinguish count from mass nouns. For instance, that a noun is count iff its counting base set is quantized/disjoint etc.

#### Implementing bi-partite semantics

Given our semantic model is enriched to include a product type constructor, the representation of bipartite lexical entries is straightforward. Common nouns are functions from contexts, worlds, and entities to an ordered pair of a proposition and a set. For a core property $\mathtt{P}$, the proposition is that the relevant entity at the relevant world in the relevant context is $\mathtt{P}$. The set is a set of entities at the world in the context that count as 'one' $\mathtt{P}$:

(4.45) Bi-partite lexical entry schema:

$$\lambda c \lambda w \lambda x \left\langle \mathtt{P}(w)(c)(x),\ \lambda y.\mathtt{Q}(w)(c)(y) \right\rangle \qquad : \langle c, \langle s, \langle e, \langle t \times et \rangle\rangle\rangle$$

Where $\mathtt{P}$ is the nominal core property and $\mathtt{Q}$ is the property of what counts as one $\mathtt{P}$.

In order to aid readability, we introduce the following notational conventions. First, we re-write (4.45) in matrix format, where 'ext' and 'cbase' label the extension and counting base fields respectively:

(4.46) Bipartite lexical entry schema (alternative notation):

$$\lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathtt{P}(w)(c)(x) \\ \text{cbase} & \lambda y.\mathtt{Q}(w)(c)(y) \end{bmatrix}$$

Where $\mathtt{P}$ is the nominal core property and $\mathtt{Q}$ is the property of what counts as one $\mathtt{P}$.

We then use the labels 'ext' and 'cbase' in lieu of the projection functions $\pi_1$ and $\pi_2$, respectively:

(4.47) a. $\pi_1(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = \text{ext}(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = p$

b. $\pi_2(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = \text{cbase}(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = Q$

### Count and mass lexical entries in bi-partite semantics

A bipartite semantics requires reworking our above definitions of $\mathcal{Q}_c$ (the object-centred quantizing function) and $\mathcal{N}_c$ (the object-neutral function).

For the object-centred quantizing function that derives count lexical entries from object-instantiated core properties, we must make a decision where to apply the different contextual parameters. This is because we now have an extension and a counting base. Recall that that contextual domain restriction is intended to cover what it is in the world that may be being referred to in the context. It does not guarantee countability. As such, we apply this parameter ($\mathbf{dom}_c$) in the extension field. The contextual quantizing parameter ($\mathbf{qua}_c$) specifically relates to what counts as 'one'. As such, we apply it only in the counting base field:

(4.48) Object-centred Quantizing Function (bipartite lexical entries):

$$\mathcal{Q}_c = \begin{cases} \lambda \mathrm{P}\lambda c\lambda w\lambda x.\begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathrm{P}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathrm{P}_{obj}(w)(y) \end{bmatrix} & \text{if } \mathrm{P}_{obj}(w) \neq \varnothing, \text{ and } QUA(\mathrm{P}_{obj}(w)) \\ \lambda \mathrm{P}\lambda c\lambda w\lambda x.\begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathrm{P}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathbf{qua}_c(\mathrm{P}_{obj})(w)(y) \end{bmatrix} & \text{if } \mathrm{P}_{obj}(w) \neq \varnothing, \text{ and } \neg QUA(\mathrm{P}_{obj}(w)) \\ \perp & \text{otherwise.} \end{cases}$$

This allows us to repeat our count noun examples of *cat* and *fence* in the bipartite semantics:

(4.49)
$$\begin{aligned} [\![ [_{\text{CN}} \ \text{cat}] ]\!]^{M,g} &= \lambda c\lambda w\lambda x[\mathcal{Q}_c(\mathtt{cat})(w)(x)] \\ &= \lambda c\lambda w\lambda x\begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathtt{cat}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathtt{cat}_{obj}(w)(y) \end{bmatrix} \end{aligned}$$

(4.50) $$[\![[_{\text{CN}} \text{ fence}]]\!]^{M,g} = \lambda c \lambda w \lambda x[\mathcal{Q}_c(\texttt{fence})(w)(x)]$$
$$= \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\texttt{fence}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathbf{qua}_c(\texttt{fence}_{obj})(w)(y) \end{bmatrix}$$

The extensions of both *cat* and *fence* are open to contextual domain restriction. However, since the set of fence-entities that are objects is not quantized, the counting base of the *fence* lexical entry is also indexed to the quantizing contextual parameter. This means that what counts as *one fence* may vary across contexts in a way that is not the case for *one cat*.

For mass nouns, we also re-work the object-neutral function to fit our bi-partite lexical assumptions:

(4.51) Object-neutral Function (bipartite lexical entries):
$$\mathcal{N}_c = \lambda \texttt{P} \lambda c \lambda w \lambda x. \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\texttt{P})(w)(x) \\ \text{cbase} & \lambda y.\texttt{P}(w)(y) \end{bmatrix}$$

Again, the main two differences here are that the core property at each $w$ is not intersected with the set of objects and there is no contextual restriction on the counting base properties of mass noun lexical entries. Like for count nouns, the extensions of mass nouns can be contextually restricted. For example, the lexical entry for the mass noun *rice* is given as:

(4.52) $$[\![[_{\text{CN}} \text{ rice}]]\!]^{M,g} = \lambda c \lambda w \lambda x[\mathcal{N}_c(\texttt{rice})(w)(x)]$$
$$= \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\texttt{rice})(w)(x) \\ \text{cbase} & \lambda y.\texttt{rice}(w)(y) \end{bmatrix}$$

### Contrast with Landman's bi-partite lexical entries

Those familiar with Landman's work should see clearly this influence the has had upon our proposal and the development of our ideas. It would be a mistake, however, to think that the proposals, Landman's and our own, are the same. Here, let us briefly discuss some of the higher-level and lower-level details that set these proposals apart, as well as clarify, in some cases, how differences in formal implementation sometimes do and sometimes do not matter.

*The relation between the two sets.* A core tenet, in all of Landman's work on the count/mass distinction since 2011 is *generation*. Setting aside the complexities for mess-mass nouns discussed at length in Landman 2020, ch. 8., the basic idea is that (at least for count nouns), the base set generates the body (extension) under mereological sum (relative to a world, context etc.). This is important for Landman, since he, in some sense, starts with bases and moves up to bodies. We, on the other hand, start with number-neutral properties (and the problem that some properties have variation in their count/mass lexicalization patterns), and look for an explanation of this variation (see especially chapter ch 5). As such, we maintain only a weaker condition that the counting base set is a subset of the extension (relative to a world, context etc.). As we discuss in section 4.3.1, we therefore allow the possibility that (plural) count granular nouns such as *lentils* can denote whole lentils and sums thereof and also bits and pieces of lentils and sums thereof (think of a Dhal for instance, a bowl of curried lentils), even if when we count *lentils*, we are forced to count *lentil*-objects (whole lentils). As far as we can see, this possibility is ruled out as a matter of foundational principle in Landman's work.

*Treatment of context.* In the earlier parts of this chapter, we presented, in some detail, a structured, Kaplanian model of context, which we argued is needed to capture the different ways in which common nouns are or are not context-sensitive. (As we there made clear, this builds upon the emphases on the importance of context in e.g., Rothstein 2010; Zucchi & White 1996, 2001.) Landman, both in his written work (and via p.c.) makes clear that he, too, thinks context is crucial for providing a fully fledged theory of countability. That said, there are a number of differences in our treatments of context, both from a technical and a more philosophical perspective. On a technical level, we provide substantially more detail about the structure of contexts, how there are different contextual parameters that can affect the interpretations of common nouns, and in what way they do (e.g., affecting the counting base set or the extension, relative to a world of evaluation). Landman is less concerned with the details of how context interacts with the lexicon. In Landman 2020, §4.7.3, however, Landman explores adopting a model of a context that is similar to the one we present here and already outlined in Filip & Sutton 2017, namely as a function from sets to sets.[20]

Landman also appeals to context in a way that we are not fully convinced of. A salient passage, for instance, is:

> Take a big juicy slab of meat. We can think of this as being built from minimal parts, without having to assume that there are 'natural minimal meat parts'; think of the meat as built from parts that are appropriately minimal in the context. (Landman 2020, p. 236)

[20]See also §7.2 for discussion of relationships and differences between Rothstein's and Landman's accounts.

This, plus there being no privileged context (no privileged set of minimal meat parts) motivates why nouns such as *meat* are mass for Landman. However, we do not think that context plays a role in explaining why canonical mass nouns such as *meat* are mass. This is recorded in our semantics by there being no indexing to context on the counting base sets of canonical mass nouns (or other mass nouns).

Put simply, although we take on some of Landman's ideas about bipartite semantics for common noun lexical entries, this does not mean our proposals are the same. We have shown that our object-centred, contextualist semantics can be implemented within a bi-partite semantics for lexical entries (and we will, in sections 4.2.2–4.2.3, argue in favour of such an implementation). However, our appeal to objects and a structured notion of context, amongst others, that we developed earlier in this chapter stands completely independently from Landman's approach. Indeed, all we have proposed in relation to the role of objects and a structured model of context are either purposefully not present in Landman's semantics (we diverge on the role of objects, for instance), or else differ from our proposal (Landman, unlike us, does not address how different types of context interact, and also lets contexts play a wider role than we do, such as motivating why canonical mass nouns such as *meat* are mass).

*Implementation in* $\mathbf{TY_{3\times}}$. We use product types for modelling lexical entries. Product types do not feature explicitly in Landman's work. His preference is to work directly in set theory where possible, whereas we find it slightly more readable to work wit a (dispensable) intermediary language, the logic of $\mathbf{TY_{3\times}}$. That said, Landman does, for instance, $\lambda$-abstract directly over pairs of sets, and uses the equivalent of projection functions, so some hint at something like $\mathbf{TY_{3\times}}$ underlies his proposal. At the very least we can say that the logic of $\mathbf{TY_{3\times}}$ could be used to implement Landman's Iceberg semantics, but it is less clear that Object-Centred contextualism could be implemented with the formal tools provided in e.g., Landman 2020, given our comments about models of context above (although, with some work, of course, one could implement our Object-Centred contextualism directly in set theory in terms of ordered tuples and projection functions).

*(Counting) Bases under modification.* Finally, as will be made clear by the end of this chapter, we do not commit to the mechanisms for counting base modification that e.g., ibid. For instance, Landman (ibid., §5.4) analyses *white cat* as pair of sets ($\langle \mathbf{body}, \mathbf{base} \rangle$), namely: $\langle \mathsf{WHITE}_w \cap \mathsf{CAT}_w, \mathsf{WHITE}_w \cap \mathsf{CAT}_w \rangle$. We do not assume that e.g., adjectival modifiers update counting bases in this way. One reason for this choice is that modification by e.g., adjectives the extensions of which have an empty intersection with a noun do

not affect countability. These data were first raised by David Barner (p.c.). He argued that the fact that, e.g., *square circle* is a count NP rules out a extensionally-based theory of countability (because such objects do not exist in any possible worlds). We think Barner's data must be accounted for, but do not share his conclusion. A simple explanation of these data, we would suggest, is that modified common nouns preserve their counting base sets. That is to say that *two white cats* denotes (relative to a world and context), the set of cat sums, each of which are white, where the sum counts as *two* with respect to the counting base set (the set of single cats). The modified noun phrase *white cat* is count because the counting base set (the set of single cats) is quantized. Likewise, setting aside the complexity that *circle* also denotes abstract entities, *square circle* is count because, relative to a world and context, the counting base set is (a subset of) the set of single circles which is quantized.

Having further differentiated our approach from Landman's (but see also chapter 3), we now turn to arguments for a bi-partite approach to the lexicon.

### 4.2.2 Argument 1: Contextual domain restriction does not override countability class

So far we have outlined both a mono-partite and bi-partite approach to the lexicon within our object-centred contextualist semantics. Now let us provide the first of two arguments for preferring the latter. In short, the argument is that, given contextual domain restrictions on common nouns, it had better not be the case that, in appropriately restricted contexts, mass nouns become count nouns. Bi-partite lexical entries are one means of blocking this: countability is determined by the counting base set, and contextual domain restriction only affects the extensions of common nouns.

One way to formulate the problem for the mono-partite approach is as follows. The argument below leads us to a conclusion (C) that is false, given some otherwise reasonable or justified premises (P1)-(P3), one of which is based upon the assumption of a mono-partite structure of the lexicon (P2):

(P1) The count/mass distinction is reflected in the semantics of common nouns.

(P2) The only relevant locus for a semantic countability distinction is the extension of a common noun at a world and in a context. E.g. that the extension is generated from a quantized/disjoint/stably atomic set etc.

(P3) Given a richly enough specified context, via contextual domain restriction, the extension of mass nouns that denote objects can be restricted to a set that is quantized/disjoint etc.

(C) Via contextual domain restriction, mass nouns that denote objects can be shifted to a count interpretation in a rich enough context.

In this argument, (P1) is the assumption that the count/mass distinction is fundamentally a semantic distinction, and so countability distinctions supervene on semantic distinctions (something we assume in this volume), i.e., is not merely a syntactic distinction. (P2) follows from a mono-partite view of the lexicon in which only the specification of the extension of a noun at a world and in a context is given in the lexical entry. (P3) requires some justification. Take any mass noun that denotes objects such as *furniture*. Given that mass nouns are as susceptible to contextual domain restrictions as count nouns, we should be able to construct a context in which just one item of furniture is in the relevant extension of *furniture*, and indeed this is simple enough. Take any visual scene in which there is an empty room save for, say, one chair or one sofa etc. If this scene is our context, $c_{room}$, then the extension of *furniture* in $c_{room}$ should be a singleton set. Now, the problematic conclusion (C) comes into force. Given (P1) and (P2) the extension of *furniture* in the context should be relevant for whether *furniture* is countable i.e, that it is quantized or disjoint etc. Yet in the context, $c_{room}$ just provided, the extension of *furniture* is a singleton which is trivially quantized and disjoint and is also stably atomic. The problem is that it is false that *furniture* is countable in this context:

(4.53) Given context $c_{room}$:
#There is one furniture.

The problem generalises to granular nouns as well. Here is a comparable example from Sutton & Filip 2021b for *rice*. There is no context in which the numeral phrase in (4.54) cannot mean 'three grains of rice':

(4.54) #Three rices fell off my spoon.

One way one could respond to this puzzle is to insist that the count/mass distinction is determined by the extensions of expressions independently of contexts of use. Problematically, however, this response makes the wrong predictions for *interconnected* count nouns such as *fence* and *wall*. If countability is determined by context-independent extensions, then these nouns do not have e.g., quantized or disjoint extensions independently of a context of use (nor do they have stable atoms if no 'ground context' is fixed, see Chierchia

2010, pp. 120-122), so should be predicted to be mass contrary to fact.

The better response to the argument, we propose, is to reject (P2), namely to reject a mono-partite view of lexical entries which only contain the specification of the extension of a noun at a world and in a context, and instead embrace bi-partitism. With a bipartite lexical entry, no problem is generated by mass nouns that denote objects like *furniture* or *rice* mentioned above, because, as we have argued, contextual domain restriction operates on the extension of a common noun, not on its counting base. In other words, in the context $c_{room}$, *furniture* is still mass. Even if it happens to have just one piece of furniture in its extension in this context, still its counting base set will not be quantized. So its denotation is not that of count nouns, and it cannot serve as input to counting constructions like (4.53).

We note that we are not the first to notice this kind of problem and use it to motivate bi-partite lexical entries. Landman provides the following as a critique of the approach to countability in Chierchia 1998a:

> "A set of atoms is sitting at the bottom of the mass noun denotation and at the bottom of the count noun denotation. The theory postulates that it can be pulled out in the second case, but not in the first case, and this is why you can't count. The problem is that it is not particularly difficult to semantically or contextually pull a set of atoms out of an atomic structure. . . a child can do it. And there, of course, is the problem: the child doesn't do it." (Landman, 2011, p. 15)

### A note on count/mass coercion

We have just discussed how context cannot override countability distinctions in some cases. However, context also features prominently in precisely facilitating count/mass coercion. For instance, for mass-to-count coercion, *n rices* is felicitous in contexts in which some portions or subkinds of rice are salient enough (packaging and sorting). Below are attested examples from Sutton & Filip 2021b of packaging (4.55) and sorting (4.56):

(4.55) We ordered the main courses with two plain rice, one egg fried rice and a nan, more than enough for the four of us.

(4.56) Context: three kinds of rice: Calmati, Texmati, Kasmati
These three rices have Basmati's viscosity and cooking style, but smaller individual grains.

For count-to-mass coercion, *grinding* is also available in appropriate contexts:

(4.57) Danny used bug spray because he didn't want to get cockroach all over his boot.

Such data have led e.g., Pelletier (1975; 2012) to suggest that count and mass senses are encoded by every (concrete) common noun:

> "Furthermore, the universal grinders and packagers show that at least the non-abstract nouns have these sorts of mass and count meanings already embedded within their semantic values, needing only some appropriate context to become highly salient." (Pelletier, 2012, p. 20)

Given our previous discussion of contextual domain restriction, these coercion data beg the question about just why mass-to-count coercion is not sensitive to factors tied to contextual domain restriction. Can the mechanisms behind contextual domain restriction alone be sufficient to also account for mass-to-count coercion?

First, we will report on data from our previous work that suggests a negative answer to this question. Then, we will suggest how a bi-partite semantics can clearly delineate contextual domain restriction on the one hand, from coerced countability shift on the other.

**Why mass/count coercion is not triggered by factors stemming from contextual domain restriction.** As we already outlined in our *fence* example in section 4.1.3, contextual domain restriction does not provide individuation criteria, even for count nouns. In that example, the context determines what fencing we are talking about, e.g., a fencing around someone's garden, for instance, but this on its own does not yet determine the counting perspective, i.e., what for us is one fence for the purpose of counting, and so how many fences we take there to be. Put differently, we need to keep variation with regard to individuation criteria distinct from general processes of contextual domain restriction.

With such preliminary observations out of the way, let us turn to mass-to-count coercion. We find a number of restrictions that would be unexpected if coercion were simply licensed by contextual domain restriction. For instance, granular mass nouns cannot be coerced into a count reading that individuates grains (see (4.54 above). Also, as indicated above by (4.53), and also discussed at length in Sutton & Filip 2016a, 2017c, object mass nouns cannot be coerced into either a reading that individuates on the basis of objects, nor on the basis of subkinds:

(4.58) Sutton & Filip 2016a, p. 353

a. ?Can you bring three furnitures to our office, please?
   Int: 'Can you bring three items of furniture to our office, please?'

b. ?I ordered three furnitures: chairs, tables and cabinets/kitchen, living room, and office.
Int: 'I ordered three kinds of furniture...'

For canonical mass nouns, too, there are restrictions on what kind of readings one can get. For instance, *three waters* can quite easily be used to refer to three glasses or bottles of water in appropriate contexts, but salient portions of water are not sufficient to allow for mass-to-count coercion:

(4.59) Context: There are three puddles of water on the floor.
?There are three waters on the floor.

If the mechanism behind contextual domain restriction and mass/count coercion were the same, these restrictions on coercion would be unexpected.

**Coercion in bi-partite semantics.** The bi-partite approach to the lexical entries of common nouns allows for a straightforward delineation between contextual domain restriction and mass/count coercion. We will only provide a sketch here, however see, e.g., Sutton & Filip 2016a, 2017c, 2021a,b.

We have already suggested that the contextual domain restriction parameter $\mathbf{dom}_c$ only applies within the extension-field in the lexical entries of common nouns, and so does not affect their individuation criteria. This prevents $\mathbf{dom}_c$ from shifting from a mass to a count interpretation in some contexts should there, by happenstance, be only a quantized set of objects in the extension of the noun in that context.

Coercion, then, may quite simply be a process by which the counting base field of a common noun lexical entry is modulated when it is used in an appropriate context. Take for instance *two plain rice* in (4.55). Here, we have a mismatch between the selectional restrictions of a numeral (which requires a count noun) and a mass common noun phrase that it modifies. This triggers a mass-to-count coercion, namely, which succeeds if an appropriate individuation criterion can be retrieved from the context that can be implicitly applied to ⟦*plain rice*⟧. In our example, it amounts to some apportioning or container classifier concept, and plausible readings include *two* BOWLS OF *plain rice* and *two* PORTIONS OF *plain rice*. Crucially, however, these classifier concepts like BOWLS OF or PORTIONS OF provide the requisite individuation criteria that modify the counting base, not the extension of the common noun *rice*, which is subject to contextual domain restriction. The latter, in our example (4.55), most likely concerns a restaurant context, or some other commercial establishment where one can order food. But this means that contextual domain restriction may facilitate identifying what relevant covert classifier concept is needed to resolve the type mismatch between, say, *two* and *plain rice* in the relevant context. I.e., restaurant contexts may make BOWLS OF salient. But contextual domain restriction alone is not the same as covertly applying this concept and thereby coercing *rice* into a count interpretation.

Of course, it is an interesting question why GRAIN OF cannot be used as a covert classifier in such cases. We have proposed an answer to this in Sutton & Filip 2016a. In the simplest of terms, there we propose that if a language were to licence applying, covertly, a generalised salient-quantity classifier, then there could be no robust count/mass distinction lexicalized in that language.

### 4.2.3 Argument 2: The co-extensionality puzzle

It is widely accepted that there are number-marking languages in which the interpretations of both count and mass nouns, including object mass nouns, are of a predicative type, i.e. they express properties and denote sets of entities.[21] Since plural count nouns and object mass nouns can both denote sets of entities, we have good prima-facie reasons for assuming that object mass nouns, such as the English mass noun *furniture*, are co-extensional with plural count nouns such as the Finnish *huonekalut* ('items of furniture'), namely, both denote the set of items of furniture and sums thereof, not least since these expressions can be used to refer to exactly the same things in the world (setting aside any across and within language micro-variation). Furthermore, such pairs can even be found within the same language such as the Dutch *meubels*/*meubilaire* (items of furniture/furniture (see Landman, 2011)). However, this assumption is problematic, since any semantic theory of the count/mass distinction must identify some way in which the denotations of such plural count and object mass noun pairs differ on pain of having no explanation for their distinct grammatical properties, as witnessed by their distinct distributional patterns. We dub this the *co-extensionality puzzle*.[22]

The puzzle can be formulated as a paradox:

(P1) The count/mass distinction is reflected in the semantics of common nouns.

[21] I.e. languages which have a [+Pred, +Arg] or [+Pred, −Arg] nominal system in the sense of Chierchia (1998a).

[22] The puzzle could also be called the co-intensionality puzzle, but, at least for most mereologically-characterised theories, it is the extension that is at issue.

(P2) The only relevant locus for a semantic countability distinction is the extension of a common noun at a world and in a context. E.g. the extension is generated from a quantized/disjoint/stably atomic set etc.

(P3) There are plural count nouns and object mass nouns that are coextensional.

(C1) There can be no coextensional plural count nouns and object mass nouns. (P1, P2)

(C3) $\perp$ (P3,C1)

(P1) and (P2) are reiterations of the premises in the argument from contextual domain restriction above. (P1) is the assumption that countability is a semantic distinction and (P2) follows from a mono-partite view of the lexicon. (P3) is a reasonable assumption given that mass/plural count pairs such as *furniture* and the Finnish *huonekalut* ('items of furniture') seem to be able to refer to the very same entities in the world. (C1) follows from the semantic countability assumption and from mono-partitism. There must be extensional differences any two that are lexicalizations of the same properties if they differ in countability (e.g., if one is a plural count noun and the other is an object mass noun). However, this straightforwardly contradicts (P3).

### Bipartite lexical entries avoid the contradiction

As with the previous argument from contextual domain restriction, the assumption that common nouns have bipartite lexical entries amounts to a denial of (P2). With a bi-partite semantics, the properties of the counting base are relevant to whether a lexical entry is that of a count noun or a mass noun. This therefore blocks (C1) and avoids paradox.

As an example, the distinction between *furniture* (mass) and the Finnish *huonekalut* ('items of furniture', count) is straightforward to express: both have the same extensions across contexts and worlds, but their counting bases are not the same.

For *furniture*, the counting base property is just the number neutral property $\mathtt{furniture}$:

(4.60) $$[\![ [_{\text{CN}} \text{ furniture}] ]\!]^{M,g} = \lambda c \lambda w \lambda x[\mathcal{N}_c(\mathtt{furniture})(w)(x)]$$

$$= \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathtt{furniture})(w)(x) \\ \text{cbase} & \lambda y.\mathtt{furniture}(w)(y) \end{bmatrix}$$

For *huonekalut* ('items of furniture', count), the extension is the set of objects that instantiate $\mathtt{furniture}$, namely $\mathtt{furniture}_{obj}$, closed under mereological sum via Link's (1983) *-operator. This is an operator that forms a closure under mereological sum. (We return to a compositional treatment of plural morphology in section 4.3.1.)

(4.61) $^*X = \{x : x = \sqcup Y, Y \subseteq X\}$, where $\sqcup Y$ is the sum of elements in $Y$.

The counting base set for *huonekalut* in (4.62) is $\lambda y.\mathbf{qua}_c(\mathtt{furniture}_{obj})(w)(y)$ and so is quantized at every context, unlike the set $\lambda y.\mathtt{furniture}(w)(y)$ in (4.60).

(4.62)
$$[\![[_{\text{CN}}\ \text{huonekalut}]]\!]^{M,g} = \lambda c\lambda w\lambda x[\mathcal{Q}_c(\mathtt{furniture})(w)(x)]$$
$$= \lambda c\lambda w\lambda x\begin{bmatrix}\text{ext} & ^*\mathbf{dom}_c(\mathtt{furniture}_{obj})(w)(x)\\ \text{cbase} & \lambda y.\mathbf{qua}_c(\mathtt{furniture}_{obj})(w)(y)\end{bmatrix}$$

Now, one may wonder if, given the lexical entries in (4.60) and (4.62), whether *furniture* and *huonekalut* are coextensional, given that for one, the extension is the upwards closure of the property evaluated at $w$ intersected with the set of objects ($^*\mathbf{dom}_c(\mathtt{furniture}_{obj})(w)$), and for the other, it is just the number neutral set ($\mathbf{dom}_c(\mathtt{furniture})(w)$). However, we can show that these two are equivalent. For any core property $\mathtt{P}$ for which objects are the minimal entities that instantiate it, it follows that $\mathtt{P}(w) = {}^*\mathtt{P}_{obj}(w)$ for all $w$, since for such properties the number neutral $\mathtt{P}$ just is the property of being a $\mathtt{P}$ object or a sum thereof. So *furniture* (mass) and the Finnish *huonekalut* ('items of furniture', count) are coextensional. However the counting base differs, since only *huonekalut* has a quantized counting base set. The counting base set for *furniture* is not quantized, either because, as we assume here, it contains all items of furniture and sums thereof, or, as we proposed in e.g., Sutton & Filip (2016b) that even the set of single items of furniture is not quantized (or disjoint), since e.g., a vanity is comprised of a sum of a table and a mirror, both of which count independently as furniture (see also Landman 2011).

In summary, assuming a bi-partite lexical entry for common nouns is one plausible way of avoiding the contradiction that the co-extensionality puzzle gives rise to.

### Chierchia's (2010; 2015) solution to the co-extensionality puzzle

An alternative solution to the co-extensionality puzzle denies (P3), i.e., denies that there are pairs of coextensional object mass nouns and plural count nouns. This is a view defended in Chierchia 2010, 2015. Chierchia proposes that mass nouns, but not plural count nouns, express singleton properties Chierchia (2010, 2015). According to Chierchia in at least some number marking languages, the extension of a mass noun is the singleton set, the sole member of which is the sum of the entities that instantiate the number-neutral core property at any given world, i.e., at each world, a mass noun denotes a set of entities with a *logically fixed cardinality* (Chierchia, 2015, p.162) such that for a number neutral core property $\mathsf{P}$, a mass noun expresses:

(4.63) $\lambda w\ \lambda x\ [x = \sqcup \mathsf{P}_w]$

which at world $w$ is the singleton set of the sum of $\mathsf{P}$s in $w$.

Thus plural count nouns and object mass nouns can be distinguished in terms of their denotations: a plural count noun denotes a number neutral set of objects, an object mass noun denotes singleton sets, the sole member of which is a sum of objects.

One of the benefits of Chierchia's proposal, he claims, is that it affords us a means of expressing what is shared by singular count nouns and (singular) mass nouns, namely singular agreement facts. Simplifying slightly, the idea is that singular nouns, be they count or mass, have singular extensions because these extensions are not closed under sum (or are only trivially so) (ibid., p. 157). Although clearly important, we set aside the complexities of agreement facts here.

### Concerns about about the singleton property approach

There are two issues that arise with Chierchia's (2010; 2015) proposal: for number-marking languages at least, it seems to undermine the semantic basis for the count/mass distinction upon which it is based, and this in turn implies a non-unified analysis of countability cross-linguistically; the account seems to require positing added complexity to account for simple predication.

*Undermining the semantic basis for the count/mass distinction:* Within Chierchia's theory, the property that explains the count/mass distinction is *stable atomicity*: count nouns are based on stably atomic properties and mass nouns are based on non-stably atomic properties (see chapter 3). Stable atomicity is also used as a selectional restriction for the semantics of expressions that select for count nouns such as numerals. For example, the cardinality function that is a part of the semantics of numerals is only defined for stably atomic properties (see Chierchia, 2010, p. 124, ex (47d)). However, as noted by Chierchia (2015), the assumption that some number marking languages encode mass nouns as singleton properties has connotations for this basic picture, since singleton properties are stably atomic (ibid., p. 164). The effect of this is that one has to add a further restriction on the semantics of numerals, namely that they select for properties that do not have a 'logically fixed cardinality' (see Chierchia, 2015, p. 162, fn. 30).

Adding this condition, however, begs the question why we need stable atomicity at all for number marking languages. If mass nouns express singleton properties, they are not countable because singleton properties have a logically fixed cardinality at each world. We do not need to mention stable atomicity at all. Furthermore, if a denial of the coextensionality of plural count and object mass nouns pairs is meant to apply only to number-marking languages which have predicative uses of mass nouns, then this implies that the explanation for countability in other languages is not the same as in number-marking languages. For example, in languages such as classifier languages in which all nouns are kind-denoting, the explanation of what nouns are countable must lie elsewhere.

*Complications for compositional semantics:* As Chierchia is well aware, assuming a different interpretation for mass nouns (singleton properties) than plural count nouns (number neutral properties) introduces some complications for the compositional system, such as the definitions of quantifiers (ibid., p.162). In addition, the structure of the the relevant number neutral property must also be retained for some constructions:

> even if listed as singleton properties, nouns like *furniture* do retain their atomic structure. Such structure can be extracted from their denotation (in fact, it has to be extracted by quantifiers like *some*, *all*, *most*,...). And such structure will be indistinguishable from that of plurals. This would explain why in some cases, fake mass nouns do pattern with count plural nouns and unlike core mass nouns, as with the 'Stubbornly Distributive Predicates' (Chierchia, 2010, p. 139)

However, it is not wholly clear to us how one can allow access to this structure in some cases, but block it in others. Consider the following two data points:

(4.64) a. That chair is (cheap) furniture. (ibid., p. 110, our parentheses)
b. ?I bought three furniture(s).

If we are to maintain the standard assumption that for simple predication in copula constructions such as (4.64a), the extension of (*cheap*) *furniture* should be a set, such that (4.64a) is true iff the referent of *that chair* is a member of this set, then we need to be able to shift *furniture* from expressing a singleton property to expressing a (number neutral) property, since single chairs are not members of the singleton set of the sum of items of furniture. At the same time, *furniture* cannot be shifted freely into denoting a number neutral set otherwise it could be combined with a numeral contra the data in (4.64b). The question is, under what conditions can we license shifting a singleton property to a number neutral one. The answer cannot be that this is a freely available shift, otherwise one could not block (4.64b).

At the very least, it seems that some additional assumptions about simple predication must be made, such as encoding ambiguity in the copula such that a type shifting operation is only applied if the property is a singleton, or that set membership is replaced by a part relation if the property is a singleton. Indeed, a similar ambiguity would also need to be propagated into much of the determiner system.

### A hybrid approach

Let us briefly raise a third possible response to the co-extensionality puzzle, namely to combine bi-partite lexical entries with the idea that mass nouns express singleton properties. For example, for *furniture*, the counting base property would be the number neutral property `furniture`, as in our bipartite semantics, but the extension-field would specify a singleton property:

(4.65) $$[\![[_{\text{CN}} \text{ furniture}]]\!]^{M,g} = \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & x = \sqcup \mathbf{dom}_c(\texttt{furniture})(w)(x) \\ \text{cbase} & \lambda y.\texttt{furniture}(w)(y) \end{bmatrix}$$

This constitutes a hybrid account of a bi-partite lexicon account for the count/mass distinction, and a singleton denotation for mass nouns. On this approach a denial of co-extensionalism would then be available, for instance, as an explanation of some singular agreement facts in the manner that Chierchia has proposed, whilst still attributing the count/mass distinction to whether the counting base set is quantized relative to context. Since we leave an account of agreement facts aside in this work, we will largely set this hybrid approach aside.

### Other possible responses to the co-extensionality puzzle

Bi-partite lexical entries and singleton property assumptions are not the only options for addressing the co-extensionality puzzle. Let us briefly consider two alternatives and explain why we do not adopt them in our analysis. It is important to note that, in the following, we are extracting what we think would be reasonable responses to the co-extensionality puzzle given the elements of each theory we consider. As such, this is an exercise in considering how different theories could respond to the puzzle, given that the proponents of each of these theories do not explicitly address the co-extensionality puzzle in their proposals.

### Mass and count nouns are of different semantic types

Another way of denying (P3), that there are coextensional plural count and object mass noun pairs is to claim that the interpretations of count and mass nouns are not of the same semantic type by developing an account along the lines of either Krifka 1989 or Rothstein 2010. For instance, in Rothstein's theory, one could provide the following lexical entries for *furniture* and *huonekalu-t* ('item-s of furniture', Finnish, count):

(4.66) $[\![\text{furniture}]\!] = \lambda x_{:e}.\mathit{FURNITURE}(x)$

(4.67) $[\![\text{huonekalut}]\!] = \lambda \mathbf{x}_{:e\times k}.{}^{*}\mathit{FURNITURE}(\pi_1(\mathbf{x})) \wedge \pi_2(\mathbf{x})(\pi_1(\mathbf{x}))$

I.e., *huonekalu-t* denotes the set of entity-context pairs $\langle x, P\rangle$ in which $x$ counts as an item of furniture or a sum thereof and is in the extension of the context $P$.

However, in chapter 3, we precisely detailed the problems related to a type-based distinction among count and mass nouns, hence, we will not address this view further.

### Vacuous plural morphology

Finally, one could deny that the co-extensionality puzzle is a genuine puzzle by assuming that, in the relevant constructions in which plural count nouns and object mass nouns have different distributional patterns (e.g., numeral constructions), plural morphology on count nouns is semantically vacuous. I.e., one can deny the co-extensionality premise of the puzzle, but only relative to certain constructions. For example, in numeral constructions such *three chairs*, on this view, the plural morphology is semantically vacuous and so the interpretation of *chairs* is a set of single chairs (i.e., the same as the interpretation of the singular noun *chair*). Mass nouns generally denote number neutral sets of entities. A proposal along the above lines regarding the vacuousness of plural morphology at least in some constructions can be found in (Deal, 2017; Ionin & Matushansky, 2004; Ionin et al., 2006; Krifka, 1989).[23] Although they do not deal with the co-extensionality puzzle directly, one could hypothesise that on this proposal the distributional differences

[23] We note that Krifka (1989) assumes that singular count nouns denote functions from numerals to pluralities of entities whereas Deal (2017), Ionin & Matushansky (2004), and Ionin et al. (2006) assume that plural count nouns in numeral constructions denote sets of single entities.

between plural count nouns and object mass nouns could be straightforwardly predicted on the basis that they are not co-extensional: count nouns denote sets of single entities while mass nouns number neutral sets of entities.

The constructions that are most commonly adduced to motivate the vacuous plural hypothesis are numeral constructions and decimals. For numeral constructions, it is observed that in some number-marking languages, such as Finnish and Turkish, numeral constructions are formed with singular count nouns (Ionin & Matushansky, 2004; Ionin et al., 2006; Krifka, 1995), and in English, for example, decimal numeral constructions and numeral constructions with *zero*, count nouns are also pluralised (Krifka, 1989, p. 85), e.g., *Zero/2.5 apples.*

However, in Turkish, singular count nouns can denote pluralities in other contexts. This suggests that singular count nouns in Turkish may denote number-neutral sets of objects. In Finnish, plural morphology and case play a role in giving rise to definiteness effects in numeral constructions. Singular marking in numeral constructions in these languages is simply not evidence for vacuous plural marking in English.

The use of plural count nouns in decimal numeral constructions and numeral constructions with *zero* also fails to provide a convincing argument in support of semantically vacuous plural morphology. Decimal and fraction numeral constructions might best be analysed as measure constructions, which impose specific syntactic and semantic constraints both on the measure phrase and the argument that denotes what is measured, and so the fact that we find plurals here is also not decisive.[24] For example, as observed by Partee & Borschev (2012), fractions and decimals can disambiguate measure readings of pseudo-partitive constructions from container readings. For example, to say *pour 0.25 glasses of wine into the sauce* (under a measure reading of *glass of wine*) is fine, but using a decimal with a container reading of *glass of wine* is highly marked: *??John picked up 0.25 glasses of wine.*

Finally, the vacuous plural hypothesis makes the wrong predictions. Crucially, the vacuousness of plural morphology is not typically supposed to hold in all constructions (Krifka, 1989, p. 85). In *Alex bought apples*, for example, the plural marking on 'apples' is not semantically vacuous. However, if that is so, then contrasts like the following one remain unexplained:

(4.68) a. apples, each of which was red
b. furniture, #each of which was red

On the above assumptions, both *apples* and *furniture* express a number

[24]See Rothstein's work for an extensive discussion of the counting/measuring distinction, including Rothstein (2010, 2011, 2017).

neutral property of objects. However, only the former, but not the latter, can serve as the antecedent for *each of*.

In sum, mass/count theories that assume that plural morphology is semantically vacuous and so that, in numeral constructions for instance, plural count nouns denote sets of single entities still have to face the co-extensionality puzzle and other problems beyond the confines of such constructions.

## 4.3 Applications

In this section, we will apply our object-centred contextualist semantics, and bi-partite approach to the lexicon to the composition of three constructions that are central to count/mass semantic theories. First, we show how numeral constructions are analysed within our system, which means that we will also present an account of plural morphology and numeral expressions. Then we will turn to an analysis of the data presented in chapter 2: (i) explaining the distribution of stubbornly distributive predicates, i.e., why they are felicitous with all count nouns, but only some mass nouns, and (ii) explaining why only a subset of nouns that are felicitous with stubbornly distributive predicates also allow for cardinality comparison readings. As we show, and in contrast to other theories (see chapter 3), our theory straightforwardly explains why stubbornly distributive predicates select for nouns with objects in their extensions. We will then discuss the, perhaps surprising, data described in chapter 2 that concern cardinality comparison readings of some granular and filament mass nouns. We tentatively propose that these data as well as the data regarding cardinality comparisons and object mass nouns can be accounted for in terms of whether the minimal entities that instantiate a are objects (i.e., whether objects are relative atoms).

### 4.3.1 Numeral Constructions in Number Marking Languages

We will now lay out how our object-centred contextualist approach can be implemented for numeral-noun constructions in number marking languages based on a bi-partite approach to the lexicon. We will address classifier languages such as Mandarin and 'all count' languages such as Yudja in chapter 6. As detailed in section 4.2.1, the interpretations of common nouns are of type $\langle c, \langle s, \langle e, \langle t \times et \rangle\rangle\rangle\rangle$ (functions from contexts to intensions, where the intension is a function from worlds to a pair of sets, the extension and the counting base set). We give examples for the count noun *lentil* and the mass noun *rice* in (4.69) and (4.70).

(4.69) $$[\![[_{\text{CN}}\ \text{lentil}]]\!]^{M,g} = \lambda c \lambda w \lambda x[\mathcal{Q}_c(\texttt{lentil})(w)(x)]$$
$$= \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \textbf{dom}_c(\texttt{lentil}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\texttt{lentil}_{obj}(w)(y) \end{bmatrix}$$

We note that the counting base set for *lentil* is not $\lambda y.\textbf{qua}_c(\texttt{lentil}_{obj})(w)(y)$, since the set of objects in the extension of *lentil* (single lentils) is anyway quantized.[25]

(4.70) $$[\![[_{\text{CN}}\ \text{rice}]]\!]^{M,g} = \lambda c \lambda w \lambda x[\mathcal{N}_c(\texttt{rice})(w)(x)]$$
$$= \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \textbf{dom}_c(\texttt{rice})(w)(x) \\ \text{cbase} & \lambda y.\texttt{rice}(w)(y) \end{bmatrix}$$

In number-marking languages such as English and German, plural markers are straightforwardly felicitous with count nouns, but not with mass nouns. We encode this count requirement of plural morphology as a presupposition of a quantized counting base set. Where $\mathfrak{P}$ is a variable for an expression of type $\langle c, \langle s, \langle e, \langle t \times et \rangle\rangle\rangle\rangle$ (i.e. the interpretation of a common noun), and where $\omega_{pl}$ is a placeholder for a plural morpheme, we assume that an expression such as *lentils* is a plural NP:[26]

(4.71) $$[\![[_{\text{NP}}\ \text{lentils}]]\!]^{M,g} = [\![[_{\text{NP}}[_{\text{PL}}\ \omega_{pl}][_{\text{CN}}\ \text{lentil}]]]\!]^{M,g}$$
$$= [\![[_{\text{PL}}\ \omega_{pl}]]\!]^{M,g}([\![[_{\text{CN}}\ \text{lentil}]]\!]^{M,g})$$

The plural morpheme semantically corresponds to the application Link's (1983) *-operator to the extension of the common noun, with the presupposition that its counting base is quantized.

(4.72) $$[\![[_{\text{PL}}\ \omega_{pl}]]\!]^{M,g} =$$

[25]We leave it as an open question whether an alternative representation for count granulars such as *lentil* could be the following where the extension is not intersected with the set of objects:

(i) $$\lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \textbf{dom}_c(\texttt{lentil})(w)(x) \\ \text{cbase} & \lambda y.\texttt{lentil}_{obj}(w)(y) \end{bmatrix}$$

This could differ, truth-conditionally, from (4.69), if the core property `lentil` is also instantiated by parts of whole lentils (as assumed for `rice` in Chierchia 2010).

[26]There is undoubtedly a lot more that one should say about the morphosyntactic and semantic analysis of plural morphology, but here, we only provide a sketch of the analysis, with a focus on specifying the selectional restrictions of plural morphology in number-marking languages.

$$\begin{cases} \lambda\mathfrak{P}\lambda c\lambda w\lambda x \begin{bmatrix} \text{ext} & {}^*\text{ext}(\mathfrak{P}(c)(w)(x)) \\ \text{cbase} & \text{cbase}(\mathfrak{P}(c)(w)(x)) \end{bmatrix} & \text{if } QUA(\\ & \text{cbase}(\mathfrak{P}(c)(w)(x))), \\ \perp & \text{otherwise.} \end{cases}$$

To unpack (4.72), $\text{ext}(\mathfrak{P}(c)(w)(x))$ is the formula in the extension field of a common noun's lexical entry, e.g., $\mathbf{dom}_c(\mathtt{lentil}_{obj})(w)(x)$, to which we can apply the upward closure operator.[27] $\text{cbase}(\mathfrak{P}(c)(w)(x)))$ is the counting base field formula for the common noun's lexical entry, e.g., $\lambda y.\mathtt{lentil}_{obj}(w)(y)$. Therefore, applying the interpretation of the plural morpheme to the interpretation of *lentil* yields the following representation:

(4.73) $$[\![[_{\text{NP}}\ \text{lentils}]]\!]^{M,g} = \lambda c\lambda w\lambda x \begin{bmatrix} \text{ext} & {}^*\mathbf{dom}_c(\mathtt{lentil}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathtt{lentil}_{obj}(w)(y) \end{bmatrix}$$

The composition is felicitous, because the set $\lambda y.\mathtt{lentil}_{obj}(w)(y)$ (the set of single lentil objects) is quantized. (Recall that for nouns such as *fence* for which the set of objects is not quantized, the $\mathbf{qua}_c$ parameter is applied to the counting base property ensuring a quantized set of entities at each context.) Compare this with *rice*, the counting base set for which is the number neutral core property $\lambda y.\mathtt{rice}(w)(y)$ which is not quantized.

For number marking languages in which singular count nouns can denote pluralities of objects, such as Turkish, and also, arguably, Hungarian (Erbach et al., 2019)[28], we assume that plural morphology has the same countability presupposition, but we allow for the interpretation/function of plural morphology to differ across different languages. For example, in Turkish, but not in English, plural morphology may introduce a specific ('definite') interpretation of nouns under certain conditions (Alexiadou, 2019b).

When used in numeral constructions, numeral expressions such as *two* and *three* are of an adjectival type.[29] With our bi-partite analysis for common nouns, this means that the interpretations of numeral expressions in numeral constructions are of type $\langle\langle c, \langle s, \langle e, \langle t \times et\rangle\rangle\rangle\rangle, \langle c, \langle s, \langle e, \langle t \times et\rangle\rangle\rangle\rangle\rangle$.

[27] Technically, this is not quite right, since $\mathbf{dom}_c(\mathtt{lentil}_{obj})(w)(x)$ is of type $t$. Therefore, implicit here is the following amended rule for application of * for functions to product types, such that * would apply to the $\lambda x.$ term in (4.72):

(i) $${}^*\lambda x.\mathcal{P}_{:\langle t\times et\rangle} \quad = \lambda x.\Big\langle ({}^*\lambda z.\pi_1(\mathcal{P}(z)))(x),\ \ \pi_2(\mathcal{P}(x))\Big\rangle$$

[28] For an alternative view on which almost all Hungarian count nouns have an additional object mass sense, see Schvarcz & Rothstein (2017).

[29] When used in argumental positions e.g., *The number of people coming is three*, numeral expressions are of type $n$ (Rothstein, 2017). For an adjectival analysis of numeral expressions, see (Landman, 2003, 2004).

Numeral expressions, like plural morphology, require that the counting base sets of the properties they modify be quantized. The definition of $\mu_{\#}$ assumed here is given in (4.74):

(4.74) $$[\![\mu_{\#}(x, P)]\!]^{M,g} = \begin{cases} |\{y : y \sqsubseteq x, y \in [\![P]\!]\}| & \text{if } QUA(P) \\ \perp & \text{otherwise} \end{cases}$$

(4.75) $$[\![[_{\text{Num}} \text{ two}]]\!]^{M,g} = \begin{cases} \lambda\mathfrak{P}\lambda c\lambda w\lambda x \begin{bmatrix} \text{ext} & \mu_{\#}(x, \text{cbase}(\mathfrak{P}(c)(w)(x))) = 2 \\ & \wedge\text{ext}(\mathfrak{P}(c)(w)(x)) \\ \text{cbase} & \text{cbase}(\mathfrak{P}(c)(w)(x)) \end{bmatrix} & \text{if } QUA(\text{cbase}(\mathfrak{P}(c)(w)(x))), \\ \perp & \text{otherwise.} \end{cases}$$

The semantic composition for numeral constructions is function application:

(4.76) $$\begin{aligned} [\![[_{\text{NumP}} \text{ two lentils}]]\!]^{M,g} &= [\![[_{\text{NumP}}[_{\text{Num}} \text{ two}][_{\text{NP}} \text{ lentils}]]]\!]^{M,g} \\ &= [\![[_{\text{Num}} \text{ two}]]\!]^{M,g}([\![[_{\text{NP}} \text{ lentils}]]\!]^{M,g}) \end{aligned}$$

The interpretation of *two lentils* is given in (4.77). This is a function from contexts and worlds to a pair, the extension of which is the set of sums of two single lentils, and the counting base for which is the set of single lentils.

(4.77) $$[\![[_{\text{NumP}} \text{ two lentils}]]\!]^{M,g} = \lambda c\lambda w\lambda x \begin{bmatrix} \text{ext} & \mu_{\#}(x, (\texttt{lentil}_{obj}(w))) = 2\wedge \\ & {}^{*}\textbf{dom}_c\texttt{lentil}_{obj}(w)(x) \\ \text{cbase} & \lambda y.\texttt{lentil}_{obj}(w)(y) \end{bmatrix}$$

This analysis ensures that the extension of *two lentils* is the set of entities that have a cardinality of 2 with respect to the set of single lentils. Constructions such as *two rice(s)* are infelicitous, since the counting base set of *rice* is not quantized.

### 4.3.2 The distribution of stubbornly distributive predicates

As we saw in chapter 2, stubbornly distributive predicates such as *slender*, *big*, and *round* cannot be felicitously combined with substance denoting mass nouns, but are felicitous with count nouns, object mass nouns, and granular and filament mass nouns, modulo specific lexical and pragmatic constraints on their combinations. Providing an analysis for such data is one of the principal motivations of our object-centred contextualist framework, given the challenge these data pose for other state-of-the-art theories of countability (see chapter 3), and the fact that, with the exception of work on object mass nouns, the selectional restrictions of stubbornly distributive predicates has largely been left under-explored.

As we argued in chapter 3, these data are a challenge for other theories. For example, we suggested that neither stable atomicity (Chierchia, 2010) nor disjointness (Landman, 2011, 2016) can be used to capture the selectional restrictions of stubbornly distributive predicates. Furthermore, we showed that if one were to use other parts of these theories, such as standardised partition (Chierchia, 2010) and grid (Landman, 2016) to fill this explanatory gap, then the result is non-unified. To reiterate, such a proposal would assign different explanations for why granular and filament nouns can be felicitously combined with stubbornly distributive predicates, on the one hand, and for why object mass nouns can be, on the other.

As we have already proposed, our theory, in contrast, can straightforwardly account for these data. Given that a central notion in our theory is that of objects capturing a necessary condition for the application of stubbornly distributive predicates falls out of our theory automatically: stubbornly distributive predicates are only compatible with nouns that have sets of objects in their extensions:

(4.73) If $X_w$ is the counting base set for $[_{\mathrm{N}}\ \mathrm{Y}]$ at $w$, then $[\![ [_{\mathrm{Stub}}\ \mathrm{Z}] ]\!]([\![ [_{\mathrm{N}}\ \mathrm{Y}] ]\!])$ is defined only if, for some $w, X_w \cap O^+_w \neq \varnothing$

This constraint on the semantics of stubbornly distributive predicates predicts that all substance denoting nouns (none of which have objects in their extension) will be incompatible with stubbornly distributive predicates (coerced 'packaging' interpretations in appropriate contexts are irrelevant to this constraint).

For example, for concrete nouns at least, *round* can only be used to modify common nouns with objects in their extensions and distributes the predicate $\mathit{Round}$ down to each of these objects:

(4.78)
$$[\![ [_{A}\ \text{round}\ ] ]\!]^{M,g} =$$
$$\begin{cases} \lambda\mathfrak{P}\lambda c\lambda w\lambda x\begin{bmatrix} \text{ext} & \text{ext}(\mathfrak{P}(c)(w)(x))\wedge \\ & \forall z[\text{ext}(\mathfrak{P}(c)(w)_{obj}(z)) \rightarrow \mathit{Round}(z)] \\ \text{cbase} & \text{cbase}(\mathfrak{P}(c)(w)(x)) \end{bmatrix} & \text{if } \mathfrak{P}(c)(w)_{obj} \neq \varnothing \\ \bot & \text{otherwise.} \end{cases}$$

For instance, the extension of *round furniture* will be anything that is furniture (subject to contextual domain restriction), such that each furniture object (item of furniture) in this context is round.

Notice that the definition above provides a necessary, but not sufficient condition for the application of (all) stubbornly distributive predicates. When it comes to specific cases of stubbornly distributive predicates, the acceptability of a stubbornly distributive predicate–object-denoting noun combination may depend on the match between further lexical restrictions imposed by the stubbornly distributive predicate on the properties of objects denoted by nouns they combine with. For instance, the contrast between *round lentils* and *?long lentils* is plausibly explained via lexical restrictions that *long* places on the shape of entities in the denotation of nouns it combines with.

For mass nouns like *rice*, stubbornly distributive predicates can also be used, since, although the lexical entry of *rice* does not make the set of rice grains available as the counting base set, the intersection of the extension of *rice* with the set of objects is nonetheless not empty. For canonical mass nouns like *air*, which have no objects in their extensions, it is predicted that stubbornly distributive predicates cannot be felicitously used to modify them.

In summary, objects are one of the centrepieces of our theory, and stubbornly distributive predicates are expressions that modify each object in the extension of a common noun, whether or not the noun is count or mass.

### 4.3.3 The availability of cardinality comparison judgements

The final pattern in the data that we wish to account for concerns the availability of cardinality comparison readings in comparative constructions, and to a lesser extent also in superlative constructions in languages such as Dutch (Landman, 2011). This reading is available with object mass nouns like *furniture* (Barner & Snedeker, 2005). We see this in (4.74a) that can be true in the context. We note that this is not the only reading, however. As pointed out by Rothstein (2017), object mass nouns may also have measure comparison readings (4.74b).

(4.74) Context: Alex has two small chairs and a table. Billie has a gigantic dresser (that weighs more and takes up more space than Alex's items).

a. Alex has more furniture than Billie. (Can be true in this context, a cardinality comparison reading).

b. Billie has more furniture than Alex. (Can be true, especially in situations where the volume or weight of the furniture is pertinent.)

It is generally (usually implicitly) assumed, in contrast, that the cardinality comparison reading is not available for granular and filament mass nouns (see chapter 2). For example, without some very heavy contextual support, (4.75) does not have a reading in which Alex has more grains of rice than Billie, but Billie has more rice by weight/volume than Alex.

(4.75) Alex has more rice than Billie.

Such data, at first blush, pose a challenge for our theory, which predicts that object mass nouns and granular and filament mass nouns should pattern alike in so far as their interpretations specify a non-quantized counting base set and are based on properties that have objects in their extensions. Prima facie, it is therefore puzzling, given the theory we have presented, why it should be that only object mass nouns, but not mass granular and filament nouns, should have cardinality comparison reading available.

Yet, as we discussed in chapter 2, the empirical picture is more complex than this. Some granular nouns, such as *pollen*, seem to admit of cardinality comparison readings. For instance, suppose last month, the pollen was of a very small size and of a larger size this month, it can be true that there was more pollen in the air last month than this month if the number of pollen grains was higher last month, regardless if the mass or volume of the pollen last month was lower than this month.

In this section, we first propose a means, within our theory to distinguish between nouns like *furniture*, on the one hand, and nouns like *rice*, on the other. Namely, that the former but not the latter has objects in its extension that are also atoms relative to that extension. Then, we show that this proposal makes predictions with respect to which granular nouns should facilitate cardinality comparison readings.

### Objects that are relative atoms

*Relative atoms*, i.e., atoms relative to some set of entities, are standardly defined as follows (see, e.g., Link, 1983):

(4.76) $AT(P) = \lambda x[P(x) \wedge \forall y[P(y) \wedge y \sqsubseteq x \rightarrow x = y]]$

We can use $AT$ as defined in (4.76) to define what it means for a property to be *object atomic* (to have a set of objects as its set of relative atoms). For a property, $\mathtt{P}$ and for any world $w$ in which $\mathtt{P}$ is defined:

(4.77) $\mathtt{P}$ is *object atomic* iff $\exists X[X \subseteq O^{+} \wedge AT(\mathtt{P}_w) = X]$

The properties upon which the lexical entries of object mass nouns are defined are all object atomic. For example, there is a set of single jewellery items such that no proper parts of any one is jewellery, and there is a set of single furniture items such that no proper parts of any one is furniture. Our 'object atomicity' has some elements in common with Landman's 'neatness' of object mass nouns, both identify the same subclass of mass nouns. The two notions differ, however, since, for example the core property `apartment` is object atomic, but, on the assumption that some apartments overlap (by sharing walls, for instance), the minimal entities in `apartment` overlap.

In contrast to object mass nouns, not all granular noun properties are object atomic. One good example is `rice`. By way of explanation, we may adduce Chierchia (2010) who argues that single grains of rice are not rice atoms on every way of interpreting *rice*, because parts of grains of rice, for instance, can still count as instantiating the core property `rice`. Based on the property of 'object atomicity' that characterises the denotations of object mass nouns, but not those of granular and filament mass nouns, we suggest the following hypothesis, (H), which makes at least two predictions (P1) and (P2):

(H) Cardinality comparison readings are based on comparing cardinalities of sets of objects in the extension of nouns that are also atoms relative to the noun's extension.

(P1) All object mass nouns have cardinality comparison readings available.

(P2) Granular and filament mass nouns only have cardinality comparison readings easily available if objects in their denotation also qualify as atoms relative to their extensions.

(P1) is a matter of a general agreement (since Barner & Snedeker 2005 at least). What is novel is our proposal encapsulated in (P2). In chapter 2, we described how, with a lot of context, some mass granular and filament nouns (illustrated with examples with *rice* and *grass*) can get a cardinality comparison reading in comparative constructions. However, these readings are hard to get and the contexts are generally a bit laboured. If not only whole rice grains and whole blades of grass, but also their proper parts can instantiate `rice` and `grass`, respectively, then (H) predicts that cardinality comparison readings will not be straightforwardly available with these nouns. Yet, as we also noted in chapter 2, this is not so for all granular nouns, pollen being one example. The question then is whether we have any reason to think `pollen` is object atomic.

Take the contrast between *pollen* and *sand*. Both of these nouns denote objects, albeit tiny, but conceptually, they are not alike, and can be distinguished. Sand is any tiny fragment of rock or mineral, so parts of a grain of sand could still count as sand, and fall under *sand*. Pollen also comes in grains, but these are structured wholes, each with a specific morphology make up, and a function in plant and tree reproduction. On this conceptualisation at least, part of a pollen grain is not pollen since it would lack the (biological) function of being pollen. A comparable distinction can be found for object mass nouns: half a carabiner is not *climbing equipment*, since half of a carabiner lacks the requisite function. If this conceptualisation is right, then, via (P2), our cardinality comparison judgements with respect to *pollen* can be explained.

We readily admit, however, that things are not quite as straightforward as (H) suggests. For example, in English, *asparagus* can refer to whole spears. However, *asparagus* can also refer to asparagus stuff as indicated by the description of a peeler in (4.74). The number of spears one gets after peeling is identical, so *more asparagus* can only mean more by e.g., weight or volume, which suggests that spears are not necessarily relative atoms in `asparagus`.

(4.74) The carefully designed blade on the Asparagus Peeler removes the woody peel from stalks so you get more asparagus with less waste. [ukWaC]

However, cardinality comparison judgements are also available for *asparagus*. In Scenario 3, the answer to the question *Who has more asparagus?* can be Ann (a cardinality based comparison) or Ben (a measure based comparison).

> **Scenario 3:** Ann has a bunch of thin-stemmed asparagus. The bunch is comprised of 15 spears and weighs 250g. Ben has a bunch of thick-stemmed asparagus. The bunch is comprised of 8 spears and weighs 350g.

What might be going on here? It could be that (H) is wrong and that, for some reason, the meaning of *more* can facilitate cardinality comparison judgements by retrieving some objects from mass denotations (*asparagus*, *pollen*), but not from others (*rice*, *sand*). However, we need not yet abandon (H), since there is a different explanation that is compatible with it: such effects could be the result of polysemy. If, for example, *asparagus* has two inter-related mass senses: (i) spears and sums thereof; and (ii) asparagus stuff, then sense (i) would license a cardinality comparison and a measure comparison, whereas sense (ii) would only license a measure comparison. In other words, we would have to ensure that a noun has at least one sense such that, on that sense, the set of atoms is a set of objects. It is, however, challenging to verify this latter option empirically.

That said, we would like to point out that the *asparagus* data is challenging for other theories as well. If the interpretation of *asparagus* is *stably atomic* (Chierchia, 2010), or if *asparagus* is *neat mass* (Landman, 2011), or is [+IND] (Barner & Snedeker, 2005), then it is hard to explain the reading of *asparagus* we get in (4.74), since the relevant interpretation in that example is *asparagus stuff that made up of proper parts of the whole spears* (i.e. spears with parts peeled of). If the interpretation of *asparagus* is *not* stably atomic and if *asparagus* is *mess mass* (Landman, 2011), and is [-IND], then it is hard to explain why *asparagus* facilitates a cardinality comparison reading in comparative constructions. Indeed, possibly aware of this issue, Landman (ibid., p. 55) proposes that all food-denoting nouns have both a count and a mass sense.[30]

Without prejudging whether our hypothesis regarding cardinality comparisons and our above thought experiments for *pollen*, *sand* and *asparagus* are on the right track, one fairly clear conclusion that comes out of these considerations is that cardinality comparison judgements are more complex than they are usually assumed to be (however see Grimm & Levin 2012; Scontras et al. 2017 for a number of different ways in which cardinality judgements have been probed). Object mass nouns constitute a class of mass nouns which clearly allow comparison in terms of cardinality, since, pretty much by definition, objects in their extensions are atoms. However, our preliminary evidence suggests that there may be other mass nouns that also allow cardinality comparisons if they also have objects as atoms, or at least have a sense in which the objects in their extensions are also atoms relative to the property they express.

### Predictions regarding context dependent cardinality readings

We have claimed that stubbornly distributive predicates should be able to modify *any* noun with objects in its denotation, and that cardinality comparison readings are only available for object atomic properties. This rules out the availability of cardinality comparison readings for e.g., *rice*. However, our semantic analysis of common nouns also includes a mechanism for contextual domain restriction. This suggests another prediction we can

[30] An anonymous reviewer suggests that *asparagus* in English could be like *asperge* in Dutch, a count noun, where (4.74) is a case of coercion. The proposal being that *asparagus* is not mass, but rather has no morphologically realised plural form. This is not the case for English according to Sutton's judgement: *asparagus* is straightforwardly mass and has a dedicated classifier *spear*. That said, on inspection of the EnTenTen20 corpus, there is some evidence that a relatively small minority of English speakers interpret *asparagus* as the reviewer suggests.

make, namely, that in rich enough contexts, if a property is contextually restricted such that its atoms are a set of objects, then cardinality comparison readings should become available.

This predicts, for instance, why, with enough context setting granular and filament mass nouns can get cardinality comparison interpretations. In chapter 2, we mentioned Landman's/Sutton's rice hunt example and the grass snipping example. As a recap, the rice hunt involves a competition hunting for bits of rice that have ben scattered around. The intuition is that in this context, the winner of the rice hunt is the person with the most grains, not the most rice by volume. Arguably, this context is exactly one where fragments of grains are contextually excluded from what counts as rice-for-the-purposes-of-the-competition. This contrasts with stubbornly distributive predicates, which can only be used in combination with substance mass nouns if the interpretation of the substance mass noun is coerced into a count (e.g., portion) reading. For instance *Carry the small oil to the yard* can only be interpreted in a context where *oil* is coerced to mean e.g., BOTTLE OF OIL (since bottles of oil are objects).

## 4.4 Summary

Three of our main questions were addressed in this chapter. Question 1 regarded the lexicalization of properties as count nouns:

QUESTION 1 **What are the necessary conditions for a core property to be lexicalized as count?**

In answer to Question 1, we proposed that, at least for concrete nouns, only core properties that are instantiated by objects can be lexicalized as count. To support this, we provided an account of *objects* that extends to entities beyond Spelke objects commonly discussed in the psychology literature. Specifically, we include in our set of objects, small and hard to distinguish entities such as grains of rice, non-cohesive objects such as multi-part devices, and connected objects such as rooms in an apartment. This semantics explains one of the core facts about variation in count/mass lexicalization patterns, namely, that we do not ever find substance denoting mass nouns as being lexicalized as count (in number marking languages at least): only nouns with objects in their extensions can be lexicalized as count. (In chapter 5, we propose an account of why e.g.., *rice*, *sand* and *pollen* are rarely if ever lexicalized as count).

Furthermore, we have argued that certain properties of the set of objects that instantiate a property are relevant for whether or not that property is likely to (also) be lexicalized as mass. Only some count nouns are sensitive to the quantizing contextual parameter, namely those derived from core properties that are instantiated by a non-quantized set of objects viz *fence* from `fence`. That an extra 'counting perspective' is needed to derive count nouns from such properties, we argued, is one reason why count nouns such as *fence* have some grammatical reflexes of canonical mass nouns (e.g., they can be used bare in pseudopartitive (measure) constructions), and why we so commonly find mass noun counterparts for them such as *fencing*.

Question 2 regarded the grammatical reflexes of common nouns, specifically their distribution with stubbornly distributive predicates:

QUESTION 2 **What are the necessary conditions for a 'concrete' noun to be felicitous with stubbornly distributive predicates?**

Our answer to Question 2 falls more or less directly out of our object-centred, contextualist semantic account: denoting objects is a precondition for the application of stubbornly distributive predicates, at least for concrete nouns denoting things or stuff. In other words, we have a unified account for why, say mass granular nouns (like *rice* and *sand*) and object mass nouns (like *kitchenware* and *furniture*) can both be felicitously used with stubbornly distributive predicates. This is so, even though these nouns and the properties underpinning these nouns cut across the theoretical divides in other theories (such as, neat (*kitchenware*) versus mess (*sand*) in Landman (2011), and stably atomic (*furniture*) versus non-stably atomic (*rice*) in Chierchia (2010)).

Question 3 regarded specifically the nature of non-canonical grammatical reflexes of countability:

QUESTION 3 **Why are the non-canonical grammatical reflexes of countability restricted to felicitous use with stubbornly distributive predicates, for instance, and not use in numeral constructions and with strong universal quantifiers such as *each* and *every*?**

Our answer to this question was that, while felicitous use with stubbornly distributive predicates only requires that a noun denote objects (i.e., lexicalizes an object-instantiated core property), many other reflexes of countability, including whether a noun is felicitous in numeral constructions, require a stronger condition. For concrete nouns at least, not only must they denote objects, but, relative to a context of individuation, their lexical entries must specify a quantized set of objects for counting. We formalised this proposal via a context-centred contextualist (Kaplanian) semantics.

We exemplified the distinction between count and mass nouns according to our view with a treatment of the vexing *co-extensionality puzzle*. We argued for a bi-partite structure in the lexicon of common nouns through which count nouns specify a quantized set of objects for counting and mass nouns do not. We also provided a further argument for bi-partite semantics relating to contextual domain restriction of the sort familiar from the interpretation of quantified noun phrases. Such domain restriction does not constrain the individuation properties of nominal predicates and neither their quantization, and so is insufficient to motivate coercion of mass noun denotations into count noun denotations, for instance.

We then discussed whether our object centred, contextualist theory can account for the data regarding cardinality comparison readings. Based on our discussion in chapter 2, in which we observed that some granular mass nouns (e.g., *pollen*) have cardinality comparison readings in appropriate contexts, we hypothesised that these readings require nouns to have a set of objects as relative atoms in their extensions. This proposal distinguishes between, say, *ball*, *furniture* and *pollen* on the one hand, and *rice* and *mud* on the other.

We therefore have an ordering of strength when it comes to the different grammatical reflexes of countability. Felicitousness with stubbornly distributive predicates is the weakest condition. The underpinning number-neutral core property need only be instantiated by objects. This includes, therefore, any lexicalizations of properties such as `lentil` and `furniture`, whether count or mass. Slightly stronger is what is needed to licence cardinality comparison readings. For these, the set of objects also need to be the atoms of the property. This includes mass lexicalizations of `furniture`, but excludes mass lexicalizations of `lentil` e.g., *čočka* ('lentil', Czech, mass), since parts of whole lentils may also instantiate `lentil`. This proposal for cardinality comparison readings also predicts that with enough contextual domain restriction, one can make cardinality comparisons more felicitous as we saw with, for example, the rice hunt case. Finally, felicitousness in numeral constructions without an intervening classifier requires an even stronger condition. Even if a noun has objects in its extension and even if these objects are relative atoms as is the case for e.g., *furniture*, such nouns cannot be combined with numerals. For this, we have argued, the lexical entry needs to specify a counting base set that is quantized by (a) at each world, deriving the set of objects that instantiate the relevant core property; and (b) if necessary, applying the $\mathbf{qua}_c$ contextual parameter to ensure a quantized set of objects at every context. The lexical entry for *furniture* does not do this, the lexical entry for e.g., *huonekalu-t* ('item-s of furniture', Finnish, count) does.

# Chapter 5

# Constraints on lexicalization patterns

Up to this point, we have provided an explanation of what conditions must be satisfied for it to be possible for a core property to be lexicalized as a concrete count noun: the property must be instantiated by objects. This accounts for count noun lexicalizations of `lentil` and `furniture`, e.g., *lentil*, and *huonekalu*, ('item of furniture', Finnish, count). We have also identified the conditions in which stubbornly distributive predicates can be felicitously combined with concrete nouns, including concrete mass nouns: they must be lexicalizations of object-instantiated core properties. This accounts for why stubbornly distributive predicates are felicitous with mass nouns such as *čočka* ('lentil', Czech, mass) and *furniture*.

What we have not yet done, and what will be the main goal of this chapter, is to identify what properties or mechanisms, beyond being instantiated by objects, give rise to the kinds of systematicity we see in count/mass variation patterns. Indeed, this next step is necessary, given concerns raised by Chierchia (2015) that theories that allow for count/mass variation are not sufficiently constrained. In this chapter, we aim to say why it is the case that we find mass lexicalizations of many core properties that are instantiated by objects (e.g., *furniture*, *rice* and *fencing*). We also wish to account for why some object-instantiated core properties are more likely to be lexicalized as mass, cross- and intralinguistically. The goal of this chapter is to rise to these challenges and thereby address the following two questions that focus on the mapping from object-instantiated properties to mass nouns:

Question 4a **Why can core properties that are instantiated by objects be lexicalized as mass nouns at all?**

| Lexicalization Pattern | Object-instantiated Core Property |
|---|---|
| Only count lexicalization | `ball`, `car`, `chair`, `student` |
| Count/Mass variation | `lentil`, `fence`, `potato` |
| Only mass lexicalization | `dust`, `pollen`, `sand`, `rice` |

Table 5.1: Examples of object-instantiated core properties that exhibit either count/mass variation or stability in their lexicalization patterns.

Question 4b **Why are some of these core properties more frequently lexicalized as count and others more frequently lexicalized as mass?**

These questions concern the limits on variation in count/mass lexicalization patterns, at least in number marking languages. There are core properties that are instantiated by objects that are only attested as being lexicalized as count in all number marking languages, for instance, `ball` and `car`, `chair` (as well as properties of animate beings like `student`). There are also core properties that are instantiated by objects that display variation in their count/mass lexicalization patterns, for instance `lentil`, `fence`, and `potato` (see chapter 2). What is perhaps surprising, and is far less widely recognised, is that not all properties that are instantiated by objects are attested as being lexicalized as count in number marking languages, e.g., `dust`, `pollen`, `rice` and `sand`. See Table 5.1 for a summary.

Recall from chapter 4, we proposed that, for properties that are instantiated by objects, mass lexicalization is modelled in terms of the application of the object-neutral function. In terms of our theory, therefore, to account for the variation (and stability) in the lexicalization of object-instantiated core properties, we must constrain the conditions upon which the object-neutral function can be applied to a core property, and thereby mass lexicalization. Furthermore, for object-instantiated properties for which we predict mass lexicalization to be possible, we must also find a means to predict whether this or count lexicalization is more dominant cross-linguistically, and to what extent.

Our answer to *Question 4a*, in simple terms, is that object-instantiated properties can only be lexicalized as mass if that property satisfies at least one of the following three perceptual-interactive constraints: INDISTINGUISHABILITY, COLLECTIVE USES OF INSTRUMENTS, and OBJECT SPLITTING, each of which characterises a partial function on the set of possible core properties (so each is a property of number-neutral core properties). The central idea is that each of these three perceptual-interactive constraints highlights how single objects that instantiate a given property can be backgrounded, or lose their privileged status of being viewed as individual and clearly individuated objects, and so be made less prominent and/or salient relative to other entities that instantiate that property.

In terms of our formal theory, the three perceptual-interactive constraints determine whether the object-neutral function can be applied to a property that is instantiated by objects, and thus whether this property can be lexicalized as mass. The object-neutral function, and the perceptual-interactive constraints thereupon, we argue, provide a joint explanation for the occurrence of prima facie disparate categories of mass nouns. For instance, it explains why we find granular mass nouns, filament mass nouns, and object mass nouns. This system of perceptual-interactive constraints is developed in section 5.1.

With respect to *Question 4b*, we argue that this system of perceptual-interactive constraints can also be used to give an empirically grounded explanation for why some object-instantiated core properties, such as `sand` and `pollen`, are seldom if ever lexicalized as count, whereas others such as `potato` more frequently are. In section 5.2, we report on the results of a corpus study an show that we can induce from corpora an ordering on core properties in terms of how well they satisfy our perceptual-interactive constraints based on the distributional patterns of the nouns that lexicalize them.[1]

In section 5.3, we then use these orderings to devise a weighted score model which can be used to predict the relative propensity with which object-instantiated properties are lexicalized as mass. The model outputs an ordering over properties that encodes a prediction regarding, from most to least, the likelihood of those properties being lexicalized as mass crosslinguistically. For instance `car` is low on the ordering, `pollen` is high on the ordering, and `lentil` is between these two. To our knowledge, no other account of the count/mass distinction has been able to generate such predictions in a systematic way, nor in a way that can be extended to new data.

## 5.1 The three perceptual-interactive constraints

The three perceptual-interactive constraints that we propose govern when an object-instantiated property can be lexicalized as mass are given below.

[1]As we will justify in section 5.2, for the COLLECTIVE USES OF INSTRUMENTS constraint, we determine whether a property satisfies this constraint on a rational basis, not from corpora.

C1 concerns, broadly, the perceptual, physical characteristics of objects that instantiate the relevant properties (their size, quantity, arrangement in clusters, heaps, and such) and our perceptual acuity in distinguishing clearly demarcated single objects. Constraints C2 and C3 concern, broadly, use and function of entities in the denotation of object-instantiated properties.

C1 **Indistinguishability:** For a core property `P`, objects that instantiate `P` are, perceptually speaking, indistinguishable relative to average human perceptual acuity. By this we mean that they are too small, alike in their perceptual properties or are clustered together in such a way that makes them hard for us to track as individuals.

C2 **Collective uses of Instruments:** There is a typical associated eventuality with a core property `P` such that in many cases, there is a least upper bound for the fulfilment of INSTRUMENT role in this eventuality, namely (usually heterogeneous) sums of objects that instantiate `P`. I.e., any proper part of these sums of instruments would not normally facilitate bringing that eventuality about.

C3 **Object splitting:** Objects that instantiate a core property `P` are often used in such a way that requires them to (first) be split apart or broken up.

Let us illustrate the above perceptual-interactive constraints with a few simple examples. For C1, let us consider, for instance, objects that instantiate `lentil` (e.g., single lentils). They are rather small, perceptually similar one to another, and we most often encounter them in clusters, heaps of uncooked lentils, or portions of cooked lentils with individual lentils often clumping and sticking together, or breaking down altogether. So `lentil` satisfies C1, and this explains why we find mass nouns such as *čočka* ('lentil', Czech, mass).

C2 can be illustrated with `kitchenware`. We propose that the dominant, typical eventuality associated with `kitchenware` is *preparing some food*, for which items of kitchenware stand in the INSTRUMENT relation. `kitchenware` satisfies C2, since, in many cases, sums of multiple items of kitchenware are needed to bring about preparing a meal (such sums form a least upper bound relative to bringing this about). This explains why we find mass nouns such as *kitchenware.*

Finally, let us consider C3. Cabbages, when they are consumed, must be first split apart or broken up, and most often also chopped up into pieces that are small enough for us to eat. So `cabbage` satisfies C3. They thus lose their inherent structural integrity as one whole integrated unit, which facilitates the lexicalization of the `cabbage` property as mass as with the German *Kohl* (the English *cabbage* is count/mass flexible).

It is via these three perceptual-interactive constraints C1-C3, that we provide answers to our *Question 4a*: Why can core properties that are instantiated by objects be lexicalized as mass nouns at all? We propose that (a) if an object-instantiated core property is lexicalized as mass, then at least one of C1-C3 holds; and (b) if at least one of C1-C3 holds of an object-instantiated core property, then it is *possible* for that property to be lexicalized as mass, since it can be lexicalized under the object neutral perspective.

Although we arrived at these perceptual-interactive constraints by extrapolating from the mass/count variation data that we have presented, the factors targeted by these constraints have also featured in some previous studies. For instance, Wierzbicka (1988) raised the importance of how distinguishable entities are in terms of size and similarity, which clearly relates to our C1. She also notes that entities in the denotations of nouns such as *furniture* are linked by a common purpose, which, although not the same as our C2, is broadly related. We do not see, for instance, rings and necklaces as having a common purpose qua rings and necklaces, but we do think that different sorts/subkinds of jewellery relate to the function of jewellery, taken as a whole. Wierzbicka (ibid.) also identified "heterogeneous classes of substances and choppable things" (ibid., p. 560) as part of a class including *vegetables*. Choppability is part of our C3, but we emphasise the more general feature of being broken up/split apart, and how this should be a common practice for these objects. As further support for our conditions C1 and C2, the impact of distinguishability and how we interact with entities has found some empirical support in studies with novel nominal expressions (Middleton et al., 2004). Our C2 builds upon, but also makes several departures from a proposal made by Grimm & Levin (2017). We identify collective uses of objects qua instruments as one constraint on whether core property that is instantiated by objects can be lexicalized as mass. As such, our appeal to collective uses of instruments is part of our explanation for why we find variation in count/mass lexicalization patterns. Grimm & Levin claim, of a particular lexical item, that similar considerations explain why it is mass, and so their proposal is not primarily geared towards accounting for variation in count/mass lexicalization patterns. We discuss this proposal in relation to ours in section 5.1.3.

### 5.1.1 Indistinguishability C1

C1 **Indistinguishability:** For a property `P`, objects that instantiate `P` are, perceptually speaking, indistinguishable relative to average human perceptual acuity. By this we mean that they are too small, alike in their perceptual properties or are clustered together in such a way that makes them hard for us to track as separate individuals.

The intuition behind why constraint C1 may license an object-instantiated property being lexicalized as mass (such that no set of objects that instantiate the property is privileged with respect to grammatical counting operations) is fairly straightforward: when objects are so small as to be perceptually for us pretty indistinguishable one from the other, their individuation structure is therefore less salient or even blurred. Hence, in effect, we tend to conceptualise the instantiations of the relevant property as amorphous stuff.

An example of a property that satisfies C1 is `rice`. Whatever the minimal parts of `rice` are (see section 4.3.3 for discussion) single rice grains, at least, are instantiations of `rice`. Single rice grains are cohesive objects, as one is clearly demarcated from another. Applying the object-centred quantizing function to `rice` would straightforwardly give us a property of single clearly distinguishable individuated grains. What licenses applying the object-neutral function to `rice`, in this case, is C1: namely, the individual rice grains are rather small, perceptually homogenous (one is more or less like the other), and we usually encounter them in clusters such as packages, sacks or bowls of (grains of) rice. Moreover, the extent to which grains of rice are perceptually distinguishable is further lessened when it comes to cooked rice. When cooked, the grains may loose their individual cohesion (they stick together and break apart) and so become fairly indistinguishable one from the other. It is understandable then, how the set of individual objects, the grains, can be conceptually backgrounded and so facilitate the lexicalization of a mass noun, the objects in the extension of which are inaccessible to counting operations etc.

The lexical entry for the mass noun *rice* is derived via applying the object neutral function $\mathcal{N}_{\mathtt{c}}$ to `rice` (see chapter 4). Recall that this does not restrict entities in the extension of *rice* to only single grains, but also sums thereof (and potentially also parts thereof, see section 5.1.4). In other words, we end up with a singular noun that is mass, because it expresses a number neutral property under which objects are but one part of a larger collection.

### 5.1.2 Eventualities in the semantics of nominals

There are a number of precedents for the idea that, in terms of (lexical) semantics, common nouns are associated with or denote (sets of) eventualities.[2]

[2] A related idea that we will not discuss in detail here is implicit in Fillmore's FRAMES (Fillmore, 1975, 1982). Pustejovsky 1995 that we discuss at greater length, cites Fillmore

In this section, in order to set up our discussion of the constraint C2 in section 5.1.3, we give an overview of some of these proposals. There are at least three different, non-mutually exclusive positions that have been taken. In all cases, the idea is that for at least some common nouns, there is a set of eventualities associated with that noun. The difference between these positions is whether this set is in the extension of the common noun, and if not, whether this set nonetheless determines the extension of that common noun.

The first position on relating (sets) of eventualities to CNs is that at least some CNs denote (sets of) eventualities.

(5.1) **The extension of at least some common nouns is (or includes) a set of eventualities.**

In its most radical form, this position is defended by Schwarzschild (2022) who proposes that ALL common nouns denote states (e.g., *boat* denotes boat-states the themes of which are boats. It is worth noting that Parsons (1990) briefly considers this idea, but ultimately does not endorse it. Alternatively, one can assume that all common nouns denote eventualities, but they fall into different aspectual classes, e.g., STATES, PROCESSES and EVENTS. Higginbotham (1985, 2000), inspired by both the event semantics of Davidson (1967) and the notion of *generic events* in Montague (1969), develops the *E-position hypothesis* that every predicate head of N (and also V, A, and P) category in the X-bar system has a situation argument, where 'situation' covers either states or dynamic non-states (i.e., 'events' in his terms), and so has an explicit reference to the situation argument as part of the lexical meaning.

The less radical position is that only some common nouns denote eventualities, or at least have a sense which denotes a set of eventualities. This idea is also implicit in Mourelatos (1978) who argues, also inspired by Davidson (1967), for the difference between nominal 'count-quantified transcriptions' (count common nouns derived from EVENT-denoting verbs) versus nominal 'mass-quantified transcriptions' (mass common nouns derived from STATE-

as an inspiration for his work. A frame in Fillmore's sense is a record of that kind of background knowledge against which the meaning of a lexical item is understood, it may also capture 'a slice of the surrounding culture' conceptualised as a kind of prototypical scenario. A frame also contains elements that are also grammatically relevant. Take, for instance, the noun *breakfast* (Fillmore 1982). It is associated with a frame that includes an eventuality type of eating that takes place early in the day, after a period of sleep, and consists of somewhat unique menu depending on the region, however, none of these three conditions are necessary for the definition and understanding of this word in a given context. As this example illustrates, frames associated with common nouns often include a specification of a type of eventuality needed for its characterisation. It is a defining property of a meal of a day like breakfast that it is an eating occasion, and hence the frame associated with a lexical item denoting a meal must include an eventuality of eating.

and PROCESS-denoting verbs). Relatedly, in Sutton & Filip 2019, 2020, 2024, we argue that a version of this position is useful for an analysis of some abstract common nouns. For instance, *statement* is polysemous between an informational entity denoting reading and an EVENT denoting reading, while *belief* is polysemous between an informational entity denoting reading and a (mental) STATE denoting reading, but we do not analyse nouns like *cat* as denoting eventualities of any kind.

In this chapter, we set the position in (5.1) aside. However, in chapter 6, we will explore one version of in relation to abstract nouns. There we analyse some abstract nouns as denoting eventualities.

Two other two positions on the relation between common nouns and a set of eventualities hold that the associated set of eventualities is not in the extension of the relevant common noun: at least some CNs (e.g., those that denote artefacts) are associated with, but do not denote (sets of) eventualities. The difference between these two positions is whether this set of eventualities determines the extension of the noun (what artefacts the noun denotes).

(5.2) **At least some common nouns (e.g., those that denote artefacts) are associated with a (set of) eventualities. This set is not in the extension of the noun, nor does it determine what is in the extension of the noun.**

An example of this position is in Pustejovsky's earlier work (e.g., Pustejovsky 1995), specifically in the relation between the extension of a noun and its qualia structure. For instance, for Pustejovsky, a set of book reading events is accessible via the information in the lexical entry of *book* to account for a reading of *start a book* as *start READING a book*. This can be seen in the lexical entries Pustejovsky gives (1995, pp. 79, 116 and 128), of which we repeat partial versions in (5.3a) and (5.3b) in linear format (we suppress complications relating to the dot type for book). For any $x$ in the extension of *book*, $x$ is the Theme of the reading eventualities $e$ (if any) involving that book, and for any $y$ in the extension of *book*, $y$ is the Agent of reading eventualities. For any $y$ in the extension of *typist*, $y$ is the Agent of the typing eventualities $e$ (if any) done by that typist.

(5.3) a. $\lambda x[\mathit{book}(x) \wedge \text{TELIC} = \lambda y.\lambda e.\mathit{read}(e, y, x) \wedge \text{AGENT} = \lambda z.\lambda e'.\mathit{write}(e', z, x)]]$
b. $\lambda y[\mathit{typist}(y) \wedge \text{TELIC} = \lambda e.\mathit{type}(e, y)]$

For both *book* and *typist*, it is important to notice that the set of associated eventualities does not determine what is or is not a book or a typist (what is in the extension of the noun). This contrasts with the third position one can take on relating (sets of) eventualities to the semantics of common nouns.

(5.4) **At least some common nouns (e.g., those that denote artefacts) are associated with a (set of) eventualities. This set is not in the extension of the noun, but it does determine what is in the extension of the noun.**

This position is defended by Grimm & Levin (2017) for artefact nouns. Following Nichols (2008), the idea is that, for instance, *furniture* denotes any physical entity that could fulfil the function of being furniture, where an "artifact evokes an associated event in which it fulfills its purpose" (Grimm & Levin, 2017, §. 3.). Grimm & Levin (ibid.) further connect the set of eventualities associated with a noun to that noun's countability class.

In this chapter, as part of formulating our constraint C2, we will adopt part of Grimm and Levin's proposal. We agree with them that for artefact denoting nouns, the set of eventualities associated with that noun are relevant to a theory of the count/mass distinction. However, we argue that this should be done based upon the position outlined in (5.2), not the one outlined in (5.4). Below, we give an overview of Grimm & Levin's (2017), which is the first, as far as we know, that links the eventualities that are associated artefact-denoting common nouns to their countability class. We then detail the specific points of agreement and disagreement we have with this proposal.

### Grimm & Levin's account

Grimm & Levin (ibid.) (G&L) focus on motivating why nouns such as *furniture* and *jewellery* are mass, given that count nouns like *chair* or *earring* describe individuated objects that are also in the extensions of *furniture* and *jewellery*, respectively. They also suggest an explanation for the lack of subkind readings for object mass nouns, which we set aside here.[3] As a disclaimer, at the time of writing, G&L's paper is under revision, and we assume that the precise formal details are still being finalised. However, their main claims can be summarised as follows:

(5.5) G&L's main claims

a. Artefact-denoting nouns have associated typical events.
b. The relevant typical events are minimal (event atoms).
c. What these typical events are determines the extension of the relevant noun (e.g., what counts as *furniture* depends on what COULD be used in minimal furnishing events in sufficiently stereotypical

[3] For our earlier work on restrictions on subkind readings, see Sutton & Filip 2017c. See also Erbach & Schoenfeld 2022.

possible worlds).

d. Whether an artefact noun is count or mass is determined by whether there are pluralities of entities as e.g., instruments, in the typical events.

e. Some instances of crosslinguistic count/mass variation can be attributed to differences of event type (e.g., `furnish` for *furniture* and `movable` for *meuble* (French, item of furniture, count)

G&L propose that lexical entries for artefact nouns specify an event type that characterises a typical event associated with the noun (e.g., furnishing-events for *furniture*). The event type is used to determine the set of physical entities in the extension of the noun. An artefact noun denotes anything that COULD be used as a participant in a MINIMAL event of the type associated with it. Formally, this is done in lexical entries via a modal operator $\mathit{ABLE}$ that takes as argument a set of events (e.g., $x$ sits on $y$ in $e$), where, approximately, $\mathit{ABLE}(x$ sits on $y$ in $e)$ is true iff there is a world that is stereotypically similar to the actual world in which $x$ sits on $y$ (the Kratzerian ordering source is based upon stereotypicality). Critically, the event type is part of what determines the extension of the noun (chairs are things that can be sat on).

However, for G&L, the events must also be minimal events. For instance, the extension of *chair* is the set of entities that COULD be used in stereotypically similar worlds in MINIMAL seating events. This is schematised as $\mathit{ABLE}(x$ *sits on* $y$ *in* $e$ *and* $\mathit{min}(e))$, where a stereotypical minimal *sit on* event associated with *chair* involves a single chair and a single agent, which for G&L is why *chair* is count.

What differentiates count artefact nouns from mass ones is that the minimal associated event for the former typically involve just one of the relevant artefact item type, whereas in the mass case, many entities typically participate in minimal events. In contrast to *chair*, for *furniture*, and furnishing a space, G&L claim that there are typical minimal furnishing events and that, in contrast to *chair* and minimal seating events, typical minimal furnishing events involve multiple furnishing entities (e.g., a collection of tables, chairs etc.).

We partially agree with Grimm and Levin (5.5a) that common nouns denoting artefacts have events associated with them. However, we disagree that these must be EVENTS as opposed to *eventualities*, in the sense introduced into event semantics by by Mourelatos (1978): namely, eventuality types denoted by linguistic expressions are classified into three main aspectual classes, STATES and PROCESSES as well as (dynamic) EVENTS). In particular, we think that some nouns are associated with PROCESSES.

We also partially agree with (5.5d). However, for us, whether an artefact noun is count or mass is NOT determined by whether there are pluralities of entities in minimal typical events in which they participate, e.g. a plurality of instruments. Instead, we propose that core properties of artefacts (e.g., `furniture`) are associated with a set of typical eventualities, and if there are pluralities of entities as e.g., instruments in these typical eventualities, then this property will display variation in its count/mass lexicalization patterns (see constraint C2 below).

On all other counts above, we disagree with G&L. We disagree with the claim (5.5b) that the relevant typical eventualities must be atoms, since, as just mentioned, we think that in some cases, nouns may have typical associated PROCESSES and the notion of an atom for a PROCESS is ill-defined (see e.g., Bach 1986 as well as Filip 2012 and references therein). We also disagree with (5.5c). Following in the tradition of e.g., Pustejovsky, we do not think that the relevant typical eventualities determine the extension of the relevant noun. Finally, contra (5.5e), we do not attribute variation in count/mass lexicalization patterns to differences between eventuality types. For us, this is explained in terms of whether a core property is instantiated by objects, and if so, whether it is defined for our system of perceptual-interactive constraints. We now briefly motivate these points of disagreement.

**Eventualities not EVENTS, and no minimality condition.** When it comes to *characterising* what artefact nouns are typically used for, it is often natural to use a characterising generic sentence, e.g., *Furniture furnishes habitable spaces*, *Furniture is for furnishing spaces, Good kitchenware makes cooking a breeze.* Such generic sentences describe affordances of objects due to their inherent design functions. All generic sentences are aspectually stative, they are neither dynamic nor EVENT-denoting (see e.g., Krifka et al. 1995). The phonologically null $\mathsf{Gen}$ operator (ibid.), which, as some argue, can be used for the logical representation of generic sentences, can bind the situation variable (standing for eventualities of various types, i.e., EVENTS, PROCESSES, STATES).

Now, the complex predicate $\mathsf{ABLE}(\mathsf{x}$ *chops a carrot with a knife in* $\mathsf{e})$ qua denoting an ability of an agent to chop a carrot with a knife is a kind of generic statement, and hence aspectually stative. G&L claim (see 5.5a) that the type of eventuality that $\mathsf{ABLE}$ applies to is a set of EVENTS: e.g., $\mathsf{x}$ *chops a carrot with a knife in* $\mathsf{e}$ in $\mathsf{ABLE}(\mathsf{x}$ *chops a carrot with a knife in* $\mathsf{e})$ (approximately, 'one can chop a carrot with a knife').[4] This is needed, since

[4]It is not clear whether the argument of $\mathsf{ABLE}$ is a set of events, e.g., $\mathsf{ABLE}(\lambda \mathsf{e}.\mathsf{chop}(\mathsf{e}) \wedge$ ...) or a proposition formed by $\exists$-closing $\mathsf{e}$, i.e., $\mathsf{ABLE}(\exists \mathsf{e}.\mathsf{chop}(\mathsf{e}) \wedge ...)$. For the purposes of exegesis, we assume the former, but either way our main points still hold *mutatis mutandis*.

they assume that the sets of eventualities that $\mathit{ABLE}$ applies to have atoms (minimal EVENTS), upon which their claims about e.g., countability for the relevant noun are based. However, notice that the argument of $\mathit{ABLE}$, $x$ *chops a carrot with a knife in* $e$, alternates between either PROCESS or EVENT interpretation: e.g., *Miriam chopped a carrot with a knife in a few seconds* (EVENT) / *for a few minutes, slowly and deliberately, and put the rest of the unchopped carrot back into the fridge* (PROCESS).

Indeed, as the following few examples demonstrate, the main function associated with artefacts denoted by some nouns is best characterised with a VP that denotes a PROCESS. This is problematic, since PROCESSES are often assumed not to have minimal parts (e.g., Bach 1986).

- *vacuum flask* and (also *Thermos™(flask)*). The typical use or purpose for a vacuum flask is to keep liquids at some desirable temperature, be it on the hot or cold side. In G&L's terms, this would be expressed by something along the lines of $\mathit{ABLE}$($x$ *keep* $y$ *hot/cold with* $z$ *in* $e$ *and* $\mathit{min}(e)$). However, VPs such as *keep the coffee hot in a vacuum flask* are predicates of PROCESSES not EVENTS, and there is no obvious minimal eventuality $e$ such that $e$ is a minimal part of a keeping-the-coffee-hot-in-a-vacuum-flask PROCESS.
- *WiFi router*. The typical use or purpose of a WiFi router is to emit or provide a WiFi signal. In G&L's terms, we may capture this roughly by $\mathit{ABLE}$($x$ *provide* $y$ *with* $z$ *in* $e$ *and* $\mathit{min}(e)$). However, *provide/emit a WiFi signal* is also a predicate of PROCESSES, not EVENTS. We note that *emit* and *provide* can be used to denote EVENTS (e.g., *the device emitted a beep*, *Alex provided Billie with a plate of sandwiches*), however, *emitted/provided a WiFi signal* is atelic. For instance, *The router emitted/provided a WiFi signal in 5 seconds* only has the inchoative reading in which it started emitting/providing the signal after 5 seconds (a property of PROCESS-denoting predicates), and in *The router emitted/provided a WiFi signal for 5 seconds/minutes* the durative adverbial measures the temporal trace of denoted PROCESSES; if the verbs *emit* and *provide* were EVENT-denoting, an iterative interpretation should be available here, but it is not.

In sum, while minimality (i.e., atoms of an associate event type) is a central notion in G&L's proposal, it does not cover all artefact nouns, notably, as we have just shown, it does not extend to nouns like *vacuum flask* and *WiFi router*, which are best associated with eventuality types that qualify as PROCESSES. We therefore do not require that artefact denoting nouns are associated with a set of EVENTS. Furthermore, under standard assumptions, predicates of PROCESSES are not atomic (see, e.g., Bach 1986; Krifka 1989). Therefore, atoms are not defined for PROCESS such as *keep coffee warm*.

**Count/mass category and count/mass variation.** G&L propose that the count/mass category of an artefact noun is derivable from whether more than one entity in the extension of the noun typically participates in the associated minimal event (5.5d), and furthermore, for at least some artefact-denoting nouns (e.g., *furniture*-nouns), variation in count/mass lexicalization patterns can be attributed to variation in the associated event type (5.5e). For example, they contrast *furniture* with *meuble* ('item of furniture', French, count), where the latter evokes a modality (disposition, capacity) of things that can be moved. The former is mass, because minimal furnishing events typically involve multiple items of furniture, and the latter is count, because typical events of moving-things do not.

As evidence against both of these claims, below are some examples of *functionally combinatorial* nouns that denote furniture, and the connection between the physical entities and their etymologically related eventualities, including the one's given by G&L:

(5.6) Germanic:
*furniture* (English, mass): *thing for furnishing a space*

(5.7) From Latin:

a. *meuble* (French, count): *movable thing*
b. *meubel* (Dutch, count): *movable thing*
c. *meubilaire* (Dutch, mass): *movable thing*
d. *Möbel* (German, pluralia tantum): *movable thing*
e. *mobilario* (Spanish, mass): *movable thing*
f. *mueble* (Spanish, count): *movable thing*

(5.8) Slavic:
*nábytek* (Czech, mass): *thing(s) acquired or gained*[5]

Across French, Dutch, German, and Spanish, we have etymologically related nouns associated with the same event(uality) type of moving things, but find three different countability classes. This suggests that whether pluralities of items of furniture are involved in moving-events does not determine the countability class of the relevant noun, contra the claim in (5.5d).

The above data also suggest that variation in count/mass lexicalization patterns is not obviously attributable to differences in eventuality type, even

[5] From *nábytek*, 'thing(s) acquired or gained', https://en.wiktionary.org/wiki/nabytek, from the verb *nabýt* 'to acquire', 'to gain'.

for *furniture*-nouns, contra (5.5e). In addition to the French, Dutch, German, and Spanish data, in Czech we have *nábytek* ('furniture', Czech, mass). Etymologically, *nábytek* stems from the verb *nabýt* 'to acquire'. However, it is not clear that G&L's account makes the right prediction with respect to the countability class of this noun. A minimal event of acquiring something can involve one acquirer (e.g., buyer), one donor (e.g., seller), one item of goods, and possibly exchange of money, and so this, we surmise, should lead G&L to predict that *nábytek* is count, contrary to fact.

**Qualia structure vs. truth-conditions.** Both G&L and Nichols (2008) attribute, in part, the association of eventualities to the semantics of artefact nouns to Pustejovsky (1995). Nichols (2008) does not provide a formal account, and the implementation G&L provide is significantly different from Pustejovsky's. As mentioned above, in Pustejovsky's account, the TELIC quale (what the entities denoted by the express are typically used for) does not determine the extension of the relevant noun. The motivation for event(uality) variables in lexical entries for Pustejovsky is to be able to explain why constructions such as *begin a book* can be resolved to mean 'begin reading/writing a book'. This mechanism is in principle available for G&L, since the event variable in their lexical entries is free. However, we worry that characterising truth-conditions in terms of modal operators binding events (e.g., that chairs JUST ARE what could be used for seating people), is too unconstrained.[6] We therefore prefer the more conservative Pustejovskyan position in which eventualities are associated but do not determine denotations of artefact-denoting common nouns.

### 5.1.3 Collective uses of instruments C2

As we detailed in section 5.2, we agree with Grimm & Levin (2017) that typical associated eventualities for artefact denoting nouns are important and relevant for a fully-fledged account of the count/mass distinction. However, given our disagreements with them on some core assumptions, we now characterise a *constraint* that capitalises on some of Grimm and Levin's insights, but does not rely on minimal eventualities and does not connect these eventualities too closely to countability. For us a core property satisfies a perceptual-interactive constraint, that property may be lexicalized as mass. We do not characterise the extensions of artefact nouns in terms of associated eventualities, nor do

[6]For instance, if Alex buys his partner a large dustbin, it does not imply that he bought him a chair, even though a dustbin could be used to seat someone in a minimal seating eventuality.

we think such eventualities *determine* whether a noun is count or mass.

Core properties like `furniture`, `jewellery`, and `kitchenware` are instantiated by objects that we typically use for furnishing spaces, adorning our bodies and clothing, and preparing food, respectively, the first two of which are given by G&L as the eventualities associated with the English *furniture* and *jewellery*. Take `furniture`, for instance. Different items of furniture have diverse uses (there are items designed for sitting on, others for storing books, etc.), but taken together, chairs, bookcases, tables, etc. are typically used for furnishing spaces. This notion of a *typical eventuality associated property*, as we call it more-or-less following the terminology of G&L, along with certain proper part relations between objects and eventualities is central to our constraint C2.

C2 **Collective uses of Instruments:** There is a typical associated eventuality with a property `P` such that in many cases, there is a least upper bound for the fulfilment of the INSTRUMENT role in this eventuality, namely (usually heterogeneous) sums of objects that instantiate $P$. I.e., any proper part of these sums of instruments would not normally facilitate bringing that eventuality about.

To unpack C2 more, the idea is that in many cases, multiple instruments are needed to facilitate bringing about the typical associated eventuality for that property, where the objects that instantiate that property are these very instruments. Let us begin by giving some concrete examples of C2. A selection of these examples are summarised in table 5.2.

`kitchenware`: One of the most typical eventualities associated with kitchenware is *preparing a meal*. Making-a-meal-with-kitchenware eventualities can be represented in neo-Davidsonian event-semantics as a set of tuples of an eventuality, a meal, and some sum of kitchenware objects (relative to some world $w$):

(5.9) $$\{\langle e, x, y\rangle | \texttt{prepare}_w(e) \wedge \textsc{theme}(e, x) \wedge \texttt{meal}_w(x) \wedge \textsc{instr}(e, y) \wedge \texttt{kitchenware}_w(y)\}$$

Call one such tuple $\langle \epsilon, m, k\rangle$, for meal $m$ and sum of kitchenware $k$. The C2 constraint applies to `kitchenware`:

**C2 for `kitchenware`:** There are some cases where $k$ is a sum of multiple items of kitchenware, and $k$ forms a least upper bound for preparing $m$ such that for any $y \sqsubset k$, $y$ does not facilitate $\epsilon$.

Suppose the meal in question is a pasta dish, which is prepared with different sorts of kitchenware, including knives, wooden spoons, chopping boards, pots and sauce pans, etc., each of which may facilitate only a proper part of the whole pasta dish preparation process. So, for example, in making a pasta dish, a knife and a chopping board may only facilitate that proper part of the pasta dish preparation eventuality during which onion, garlic and tomatoes are chopped, while a sauce pan and spoon facilitate the mixing and cooking of these ingredients into a tomato sauce, and other kitchenware like pots are needed for cooking pasta. Furthermore, any fewer sorts of kitchenware may not, in this case, be sufficient to prepare the meal. E.g., without a knife (and board), one couldn't chop the onions, and without a pan, one couldn't heat the sauce etc.

To take another example, think of preparing whipped cream. To do this, one needs a receptacle (e.g. a bowl) and a whisk. A bowl alone or a whisk alone would not do. So, in regard to whipping cream, the sum of the bowl and whisk form a least upper bound of what is needed to fulfil the *instrument* role.

With this concrete example now in mind, we can underscore an additional difference between the way we appeal to typical associated eventualities and the way that G&L do. As we shall go on to elaborate in more detail in relation to abstract nouns in chapter 6, we do not take individuation of eventualities relative to a predicate as a given. As such, unlike G&L, we do not assume one can define a eventuality atom relative to, say, $\texttt{prepare}_{w}$ without also specifying the full range of thematic roles for that eventuality type, looking at the values for any given constant of type $v$ (for eventuality), and then fixing one counts as one in terms of these values. For instance, whether an eventuality counts as one or two meal preparations, or as an uncountable process, supervenes on whether e.g., the cardinality the value of the THEME (the meal(s)) form s a quantized set and what the cardinality of this set is. This is a development of the idea of *anchoring* in Grimm (2014), see chapter 6.

`jewellery:` The typical eventuality associated with jewellery is *adorning different parts of someone's body*, we can represent this in the following way (relative to some world $w$): namely, as a set of tuples where the notion of *facilitation* is captured by jewellery being an instrument for adorning a body.[7]

[7]What we have in mind with respect to facilitation could perhaps be formalised in terms of Gibsonian affordances (Gibson, 1979), such that jewellery affords one the possibility of adorning one's body. However, here, we remain neutral on how this term is spelt out.

| Property | Assoc.Eventuality | C2 applies |
|---|---|---|
| `kitchenware` | preparing a meal | Yes. E.g. knife and pan etc. needed for making a sauce |
| `jewellery` | adorning different parts of a body | Yes. E.g., earrings and necklace needed in some contexts |
| `furniture` | furnishing some space | Yes. E.g., bed, closet etc. needed for a furnished bedroom |
| `chair` | seating someone | No. Single chairs are sufficient to seat someone |

Table 5.2: Examples of Constraint C2 and whether it applies.

(5.10) $$\{\langle e, x, y\rangle | \texttt{adorn}_w(e) \wedge \textsc{theme}(e, x) \wedge \texttt{body}_w(x) \wedge \textsc{instr}(e, y) \wedge \texttt{jewellery}_w(y)\}$$

We assume that the Theme (body) is singular, but allows for there to be multiple items of jewellery used in the adorning. We therefore have a set of tuples, in this case of an eventuality, some body, and some amount of jewellery. Call one of these $\langle \epsilon, b, j\rangle$. The C2 constraint applies to `jewellery`.

> **C2 for `jewellery`:** There are some cases where $j$ is a sum of multiple items of jewellery (e.g., sums of rings, necklaces etc.) and $j$ forms a least upper bound for adorning the different parts of $b$ such that for any $y \sqsubset j$, $y$ does not facilitate $\epsilon$.

Now, we do not deny that there are limiting cases where, for instance, one necklace may be sufficient to adorn one's body. However, in many cases, multiple pieces of jewellery are used for the personal, contextually relevant purposes and desires of the wearer. For instance, someone may feel that an outfit needs both earrings and a necklace to complement it.

`furniture`: The typical associated function of furniture is to furnish some room or space (furniture facilitates the furnishing of a space).

(5.11) $$\{\langle e, x, y\rangle | \texttt{furnish}_w(e) \wedge \textsc{theme}(e, x) \wedge \texttt{space}_w(x) \wedge \textsc{instr}(e, y) \wedge \texttt{furniture}_w(y)\}$$

Call one of these tuples, of an eventuality, some apartment, and some amount of furniture, $\langle \epsilon, a, f\rangle$. The C2 constraint applies to `furniture`.

> **C2 for `jewellery`:** There are some cases where $f$ is a sum of multiple items of furniture (e.g., a bed, closet, table and chairs

may be needed for an apartment to count as *furnished*). $j$ forms a least upper bound for furnishing $a$ such that for any $y \sqsubset f$, $y$ does not facilitate $\epsilon$ (e.g., minus a bed, an apartment would not count as (fully) furnished).

**Superordinate properties of superordinate properties:** `tableware`**.** This is an interesting case, since `tableware` has subordinate properties that themselves satisfy C2, namely, `crockery`, `cutlery`, and `glassware`. The typical eventuality associated with tableware is to facilitate serving and eating a meal. The cutlery alone or the plates alone, in many cases, only partially facilitate serving and eating the meal. I.e., for ramen, the chopsticks alone, the spoon alone or the bowl alone only partially facilitate the serving and eating of the ramen. Therefore `tableware` satisfies C2. So our C2 constraint also applies to superordinate properties that have superordinate properties as subkinds. For `cutlery`, the typical function is to facilitate serving and eating food in virtue of cutting, spooning, and lifting food etc. The knives alone may only partially facilitate the serving and eating of food in this way, therefore `cutlery` also satisfies C2.

**A case where C2 is not satisfied:** `chair`**.** The typical eventuality associated with `chair` is to seat someone (chairs facilitate seating people):

(5.12) $$\{\langle e, x, y\rangle | \texttt{seat}_w(e) \wedge \textsc{theme}(e, x) \wedge \texttt{person}_w(x) \wedge \textsc{instr}(e, y) \\ \wedge \texttt{chair}_w(y)\}$$

Call one such tuple of an eventuality, some person, and some amount of chairs, $\langle \epsilon, p, c\rangle$. The C2 constraint does not apply to `chair` since a single chair typically counts as a least upper bound for fulfilling the instrument role in seating someone.

**Another case where C2 is not satisfied:** `pen`**.** The typical eventuality associated with `pen` is using it to write some text (pens facilitate writing).

(5.13) $$\{\langle e, x, y\rangle | \texttt{write}_w(e) \wedge \textsc{theme}(e, x) \wedge \texttt{text}_w(x) \wedge \textsc{instr}(e, y) \\ \wedge \texttt{pen}_w(y)\}$$

Call one such tuple in this set $\langle \epsilon, t, p\rangle$ (an eventuality, some text, and some amount of pens. The C2 constraint does not apply to `pen` for the following reasons. As observed above, we often associate objects with eventuality types to which they are (thematically) related. So a pen is typically associated with a writing eventuality type denoted by a verb like *write* (in the simplest case at least), and also by virtue of the assumption that the verb *write* in turn is taken to include a writing implement as one necessary participant in the writing FRAME, with FRAME taken in the original sense of Fillmore (1975). It minimally includes four participants: namely, somebody (writer, Agent) guiding some trace-leaving implement (Instrument), such as a pen, for instance, across a surface (Location) on which the traces are left, the 'product', which must be something linguistic, rather than a picture or a smear. This means that the verb *write* simultaneously activates a FRAME of writing and also a FRAME of linguistic communication linked to it via the created linguistic object of the act of writing. Put in our terms, a pen may be part of a collection of participants involved in writing, whereby the least upper bound for what constitutes writing involves the four participants in Fillmore's writing FRAME. In any case, a single particular eventuality with a single Agent participant that satisfies a writing FRAME does not include multiple pens, but it does include multiple writing implements, that is, apart from a pen minimally also a writing surface.

In order to clarify the import of our C2, we may thus contrast the property denoted by the singular count noun *pen* with the property denoted by the mass noun *stationery*. The objects that instantiate `stationery` comprise a collection of diverse materials needed for writing, such as paper, writing implements like pens, pencils, ink, cartridges, envelopes, ink, and other equipment such as computer printers. Multiple items of stationery are collectively used for different, but related, activities like writing a text, printing a text, stamping of signs and images, among others. In contrast, the objects that instantiate `pen` (which also instantiate `stationery`) are typically used as single objects: typically a single pen is used for writing (of a single text by a single agent). Hence, only `stationery` satisfies C2, but not `pen`, even if both are typically associated with a writing eventuality type.

**A final case where C2 is not satisfied: `vacuum_flask`.** We noted in section 5.1.2 that *vacuum flask* is problematic for G&L, since the typical use for a vacuum flask is a PROCESS (e.g., keeping one's coffee warm), which does not have minimal parts. Our C2 does not require minimal parts of eventualities in order to be well-defined, and also correctly does not categorise `vacuum_flask` as satisfying C2. We use vacuum flasks for keeping portions of e.g., coffee warm, but for each portion of coffee one vacuum flask is sufficient to bring this about. It does not matter whether such a process has a minimal part and the characteristics of any such minimal eventualities is not relevant to why `vacuum_flask` does not satisfy C2.

### From Collective uses of Instruments to Functional Combination

In chapter 2, one of the noun classes we identified as having non-canonical reflexes of the count/mass distinction were *Functionally Combinatorial Nouns* (which subsume object mass nouns). There we hypothesised that what was relevant to why we find mass nouns in this class is that the entities in their denotations are, in some sense, used together to fulfil some function or purpose. Here, we have made this claim more precise in terms of associated eventualities for properties and the objects used to fulfil the instrument role. To say that some sum is a least upper bound to fulfil the instrument role is just to say that objects in that some, in some sense, must be used together (either simultaneously, or at different stages of the eventuality), to fulfil some relevant function.

It is this 'collectiveness' of use that, we propose, motivates why the object-neutral perspective can be applied to such a property, which, in turn, motivates why that property can be lexicalized as mass. If different sorts of objects that instantiate a property are usually used together for some function or purpose, the collectivity of purpose or function overrides the individuality of items so that they become backgrounded qua independent individuals.

### Extension to interconnected mass nouns

We now turn to whether the *collective fulfilment of function* constraint also captures why we find count/mass variation for properties that are lexicalized as interconnected nouns. For instance, `fence` and `hedge` can be lexicalized as mass nouns (e.g., *fencing* and *hedging*) as exemplified in (5.1) in which the real estate referred to is enclosed by (i.e. surrounded by) fencing and hedging (i.e. objects that instantiate `fence` and `hedge`).

(5.1) The property backs onto adjoining farmland and is enclosed by fencing and hedging. [ukWaC]

Enclosing and/or partitioning spaces is a typical function of entities in the denotation of the properties `fence` and `hedge`. This prompts the question whether `fence` and `hedge` satisfy C2, and we claim that they do, because there are eventualities involving enclosing or partitioning that involve, as instruments, multiple objects that instantiate `fence`/`hedge`.

Now, in chapter 4, we suggested that the reason why a property such as `fence` can be lexicalized as mass is because the set of objects that instantiate it fails to be quantized. With C2, we have a means of connecting this observation to a wider pattern we find in the count/mass lexicalization patterns of properties underpinning common nouns. It is partly because the fencing around, say, a property can count as both one fence or as more than one that allows for properties such as `fence` to satisfy C2. There are sums of fence objects (that may themselves each also constitute fence objects) that form the least upper bound as instruments in eventualities of enclosing or partitioning spaces. That is to say that the least upper bound for instruments in such eventualities can count as one fence relative to some contexts or as more than one relative to others, and this is, in a sense, another way of articulating the observation that the set of objects that instantiate `fence` fails to be quantized.

This contrasts with properties such as `chair`. Sums of chairs cannot count as a single chair, and so the set of chair objects is quantized. This in turn underlies why sums of multiple chairs do not form a least upper bound of instruments in seating eventualities.

#### A possible counterexample to C2.

Let us consider a possible objection to C2, one that is raised by G&L in relation to their own proposal (Grimm & Levin, 2017, §7.1.1). The objection is that C2 is too weak (it potentially includes too many properties). For instance, take `chop_stick`. Pairs of chopsticks arguably do constitute a least upper bound for eating, and so `chop_stick` would seem to satisfy C2, but nonetheless is lexicalized as count in English. Although we concede that this may well be the case, we suggest that this is not, after all, problematic. We know that properties denoting entities that, in some sense, are formed of two parts, both of which are needed to fulfil some purpose are frequently not lexicalized as count. In English, such properties are at least sometimes lexicalized, not as mass, but as pluralia tantum nouns e.g., *binoculars*, *(eye) glasses*, *pliers*, *pyjamas*, *scissors*, *trousers*, *tongs*, *tweezers*. All of these nouns have the same dedicated classifier in English, *pair*. It is plausible, therefore, that C2 can help explain why the properties underlying these nouns are not always lexicalized as count. In other words, we suspect that C2 also underpins why some properties are lexicalized as pluralia tantum nouns, which although not mass, are non-count.

G&L's explanation of this example is different. They suggest that *chopsticks* in English is count, because this countability class is propagated up from *stick*. While this may be a plausible explanation for *chopstick*, it does not generalise for explaining count/mass lexicalization patterns. For instance, as is currently being explored by Maximilian Gottwein as part of his MA project, *Zeug* ('trinket/stuff', German) is non-countable and lacks a plural form, but many compounds with *Zeug* are count, for instance, *Feuerzeug-e* (cigarette lighter-s, German) and *Spielzeug-e* (toy-s, German).

### 5.1.4 Object splitting C3

C3 **Object splitting:** Objects that instantiate `P` are often used in such a way that requires them to (first) be split apart or broken up.

The *object-splitting* constraint C3, like *collective fulfilment of a function* C2, is related to the use of objects. Unlike C2, and also unlike *indistinguishibility* C1, C3 concerns the splitting apart of objects and destroying the integrated structure of whole natural units, in order for us to use them. For instance C3 applies to many properties of edibles that are typically not eaten whole, because they are either too large or have parts that cannot be consumed by us, such as `mango`, `watermelon`, `broccoli`, `cabbage`[8]. C3 also concerns properties that are instantiated by artefacts, such as (`rolls of`) `fabric`. The reason for cutting up objects that instantiate such properties is also tied, in practical necessity, to their various uses.

The reason why we propose that the object-neutral perspective can be applied to properties that satisfy constraint C3, and so why such properties can be lexicalized as mass, is simply as follows: if we typically cut up or break up clearly individuated objects that instantiate a property and use their proper parts, the objects qua integrated, discrete, countable entities become backgrounded. Take *cabbage* in English, for example. This noun is dual life in that it can just as naturally and straightforwardly be used in count or mass contexts. When used as a count noun, it denotes whole heads of cabbage and when used as mass, it denotes the stuff whole cabbages are made of. We even find cases where both senses are used in the same passage:

(5.2) For the cabbage, finely shred the **three cabbages** making sure that you keep each of them separate from the other. In three pans, quickly **blanche the cabbage** in boiling salted water, then drain well. [ukWaC 2017]

Since cabbages come in natural units that are fairly big, and so distinguishable as clearly countable units, it is unsurprising that `cabbage` can be lexicalized as count. For the cases where `cabbage` is lexicalized as mass (or at least as as a noun with a mass sense, possibly in addition to a count sense), we propose that it is C3 that explains why the object-neutral perspective can apply to this property thus giving rise to the lexicalization of a mass noun.

Indeed, for such properties, their mass lexicalization cannot reasonably be explained in terms of constraints C1 or C2. C1 is much less suitable as a

[8] For instance, watermelons are a case where both size and the inedibility of the rind seed play a role in the way in which we consume them. Their rind is typically not consumed, and is removed to access their edible part, which is chopped up in chunks for our consumption.

plausible explanation, since `cabbage` does not satisfy C1 to a high, or even middling degree given the size of its natural units (although cabbages of the same kind are fairly perceptually homogenous), while the conditions of C2 do not arise for it at all.

Turning now to the connection between what objects instantiate a property and whether that property satisfies C3, there is a generalisation that can be made with respect to properties that are lexicalized as mass and that satisfy C3:

(5.3) For an object-instantiated property `P` and a mass lexicalization of `P`, N, if `P` satisfies C3, then not only whole objects and sums thereof, but also at least some of their proper parts are in the extension of N.

The idea here is that, if C3 motivates why a core property can be lexicalized as mass, then, since C3 concerns the use of proper parts of objects that instantiate that property (because the objects have been split apart or broken up for use), the extension of the resulting mass expression will include, not just the objects and sums thereof, but also (at least some) proper parts of those objects (e.g., flesh for fruits, and edible parts for brassicas etc.).

Interestingly, (5.3) points towards a connection with learning. It seems plausible to suppose that the way we interact with objects as children affects how we learn what instantiates concepts for those objects. For example, if a child learns that cabbage is a chopped up stuff (parts of a whole head of cabbage), it is plausible that this stuff will be learnt as being an instance of `cabbage`. Given that this is how at least some interactions with cabbage are for many if not most of us, and perhaps also the first ones, it is therefore not surprising that, in some languages at least, the noun that lexicalizes this concept has a mass sense.

Notice that (5.3) does not preclude properties that do NOT satisfy C3 from also being instantiated by proper parts of objects. Take `rice`, for instance. `rice` is a property that satisfies *indistinguishability* C1, but does not satisfy *object-splitting* C3, since rice grains are not first broken up or split apart in order to be used. Yet, as claimed by Chierchia (2010), parts of grains of rice instantiate `rice`, and so are whole grains of rice (in some contexts at least). From our perspective, the conclusion that `rice` is (also) instantiated by parts of grains of rice can be motivated on perceptual grounds. Rice grains are, on the one hand, large enough to see, but are, on the other hand highly perceptually similar to each other, and the fact that a proper part of a rice grain is, relative to average human perceptual acuity, pretty similar looking to a whole rice grain, it seems plausible that proper parts of individual grains as well as whole grains and their sums instantiate `rice`.[9]

### 5.1.5 The gradability of the constraints

In this section, we argue that of constraints C1–C3, only C1 (*indistinguishability*) and C3 (*object-splitting*) are gradable. This means that a property can satisfy C1 or C3 to some degree, but can only satisfy C2 fully or not at all. For example, it is possible for a property to satisfy C1 to a high degree, C3 to a low degree and C2 not at all. This discussion will then motivate our corpus study in section .

**C1 Indistinguishability.** C1 is a gradable property of properties. A property satisfies C1 if the objects that instantiate it are small, perceptually homogenous (e.g., look alike) and are typically encountered as clustered together. It follows that a property can satisfy C1 to a greater or lesser degree, since smallness, perceptual homogeneity, and degree of clustered-togetherness are all themselves gradable concepts. For example, grains of sand are very small, are almost always encountered in clusters, and are also perceptually homogenous (look very alike, at least with the naked eye). In contrast, grapes are much larger than grains of sand, are often clustered together (in bunches) and are also fairly perceptually homogenous, although less so than sand. In further contrast, chairs are much larger than grapes and do not typically come 'in clusters' (except some kinds of chairs which are sometimes stacked), and even as sets, chairs usually stand some distance apart (e.g., around a table). In any case, however, we may clearly distinguish what is one chair. As a class, for chairs, there is more variation with regard to perceptible shapes, sizes and colours than there is for either grains of

[9]Interestingly, this combination of factors, namely, why a property may be instantiated by proper parts of objects (a) as a result of C3 or (b) as a result of a special case of C1 like `rice`, could, together, be used to provide an alternative characterisation of what Chierchia (2010) means by a property that is not stably atomic. This alternative characterisation would not require supervaluationism, but instead would merely rely upon our use of parts of objects that instantiate the property C3 and, in some cases, whether our perceptual acuity is sufficiently fine-grained to distinguish whole grains from their parts C1. The advantage to this characterisation, we suggest, is that it makes it easier to test whether or not a property is "stably atomic" since it turns on non-linguistic facts. The problem with the definition of stable atomicity in (ibid.) is that the only way to test whether or not a property is stably atomic is to ask questions using some lexicalization of that property, i.e., by using a count noun or a mass noun. However, this introduces a confounding variable. For example, an English speaker might judge that parts of whole lentils do not instantiate *lentil(s)*, in part, because they have a count lexicalization of `lentil` in their language and a Czech speaker may be more likely to make the opposite judgement because they have a mass lexicalization of `lentil` in their language, namely *čočka* ('lentil', mass).

sand or grapes. For example, chairs can come in any colour and in many different designs, whereas sand and grapes come in fewer colours, and in uniform shapes, all sand is granule-like and all grapes are roundish. So `sand` satisfies C1 to a very high degree, `grape` satisfies C1 to a lower degree and `chair` either to a very low degree or not at all. This, we suggest, may be used to explain why `sand` is always lexicalized as mass, whereas `grape` only sometimes is (it is lexicalized as a mass noun, *vinograd* 'grapes', in Russian, as other properties for small fruits and berries are (Wierzbicka, 1988)), and why `chair` is never lexicalized as mass.

**C3 Object splitting.** C3 is also a gradable property of properties. Gradability here arises on the basis of how frequently objects that instantiate properties need be first cut up or split apart so as to be used. For example, for us, in order to consume objects that instantiate `melon` and `cabbage`, their size means that we must first cut them up, shred them etc.. For objects that instantiate `potato`, we must sometimes do this, but not always, primarily because some potatoes are small enough to leave whole, and large(r) potatoes are baked whole, for instance. Objects that instantiate `apple` are sometimes cut up (e.g., slices of apple in a salad), but we also very frequently just pick up a whole apple and bite into it. Objects that instantiate `chair` do not need to lose their structural integrity in order to be used for sitting (their design function) or for most other uses they are fit (e.g., serving as a night stand next to a bed). Thus we can hypothesise a preorder with regard to how well properties satisfy *object-splitting* C2: `cabbage` > `potato` > `apple` > `chair`. As with C1, the degree to which a property satisfies C3 is connected to how frequently that property is lexicalized as mass across and within languages. Given the above observations, it is to be expected that `cabbage` is relatively often lexicalized as mass in languages with a grammaticalised count mass distinction. In contrast, `apple` is never lexicalized solely as mass to our knowledge but it does often admit of ROUTINISED mass uses, see e.g., (5.4) below. `chair` is never lexicalized as mass and has no ROUTINISED mass uses (particularised *grinding* examples notwithstanding, e.g., *there was chair all over the floor*).

Interestingly, we arguably see the effects of such gradation with respect to C3 when it comes to how easily nouns with a count sense can be used in mass syntactic environments. Most count nouns can be coerced if used in mass syntactic environments, but as observed by Fillmore & Kay (1987), not all such environments are equal. Count nouns like *apple* can be relatively easily coerced in existential constructions such as (5.4a), but are highly marked if, say, used as bare direct objects, as in (5.4b).

(5.4) a. There is apple/pear in the fruit salad.
b. ?We ate apple/pear for dessert.

Nouns such as *melon* and *mango* predominantly have count uses in English, but, as we see in (5.5), they are also natural when used bare in the direct object position.

(5.5) a. There is melon/mango in the salad.
b. We ate melon/mango for dessert.

Arguably, then, if we view how countable a noun is on a scale from completely count to completely mass, nouns such as *melon* and *mango* are further away from the completely count end of the scale than nouns such as *apple*[10]

Finally, nouns like *chair* cannot be used in any mass contexts without being highly marked (5.6). For (5.6a), it requires a lot of heavy contextual lifting and a particularised grinding context to make it felicitous (see above), and (5.6b) even more so (if possible at all).

(5.6) a. #There is chair behind the desk.
b. #Chair is comfortable for sitting on.

**C2 Collective uses of instruments.** Unlike *Indistinguishibility* C1, and *Object-splitting* C3, we treat *Collective uses of instruments* as a categorical constraint. This is for theoretical reasons and for practical reasons. The way C2 is defined is that a property satisfies C2 if at least some entities that instantiate that property are typically used collectively as instruments. For instance, using different items of kitchenware, collectively, to prepare a meal. As such C2 has quite weak satisfaction conditions (based on existential quantification), and so, in principle, is completely satisfied if there are at least some cases where objects that instantiate the property are used collectively as instruments.

From a practical point of view, we doubt whether there would be sufficient returns on trying to accurately quantify how well a property satisfies C2. C2 is the most complex of our constraints, and also turns on theoretical distinctions relating to event structure and thematic roles. While estimating whether a property satisfies this constraint in a (semi-)automatic way might not be beyond the realms of possibility, we doubt that doing so would generate

[10] Allan (1980) shows that not all count nouns or not all mass nouns are equally felicitous in the same count/mass diagnostic environments (i.e. some nouns are more straightforwardly count/mass than others).

enough returns for the effort of doing so. For these reasons, we shall, in our weighted scoring model, treat C2 as a categorical constraint.

## 5.2 Corpus study: constraint satisfaction

So far, we have used our system of perceptual-interactive constraints to answer 'Question 4a: Why can properties that are instantiated by objects be lexicalized as mass nouns at all?' We now turn to 'Question 4b: Why are some properties more frequently lexicalized as count and others more frequently lexicalized as mass?' (variation in count/mass lexicalization patterns). We propose that the answer to this question depends on the extent to which a property satisfies our perceptual-interactive constraints.

Specifically our focus is on the two **gradable constraints C1 (indistinguishability) and C3 (object splitting)**. As justified in section 5.1.5, C1 and C3 are gradable insofar as properties can satisfy them to different degrees. The constraint C2 (collective uses of instruments), which we treat as categorical, as we also argued in section 5.1.5, is not included in our corpus study. The main purpose of this study is to place the gradable constraints C1 (Indistinguishability) and C3 (Object splitting) on a firmer empirical footing. Integrating some assumptions and methodologies from corpus linguistics, vector space semantics and computer science, we aim to test whether we can induce the approximate extent to which a property satisfies each of these two constraints from the distributional patterns of a noun that lexicalizes this property as they are attested in a corpus.

To this end, we do the following. First, for these two gradable constraints C1 and C3, we provide an empirically grounded means of estimating the degree to which a property satisfies each constraint. Second, in section 5.3, we propose a means of combining the degree scores for C1 and C3 into a single score, thereby deriving an ordering on properties that reflects their propensity to be lexicalized as mass.

In sections 5.2.1-5.2.3, we outline our assumptions, hypotheses, methodology and experiment design. The experiment is based upon comparing, for each of C1 and C3, a PREDICTED partial order over properties based upon whether they should rank highly or not, with a MEASURED partial order derived from the corpus. For the predicted partial order for C1, for instance, we base the ordering upon the approximate size of objects that instantiate them them (e.g., dust > bean > potato > chair).

We derive the MEASURED partial order based on the distributional properties of nouns that lexicalize the relevant property in the corpus based upon, relative to the noun's frequency, their RELEVANT cooccurrence with certain verbs, adjectives and nouns that we propose to be indicative for each constraint. For instance, for C1 (indistinguishability) and the properties `rice` and `potato`, we look at how often the nouns *rice* and *potato(es)* respectively are modified by expressions indicating indistinguishability, such as *sprinkle, sprinkling, cloud, scatter* and *homogenous* (e.g., *a sprinkle/sprinkling/cloud of rice*, *scatter the rice* etc.). For C3 (object splitting), indicator expressions include *chop, grind* and *halve* (e.g., *chopped/halved potatoes*, *chop/halve/grind the potatoes* etc.). From these corpus measures we calculate, for each noun, a score between 0 and 1 for constraint C1 and constraint C3. We then map these scores to a partial order, our *measured partial order*. We represent the predicted and measured partial orders as vectors. for instance, for the partial order N1 > N2/N3, this vector would be $[1, 2.5, 2.5]$, the mean rank for the property underpinning each noun.

To compare our predicted and measured partial orders, we took a standard measure for comparing vectors, namely *Cosine Distance*. We then ran Monte Carlo simulations to estimate the likelihood that this Cosine Distance is as low as it is by chance. Our results are given in section 5.2.5 and we discuss these results in section 5.2.6.

In section 5.3, these scores, as well as scores assigned for C2 on a rational basis, are then used as input to the weight scoring model outlined in section 5.3 to predict propensities for mass lexicalization.

### 5.2.1 Assumptions and Hypotheses

**C-relevant constructions for N.** For each constraint C1 (Indistinguishability) and C3 (Object splitting), we define a set of constructions in terms of a set of syntactic environments, and a list of C-relevant lemmas for N (where the lemma can be lexicalized as an adjective A, verb V, and/or noun N'), the following are the syntactic environments we examined for each N.

(5.7) a. A N
b. N is A
c. x Vs/Ved N
d. N was Ved
e. a/the N' of N

If we take `pile` as a C1-relevant lemma, the C1-relevant constructions for N for this lemma would include:

(5.8) a. piled (a/the) N
b. (a/the) N is piled

c. x piled (a/the) N
d. N was piled (up)
e. (a/the) pile of N

**Adapting the distributional hypothesis.** In distributional semantics, the underlying hypothesis is often characterised in terms of the dictum: *you shall know a word by the company it keeps* (Firth, 1957, p. 11). Typically, multiple dimension vectors for words are extracted from corpora, and these vectors are taken to characterise the MEANING of that word.

We take a related, but nonetheless different approach. Our perceptual-interactive constraints C1-C3 evoke, for instance, how we conceptualise certain objects, and how we typically interact with certain objects. These are not, at least strictly speaking, parts of the meanings of nouns such as *rice* and *cabbage*, but do, as we argue, affect how the core properties underpinning such words are lexicalized (as count or mass) across and within languages. Specifically, we propose the following hypothesis:

> **The modified distributional hypothesis:** the extent to which a core property satisfies C1 and C3, can be induced by looking at the distribution of a noun that lexicalizes that property with respect to the C-RELEVANT CONSTRUCTIONS in which that noun occurs.

In summary, we propose that if a noun $N$ lexicalizes a core property that satisfies the indistinguishability constraint, C1, and so denotes small, homogenous, typically clustered together entities, we will be able to detect this in a corpus as a function of the relative frequencies for which we find constructions such as *mounds/piles of N*, *N was scattered/sprinkled (over the floor)*, *a cloud of N*. Likewise, if a noun $N$ lexicalizes a core property that satisfies the object-splitting constraint, C3, and so denotes objects that are typically split apart in order to be used, we will be able to detect this in a corpus as a function of the relative frequencies for which we find constructions such as *cut/chop the N*, *slices/wedges/halves of N*.

**Independent variables.** For each common noun, and for each of C1 and C3, our independent variable is a vector that represents a mean rank derived from a PREDICTED partial ordering. The partial ordering is a prediction for the approximate relative extent to which a property that that noun lexicalizes satisfies each of constraints C1 and C3: a PREDICTED C-ORDERING. This gives us our (ordinal) independent variables. For instance for C1, based upon usual sizes and how often the relevant entities are clustered together, we predict that `pollen` is ranked above `lentil`, `lentil` is ranked above `potato` and `potato` is ranked above `chair`.

**Dependent variables.** For each common noun, and for each of C1 and C3, a rank is derived from an OBSERVED ordering of the extent to which a noun appears in any C-RELEVANT CONSTRUCTIONS. First we measure the entropy-adjusted probability that noun appears in any C-RELEVANT CONSTRUCTION. From these probabilities we derive an OBSERVED C-ORDERING on the class of common nouns.

Based on these variables, we tested the following hypotheses:

**Null hypothesis:** For constraint C, there is no relationship between the PREDICTED C-ORDERING and the OBSERVED C-ORDERING.

**Alternate hypothesis:** For constraint C, there is a relationship between the PREDICTED C-ORDERING and the OBSERVED C-ORDERING.

If our method of inducing the approximate degree to which a noun (and thereby the core property underpinning it) satisfies C1 and C3 is not successful, we expect to find that the OBSERVED C-ORDERING matches the PREDICTED C-ORDERING to a degree no better than chance. If we are able to reject the null hypothesis, we should find that the OBSERVED C-ORDERING matches the PREDICTED C-ORDERING to a significant degree and thus provides evidence against the null hypothesis.

## 5.2.2 Methodology

### Corpora

We chose to work with English (however, see section 5.2.6 for a discussion of expanding the study to other languages). As with the corpus study in chapter 2, we used the English Web 2020 (enTenTen20) corpus (43,125,207,462 tokens). This corpus is POS tagged but not dependency parsed. Data was extracted via the Sketch Engine platform (full corpus information available at `sketchengine.eu`). Sketch Engine supports CQL searches via API requests, as well as providing a Word Sketch which includes, relative to a POS and lemma, a frequency count for the whole corpus.

### Data collection

The set of lemmas that we included for testing are given in (5.9). In extracting data, expressions that instantiate these lemmas were also required to be POS tagged as nouns. This included expressions we expected to score high on at least one constraint, plus expressions we expected to score low on all constraints (i.e. canonical count nouns).[11]

(5.9) Set of test noun lemmas:
apple | ball | bean | berry | cabbage | car | chair | dust | equipment | furniture | grape | gravel | jewelry | kitchenware | lentil | sand | pebble | pollen | potato | rice | seed

For our C1- and C3-RELEVANT CONSTRUCTIONS, we selected lemmas that we expect to indicate satisfaction of these perceptual-interactive constraints if used with the relevant noun (e.g., *sprinkling rice* for C1 and *chopping potatoes* for C3). We then group these lemmas into approximate synonymy groups.

(5.10) Groups of C1 indicating lemmas

a. heap | mound | pile
b. cluster | scatter | scattering | shower | sprinkle | sprinkling | smatter | smattering
c. cloud | dusting | mist
d. homogenous | indistinguishable | uniform
e. flake | granule | particle

(5.11) Groups of C3 indicating lemmas

a. chop | cut | dice | slice
b. break | grate | grind | mince | powder
c. divide | halve | quarter
d. fragment | sliver | wedge

To collect the data, we first extracted all sentences in which noun lemmas and the lemmas for C1- and C3-RELEVANT CONSTRUCTIONS occur:

```
<s/> containing ([lemma="noun lemma"&tag="NN|NNS"]) within
(<s/> containing [lemma="Cn indicating lemma list"])
```

This gave us an upper limit for the frequency of co-occurrence of, for instance, *potato* and any expression derived from the C1-indicating lemma list. For *potato*. We then used the spaCy package[12] and the `en_core_web_trf` pipeline to dependency parse these sentences, and using the dependency parsed information, we wrote Python code to find instances of C1- AND C3–RELEVANT CONSTRUCTIONS in the data. See appendix C.

[11]We chose the lemma *jewelry* over *jewellery* due to it's higher occurrence in the corpus.
[12]https://pypi.org/project/spacy/

### 5.2.3 Experiment Design

#### Predicted partial orderings

To derive our predicted partial orderings, on a rational basis we organised the list of nouns into two partial orders, one for C1 and one for C3, and then mapped this to a vector that represents the average rank of this ordering. (This is a method familiar from, for instance, preparing data for statistical tests such as the Mann Whitney-U test.) For example, from the partial order given in (5.12), we can derive the mean rank given in (5.13) as the average of the ranks shared across groups, represented as the vector in (5.14).

(5.12) $$\begin{matrix} n_1 \\ n_2 \end{matrix} > \begin{matrix} n_3 \\ n_4 \\ n_5 \end{matrix} > n_6 > \begin{matrix} n_7 \\ n_8 \end{matrix}$$

(5.13)

| Noun(s) | $n_1, n_2$ | $n_3,$ | $n_6$ | $n_7, n_8$ |
|---|---|---|---|---|
| Rank ranges | $1-2$ | $3-5$ | $6$ | $7-8$ |
| Mean rank | $1.5$ | $4$ | $6$ | $7.5$ |

(5.14) $[1.5, 1.5, 4, 4, 6, 7.5, 7.5]$

Our definitions of C1 and C3 are repeated below:

(C1) **Indistinguishability:** For a core property `P`, objects that instantiate `P` are, perceptually speaking, indistinguishable relative to average human perceptual acuity. By this we mean that they are too small, alike in their perceptual properties or are clustered together in such a way that makes them hard for us to track as individuals.

(C3) **Object splitting:** Objects that instantiate `P` are often used in such a way that requires them to (first) be split apart or broken up.

For C1, the predicted partial order, and the average ranks derived from them are given in Table 5.3. This is based on approximate size of the entities (if anyway small) in the denotation of the relevant noun, and additionally, whether these things are generally perceived as homogenous to the 'naked eye', and found clustered together. So, for instance `dust` and `pollen` are above `bean` and `gravel`, which in turn are above `berry` and `grape`. `jewelry` is low on the order because, although they can be small, items of jewellery are not typically homogenous.

For C3, the predicted partial order, and the average ranks derived from them are given in Table 5.4. We based this primarily on judgements of how often the relevant entities are typically chopped up to be used/eaten,

Table 5.3: Mean rankings over nouns derived from our predicted partial orderings for satisfaction of C1 (Indistinguishability).

| C1 Grouping | dust<br>pollen<br>sand | bean<br>gravel<br>lentil<br>pebble<br>rice<br>seed | berry<br>grape | potato<br>apple | ball<br>car<br>chair<br>cabbage<br>equipment<br>furniture<br>jewelry<br>kitchenware |
|---|---|---|---|---|---|
| Rank ranges | 1-3 | 4-9 | 10-11 | 12-13 | 14-21 |
| Group size | 3 | 6 | 2 | 2 | 8 |
| Mean Rank | 2 | 6.5 | 10.5 | 12.5 | 17.5 |

approximated as a function of size (so `potato` and `cabbage` are above `bean` and `apple`).

These ranks define, for each of C1 and C3, a *21 place vector* that constitutes a prediction about what we should find in the corpus. We use alphabetical order to order the the vector (i.e., *apple*, *ball*, *bean*, ... *rice*, *sand*, *seed*).[13] For C1, this gives us the 21 place vector $[12.5, 17.5, 6.5, ..., 6.5, 2, 6.5]$ and for C3, the 21 place vector $[3, 14, 5, ..., 14, 14, 14]$.

### Test measures

#### Frequency of C-relevant constructions

Taking the case of *potato* as an example, we followed the following process for counting the frequency of C-relevant constructions for each noun.

- Using the *Word Sketch* tool from SketchEngine, for each noun, we calculated the total frequency of that noun in the corpus. To control for polysemy, we then took a random sample of between 100 and 300 sentences containing the relevant noun (100 for nouns not expected to be polysemous and 300 for nouns expected to be polysemous), and manually counted how many of these were instances of the relevant sense. See section C.2 in the appendix for the results of this process. This proportion was used to estimate the number of occurrences of the noun

[13] The ordering of this vector is unimportant as long as it is kept constant across any comparisons. We use the alphabetical order of our noun list as determining the order of our vectors.

Table 5.4: Mean rankings over nouns derived from our predicted partial orderings for satisfaction of C3 (Object splitting).

| C3 Grouping | cabbage<br>potato | apple | bean<br>berry<br>grape | ball<br>car<br>chair<br>dust<br>equipment<br>furniture<br>gravel<br>lentil<br>jewelry<br>kitchenware<br>pebble<br>pollen<br>rice<br>sand<br>seed |
|---|---|---|---|---|
| Rank ranges | 1-2 | 3 | 4-6 | 7-21 |
| Group size | 2 | 1 | 3 | 15 |
| Mean Rank | 1.5 | 3 | 5 | 14 |

in the corpus for the relevant sense. For *potato* this was approximately 650,000 (666,523).

- We only looked at within-sentence examples of C-RELEVANT CONSTRUCTIONS. The CQL query we used is schematised below:[14]

```
<s/> containing ([lemma="noun lemma"&tag="NN|NNS"] within
(<s/> containing [lemma="C_n indicating lemma list"]
```

  This gave us an upper limit for the frequency of co-occurrence of, for instance, *potato* and any expression derived from the C1-indicating lemma list. For *potato* and C1 this was 10,671. This represents of the approx. 650,000 instances of *potato* with the relevant sense, the possible candidates for C1-RELEVANT CONSTRUCTIONS.

- We then took a random sample of 200 sentences from the data collected, and dependency parsed them using the spaCy package[15] and the `en_core_web_trf` pipeline. Using the dependency parsed information, we wrote Python code to find instances of C1-RELEVANT CONSTRUCTIONS in the data. See appendix C. We then manually cleaned the resulting hits to estimate the proportion of the 200 instances that were genuine cases of C1-RELEVANT CONSTRUCTIONS. For *potato*, for instance, this was 31. From this we could estimate the number of instances of genuine cases of C1-RELEVANT CONSTRUCTIONS for each noun. (E.g., for *potato* $(31/200) \times 10,671 = 1654$).

[14] For mass nouns *dust equipment, furniture, gravel, jewelry, kitchenware, pollen, rice, sand* we only extracted sentences containing singular uses, i.e., `tag="NN"`.

[15] https://pypi.org/project/spacy/

- From the total (cleaned and estimated) noun count, we could estimate the probability of genuine cases of C1-RELEVANT CONSTRUCTIONS, given a noun. For *potato*, for instance, this was $(1654/666,523) \approx 0.0025$.

The formal details of this process are given below, where for each noun, we estimate the probability of the noun appearing in a C-RELEVANT CONSTRUCTION. For a set of modifiers that define the C-RELEVANT CONSTRUCTIONS $M$, and for a noun to be tested $N$, we were estimating $Pr(M|N)$. Where $Pr_c$ is a corpus probability and $Pr_s$ is a sample probability. Our sample sizes were 200, where sampling was based upon co-occurrence of the target noun with at least one of the relevant modifiers in a sentence. $Fr$ is a frequency function. $Mod_s(M,N)$ means $M$ modifies $N$ in a sentence in the sample. $Co_s(M,N)$ means $M$ co-occurs with $N$ in a sentence in the sample:

(5.15) Probability of $M$ modifying $N$, given $M$ co-occurs with $N$ in the sample:

$$Pr_s(Mod_s(M,N)|Co_s(M,N)) = \frac{Fr(Mod_s(M,N))}{\textit{sample size}}$$

(5.16) Estimation of frequency of any $M$ modifying $N$ in the corpus. The co-occurrence of $M$ with $N$ in the whole corpus, factored by the probability that $M$ modifies $N$ in the sample:

$$Fr(Mod_c(M,N)) \approx Fr(Co_s(M,N)) \times Pr_s(Mod_s(M,N)|Co_s(M,N))$$

(5.17) Estimated probability of $M$ modifying $N$, given $N$ in the corpus. The estimated frequency of any $M$ modifying $N$ in the corpus as a proportion of total occurrences of $N$:

$$Pr_c(M|N) \approx \frac{Fr(Mod_c(M,N))}{Fr(N)}$$

As with the corpus study in chapter 2, we also wanted to control for the possibility that some nouns appear in fixed collocations that might skew our results. We therefore adjusted $Pr(M|N)$ using an entropy measure based upon how much variation there was in the C1-RELEVANT CONSTRUCTIONS for each noun (see chapter 2 for references regarding the use of information entropy to measure variation).

To do this, we first split the modifiers into rough family resemblance groups as shown in (5.10) and (5.11). Where $Mod_s(G,N)$ means a member of $G$ modifies $N$ in the sample, we can then calculate the probability distribution over modifier groups for the sample, given the distribution of modifiers over nouns in the sample.

(5.18) Probability of a group $G$, given $M$ modifies $N$ in the sample:

$$Pr_s(G|Mod_s(M,N)) = \frac{Fr(Mod_s(G,N))}{Fr(Mod_s(M,N))}$$

From this, it is straightforward to calculate the entropy score for this distribution for each constraint. Where $\mathcal{G}$ is the set of groups of modifiers, our entropy score is the entropy of the distribution of groups that modify the relevant noun:

(5.19) Entropy of $Pr_s(G|Mod_s(M,S))$:

$$\mathbb{H}(Pr_s(G|Mod_s(M,S))) = \\ -\sum_{G\in\mathcal{G}} Pr_s(G|Mod_s(M,S)) \times Ln(Pr_s(G|Mod_s(M,N)))$$

For example, if the counts for groups a.-e. in (5.10) for C1 RELEVANT CONSTRUCTIONS was $[34, 10, 7, 1, 23]$, the probability distribution $Pr_s(G|Mod_s(M, \textit{sand})$ is therefore (with rounded values), $[0.45, 0.13, 0.09, 0.01, 0.31]$, which gives an entropy of $1.269$.

In case a noun featured no C-RELEVANT CONSTRUCTIONS for any groups, this 0-count was substituted with an arbitrarily low value of 0.01. This was done to ensure that we could distinguish between cases where counts included C-RELEVANT CONSTRUCTIONS from only one group, from those where counts included C-RELEVANT CONSTRUCTIONS from no groups. For instance, if a C3 count for groups a.-d. in (5.11) was $[0, 13, 0, 0]$ this would generate and entropy score of 0, and so be indistinguishable from a count of $[0, 0, 0, 0]$ (in which case $Pr_s(G|Mod_s(M,S))$ would be 0). Therefore, such a count would be mapped to $[0.01, 13, 0.01, 0.01]$, which generates an entropy score of $0.019$.

The *Entropy adjusted score*, $\mathbb{S}$, for group $G$, given $M$ modifies $N$, for a constraint is the product of $Pr_s(G|Mod_s(M,S))$ and $\mathbb{H}(Pr_s(G|Mod_s(M,S)))$ multiplied by 100. (We multiplied by 100 in order to avoid computational issues with very small values returning 0 in the next step of the analysis, so are working with percentages, rather than probabilities):

(5.20) Entropy adjusted score for group $G$, given $M$ modifies $N$, for constraint $Cn \in \{C1, C3\}$:

$$\mathbb{E}_{Cn} = 100 \times Pr_s(G|Mod_s(M,N)) \times \mathbb{H}(Pr_s(G|Mod_s(M,S)))$$

In order to be able to compare scores meaningfully between constraints, we then scaled $\mathbb{E}_{Cn}$ values to the range $[0, 1]$ by taking $1$ minus the exponential of $-\mathbb{E}_{Cn}$[16]:

[16]For example, where the first row is $\mathbb{E}_{Cn}$, the second row is $1 - exp(-x)$, i.e. $1 - e^{-x}$:

| $\mathbb{S}_{Cn}$ | 5 | 4 | 3 | 2 | 1 | 0.5 | 0.1 |
|---|---|---|---|---|---|---|---|
| $\mathbb{S}_{Cn}$ | 0.99 | 0.98 | 0.95 | 0.87 | 0.63 | 0.39 | 0.09 |

(5.21) $\mathbb{S}_{Cn\in\{C1,C3\}}(N) = 1 - exp(-\mathbb{E}_{Cn})$
Such that $\mathbb{S}_{C1,C3}(N) \in [0, 1]$

(5.22) $\mathbb{S}_{C2}(N) \in \{0, 1\}$

### 5.2.4 Statistical Analysis

Recall that our predictions for C1 and C3 can be represented as two 21-place vectors (ordered corresponding to the alphabetical order of our noun list). Our results will provide us also with two orderings, one for each of C1 and C2, derived from the $\mathbb{S}_{C1}$ and $\mathbb{S}_{C2}$ scores. These each also define a 21-place vector (relative to the alphabetical order of our noun list). So, for C1, we will have two 21-place vectors to compare, a predicted vector and an observed/measured one, and likewise for C3.

For each of C1 and C3, we can then measure the similarity of the predicted and measured vectors, and then calculate the probability that the measured vector would be at least as similar to the predicted vector as a matter of chance. If this probability is sufficiently low, relative to a confidence interval, then we have evidence to reject the null hypothesis.

The metric for assessing vector similarity that we will use is widely used in corpus approaches to lexical semantics (vector space semantics, see e.g., Baroni & Zamparelli 2010), namely *Cosine Similarity*. For small vectors, we would be able to calculate the probability that this similarity was obtained by chance. To give a toy example, suppose that we have the following two vectors Predicted and Measured:

(5.23) a. $P_{toy} = [1, 2, 3]$
b. $M_{toy} = [1.5, 3, 1.5]$

The cosine similarity between them, $CosSim([1, 2, 3], [1.5, 3, 1.5])$ is approximately $0.127$ (where perfect similarity is 0). Since there are three possible permutations of $M_{toy}$, including itself, namely, $[1.5, 3, 1.5]$, $[1.5, 1.5, 3]$, and $[3, 1.5, 1.5]$, we can also calculate the cosine similarity between $[1, 2, 3]$ and each permutation ($S_C([1, 2, 3], [1.5, 1.5, 3]) = 0.018$; $S_C([1, 2, 3], [3, 1.5, 1.5]) = 0.236$. From this, we can calculate the probability that, as a matter of chance, we would have got a measured vector that was at least as similar to $P_{toy}$ as $M_{toy}$ is. Since $0.127$ is only lower than one of the other permutations, then getting a closeness at least this small would occur 2 in 3 times by chance, or

In other words, if the entropy weighted probability of a noun being modified in the relevant way is $0.05$ (5%), then the $\mathbb{S}_{Cn}$ score is $0.99$. If the entropy weighted probability of a noun being modified in the relevant way is $0.001$ (0.1%), then the $\mathbb{S}_{Cn}$ score is $0.09$

approximately 0.66. In other words, for our toy example, the result is not significant. We easily could have got results a good as those between $P_{toy}$ and $M_{toy}$ by chance.

We cannot, however, follow the same procedure for vectors of length 21. With a vector of length 21 (where any of ranks 1 to 21 is a possible value), there would be $21!$ ($> 5 \times 10^{19}$) possible permutations, too many to calculate the probabilities directly. Therefore instead of directly calculating the probabilities, we employ a Monte Carlo method to estimate them. Monte Carlo simulations are not widely used in more traditional corpus linguistics, but see e.g., Inohara & Ueno 2023.[17] They are however a common tool in computer science, and have been used in probabilistic pragmatics models. See e.g., Bernardy et al. 2018; Emerson 2020; Fricke et al. 2023; Lassiter & Goodman 2015 for uses of Markov Chain Monte Carlo simulations in such applications.

Monte Carlo simulations run over two loops, an 'outer' loop and an 'inner' loop. The inner loop uses pseudo-randomisation to generate the value of a variable. To take a simple case, suppose we want to know the probability that a fair die (a die where each face has an equal probability of landing when rolled) lands even, we can do this by generating $n$ random integers between 1 and 6 and then counting the $i$ times that this is 2, 4 or 6. This loop then outputs $i/n$, the approximate probability that our simulated die lands even, The outer loop then iterates this process $m$ times, and the outputs for each run can be aggregated. With high enough values for $n$ and $m$ the model will then converge on the actual probability, which, in this case, we know to be 0.5.

In our simulations, the inner loop samples $n$ random permutations of our predicted vector $P$ and then calculates the cosine similarity between this and the predicted vector, $P$. We then count the number of $i$ times this is lees than or equal to $CosSim(P, M)$. Each inner loop run returns a value $i/n$ The outer loop repeats the inner loop $m$ times. See Appendix C.1.2.

This set-up of the model requires some discussion. Instead of permuting either a total rank vector of $[1, 2, ..., 21]$ or permuting the measured rank $M$, we chose to permute the predicted vector $P$. Permuting a total rank of 1-21 would approximate the probability that $M$ and $P$ are as close as they are given no assumptions about any structure in either $M$ or $P$ (i.e., that in neither the measured or predicted rankings are there any properties with shared rank positions). Given that our measured vectors will return fine-grained values, permuting $M$ would also likely give the same approximated probability as

[17] That said, Monte Carlo methods underpin a class of linear regression models, and linear regression models are widely used in corpus linguistics.

permuting $[1, ..., 21]$ (as indeed turned our to be the case for C1, see (5.25) below). However, our predicted rankings are more coarse grained, especially for C3 which has a long flat tail (many properties assigned rank 14, see (5.4)). If we ignore this, then we would be assuming more randomisation is possible in our sample of nouns than there actually is. I.e., we did not randomly pick our list of nouns for this trial study, and so we cannot safely assume that the predicted rankings we derived have the structure they have as a matter of chance. Now, given that there are more ways to randomly permute vectors where each position on the vector has a unique value (e.g., a ranking from 1-21), than there are if this vector has many values with the same mean rank[18], we can be sure that the probability we estimate with this model will be higher if we permute $P$, given that our predicted rankings $P$ for C1 and C3 have many values with the same mean rank. In other words, we are not giving ourselves the advantage of assuming that our noun sample was random. That is to say, the probability we calculate via our Monte Carlo models will be higher by permuting $M$ than it would be if we permuted $P$ or $[1, 2, ..., 21]$, and so if we find a significant result by permuting $M$, we can be sure it would also be significant even if our sample of nouns were a representative sample of those in the corpus.

### 5.2.5 Results

#### Scores for each perceptual-interactive constraint

The scores for each perceptual-interactive constraints are provided in Table 5.5. For C1, small homogeneous granular denoting properties score the highest, with properties underpinning canonical count nouns and *functionally combinatorial* nouns (with heterogeneous entities in their denotations) scoring low. For C2, scores of 0 or 1 were assigned on a rational basis. For C3, promisingly, properties that denote entities that are frequently cut up score highly, with all other properties scoring low.

#### Predicted and measured vectors

The measure rankings from our C1 and C3 scores are given below along as vectors as well as a reiteration of predicted vectors (recall, vectors are ordered alphabetically where the first position is for `apple` and the last is for `seed`).

[18] For instance, for a vector of length 3, the number of possible permutations decreases with the number of shared mean rank values.: $[1, 2, 3]$ has 6 possible permutations (including itself), $[1, 2.5, 2.5]$ and $[1.5, 1.5, 3]$ each have 3 and $[2, 2, 2]$ has only 1 (itself).

| Property | $\mathbb{S}_{C1}$ | Property | $\mathbb{S}_{C2}$ | Property | $\mathbb{S}_{C3}$ |
|---|---|---|---|---|---|
| dust | 0.998 | equipment | 1 | potato | 0.917 |
| sand | 0.799 | furniture | 1 | cabbage | 0.811 |
| pollen | 0.660 | jewelry | 1 | bean | 0.715 |
| pebble | 0.503 | kitchenware | 1 | apple | 0.585 |
| gravel | 0.450 | apple | 0 | berry | 0.224 |
| rice | 0.312 | ball | 0 | pebble | 0.170 |
| seed | 0.276 | bean | 0 | grape | 0.134 |
| berry | 0.232 | berry | 0 | ball | 0.068 |
| potato | 0.180 | car | 0 | pollen | 0.066 |
| cabbage | 0.103 | cabbage | 0 | chair | 0.050 |
| bean | 0.101 | chair | 0 | kitchenware | 0.026 |
| apple | 0.084 | dust | 0 | sand | 0.020 |
| grape | 0.083 | grape | 0 | car | 0.018 |
| lentil | 0.079 | gravel | 0 | lentil | 0.007 |
| furniture | 0.065 | lentil | 0 | rice | 0.006 |
| ball | 0.041 | pebble | 0 | seed | 0.005 |
| chair | 0.038 | pollen | 0 | furniture | 0.002 |
| kitchenware | 0.018 | potato | 0 | dust | 0.000 |
| jewelry | 0.012 | rice | 0 | equipment | 0.000 |
| equipment | 0.011 | sand | 0 | gravel | 0.000 |
| car | 0.007 | seed | 0 | jewelry | 0.000 |

Table 5.5: Entropy adjusted scores for perceptual-interactive constraints. Scores for C1 and C3 derived from the EnTenTen20 corpus. C2 scores assigned on a rational basis. Properties ordered from high to low for each score.

(5.24) Predicted and measured vectors for C3: $P_{C3}$ and $M_{C3}$:

$$P_{C3} = [\,3 \quad 14 \quad 5 \quad 5 \quad 1.5 \quad 14 \quad 14 \quad 14 \quad 14 \quad 14 \quad 5 \quad 14 \quad 14 \quad 14 \quad 14 \quad 14 \quad 14 \quad 1.5 \quad 14 \quad 14 \quad 14\,]$$

$$M_{C3} = [\,4 \quad 8 \quad 3 \quad 5 \quad 2 \quad 13 \quad 10 \quad 19.5 \quad 19.5 \quad 17 \quad 7 \quad 19.5 \quad 19.5 \quad 11 \quad 14 \quad 6 \quad 9 \quad 1 \quad 15 \quad 12 \quad 16\,]$$

(5.25) Predicted and measured vectors for C1: $P_{C1}$ and $M_{C1}$:

$$P_{C1} = [\,12.5, 17.5, 6.5, 10.5, 17.5, 17.5, 17.5, 2, 17.5, 17.5, 10.5, 6.5, 17.5, 17.5, 6.5, 6.5, 2, 12.5, 6.5, 2, 6.5\,]$$

$$M_{C1} = [\,12, 16, 11, 8, 10, 21, 17, 1, 20, 15, 13, 5, 19, 18, 14, 4, 3, 9, 6, 2, 7\,]$$

The cosine distances between the predicted and observed vectors for C1 and C3 were as follows:

| | |
|---|---|
| Cosine distance between predicted and observed vectors for C1: | 0.03021 |
| Cosine distance between predicted and observed vectors for C3: | 0.04637 |

### Results of the Monte Carlo model

We found that in pretesting the model, due to the larger number of shared mean ranks and the long tail in the predicted vector for C3, we could run fewer inner loop iterations for C3 (the number of iterations was chosen to avoid any loop returning no hits):

(5.26)

| | Inner loop iterations (n) | Outer loop iterations (m) |
|---|---|---|
| C1 | $5,000,000$ | $300$ |
| C3 | $10,000$ | $300$ |

So for C1, for instance, we sampled 5,000,000 random permutations of the predicted vector $P_{C1}$ and calculated the probability that this cosine distance was at least as small as 0.03021. This process was repeated 300 times. The results are given in Table 5.6.

The mean probability that the predicted and measured vectors were as close as they were by chance, $\overline{d}$, is calculated as in (5.27). For each run of the outer loop $r_1, ..., r_m$, we have a number of hits, $h_1, ...h_m$ in which the cosine similarity between the random permutation of the measured vector and the predicted vector was less than or equal to $0.03021$ for C1 and $0.04637$ for C3. This means that $r_i/n$ is the probability that at least as similar a cosine distance was achieved by randomly permuting the measured vector. The sum of these probabilities over $m$ gives us the desired mean probability:

(5.27) $$\overline{d} = \frac{\sum_{i \in [0,m]} h_i/n}{m}$$

The confidence interval for a $z$ value of $\approx 2.5758$ (for a 99% confidence interval), can be calculated in the normal way (where $\sigma_d$ is the standard deviation for the distribution formed of the different values for $h_i/n$:

(5.28) $$CI = \overline{d} \pm z.\frac{\sigma_d}{\sqrt{m}}$$

For C1, the mean probability that our predicted and measured vectors were as close as they were by chance was $< 0.00001$ $(0.00000269)$, $\sigma = 0.00000072$, $99\% CI[0.00000259, 0.00000288]$.

For C3, the mean probability that our predicted and measured vectors were as close as they were by chance this was $< 0.01$ $(0.00127)$, $\sigma = 0.000348$, $99\% CI[0.00122, 0.00133]$.

Table 5.6: Results for Monte Carlo Simulations for C1 and C3. *Hits per run* is the number of times per $n$ samples that the sample had at least as close a cosine distance to that between our predicted and observed rankings. *Frequency* is the number of times across the $m$ repeats of this process.

(a) Results for Monte Carlo Simulations for C1: $n = 5,000,000$, $m = 300$.

| Hits per run (hits/$n$) | Frequency |
|---|---|
| 4 ($8e^{-7}$) | 1 |
| 6 ($1.2e^{-6}$) | 3 |
| 7 ($1.4e^{-6}$) | 8 |
| 8 ($1.6e^{-6}$) | 16 |
| 9 ($1.8e^{-6}$) | 13 |
| 10 ($2e^{-6}$) | 21 |
| 11 ($2.4e^{-6}$) | 29 |
| 12 ($2.6e^{-6}$) | 34 |
| 13 ($2.6e^{-6}$) | 33 |
| 14 ($2.6e^{-6}$) | 31 |
| 15 ($2.6e^{-6}$) | 23 |
| 16 ($2.8e^{-6}$) | 18 |
| 17 ($3.0e^{-6}$) | 29 |
| 18 ($3.2e^{-6}$) | 14 |
| 19 ($3.4e^{-6}$) | 13 |
| 20 ($3.6e^{-6}$) | 7 |
| 21 ($4.0e^{-6}$) | 3 |
| 22 ($4.2e^{-6}$) | 3 |
| 23 ($4.4e^{-6}$) | 1 |
| | 300 |

(b) Results for Monte Carlo Simulations for C1: $n = 10,000$, $m = 300$.

| Hits per run (hits/$n$) | Frequency |
|---|---|
| 5 ($5e^{-4}$) | 5 |
| 6 ($6e^{-4}$) | 6 |
| 7 ($7e^{-4}$) | 8 |
| 8 ($8e^{-4}$) | 15 |
| 9 ($9e^{-4}$) | 20 |
| 10 ($1e^{-3}$) | 23 |
| 11 ($1.1e^{-3}$) | 31 |
| 12 ($1.2e^{-3}$) | 36 |
| 13 ($1.3e^{-3}$) | 31 |
| 14 ($1.4e^{-3}$) | 38 |
| 15 ($1.5e^{-3}$) | 23 |
| 16 ($1.6e^{-3}$) | 24 |
| 17 ($1.7e^{-3}$) | 17 |
| 18 ($1.8e^{-3}$) | 10 |
| 19 ($1.9e^{-3}$) | 2 |
| 20 ($2e^{-3}$) | 4 |
| 21 ($2.1e^{-3}$) | 5 |
| 22 ($2.2e^{-3}$) | 1 |
| 25 ($2.5e^{-3}$) | 1 |
| | 300 |

### 5.2.6 Discussion

The goal of this study was to evaluate the viability of using corpus methods in order to estimate the extent to which core properties such as `cabbage` and `rice` satisfy our perceptual-interactive constraints C1 and C3. In this regard, the study is successful. We took 21 such properties and looked at the distributions of the nouns that lexicalize them in a large English corpus with regard to C-RELEVANT CONSTRUCTIONS that we hypothesised to be indicative of either *indistinguishability* (C1) or *object splitting* (C3). For instance, *heap/mound/pile of N* for C1. We assigned on a rational basis the extent we would expect the relevant properties to satisfy our perceptual-interactive constraints based on the typical size of the objects that instantiate them (C1), how often we split them up in order to use them (C3). We then evaluated whether the distributions of the relevant nouns in the corpus with respect to the C-RELEVANT CONSTRUCTIONS reflected these rational classifications. For both C1 and C3 the results were highly encouraging, especially for C1.

We have provided the basis for extending such a study to other corpora and to other languages. In future work, we anticipate such extensions to be necessary in order to rule out either corpus-specific or language specific effects. For instance, outliers for our C1 results include `lentil` and `bean`. Based on the size of lentils and beans, we expected `lentil` and `bean` to score substantially higher than, for example, `apple`, `cabbage`, and `potato`, but they did not. One possible reason for this is that we are seeing an effect of countability class, namely, we think it is possible that our scores for `lentil` and `bean` might be artificially deflated as a result of *lentil* and *bean* being count in English.

We have also provided an exploratory investigation into a more moderate form of the distributional hypothesis. We have not assumed that the meaning of an expression can be reduced to distribution (i.e., a strong interpretation of Firth's dictum *you shall know a word by the company it keeps*). However, the way we talk about entities in the extensions of common nouns, and how we describe interacting with them can give us at least some insights into the way in which we conceptualise those entities. Specifically, we have proposed that distributional properties of nouns can provide some, but not all of the explanation for why some core properties display variation in their count/mass lexicalization patterns.

## 5.3 Predicting count/mass variation: A weighted scoring model

In this section, we present the results of an innovative and exploratory methodology for generating predictions regarding count/mass variation, which takes as input the results of the previous corpus study. Namely, we hypothesise that we can estimate an ordering on such properties from most to least likely to be lexicalized as mass cross-linguistically, based on whether a property satisfies C1-C3 (and to what degree).

Our model takes, as input, the output from the previous study, namely the C1 and C3 scores for each core property, along with our rationally assigned C2 scores. Parameters of the model are a set of weights which set how much of an effect each perceptual-interactive constraint has. The model outputs an ordering that reflects propensity for mass lexicalization for that core property.

Of course the parameters (the weights on C1-C3) could be set in any way, and so our hypotheses regarding the model concerns how these weights are set. We hypothesise that C1 should be weighted above C3, and C3 should be weighted above C2, and then evaluate the model based upon whether it predicts observed patterns regarding propensity for mass lexicalization in the literature. For instance, that properties like `dust` and `pollen` should be rated above properties like `bean` and `potato`, which in turn should be rated above properties like `furniture` and `jewellery`, which, again, in turn, should be rated above properties such as `ball` and `chair`. In discussing the results of this model, we propose that it forms the basis for a sufficiently constrained theory of variation in count/mass lexicalization patterns.

### 5.3.1 Assumptions, Hypotheses and the Model

**Assumption: Propensity for count/mass variation.** Based upon our own previous investigations, as well as numerous observations in the literature, we assume that there is an ordering on how likely it is for a core property to be lexicalized as count or mass across and within languages. This ordering still requires more extensive empirical work, but we assume we can already make certain broad-stroke generalisations. For instance that properties such as `dust`, `pollen`, and `sand` are always (to our knowledge) lexicalized as mass in number marking languages, and properties such as `ball`, `car`, and `chair` never are. Between these poles, we find different degrees of variation, with granular properties like `rice` and `lentil` having a high propensity for mass lexicalization, and properties such as `furniture` and `kitchenware` a lower propensity for mass lexicalization than granular nouns. Between these, we find properties like `bean`, `berry`, `cabbage`, and `potato`.

**Success criteria.** Given that we input into the model the results of our previous corpus study, the model is based upon one monolingual corpus of English. However, even given this sample, we hypothesise that we can extract an ordering on properties from most stably count to most stably mass, with properties undergoing mass/count variation in between. For example, a successful outcome of the model would yield the properties `car`, `chair`, and `ball` at one end, and the properties `dust`, `pollen` and `sand` at the other. We would also want properties such as `equipment`, `furniture` and `kitchenware` not to be very high, given that the distribution of mass lexicalizations of these properties is lower than that for e.g., mass granular nouns. For instance, there are languages that have been claimed to have no, or very few, object mass nouns (e.g. Greek (Tsoulas, 2006) and Finnish), but no number marking languages have been claimed to lack mass granular nouns (i.e., mass granular nouns are attested in all number marking languages, to the best of our knowledge).

These success criteria are summarised in (5.29):

(5.29) Success criteria for the model

a. Scores for `dust`, `pollen` and `sand` should be higher than all others:
`dust`/`pollen`/`sand` > ...

b. Scores for `car`, `chair`, and `ball` should be lower than all others:
... > `car`/`chair`/`ball`.

c. Scores for properties underpinning *functionally combinatorial* nouns should be low (but above those of `car`, `chair`, and `ball`):
`furniture`/`kitchenware`/`jewelry`/`equipment` > `car`/`chair`/`ball`.

d. Scores for other properties (e.g., `bean`, `cabbage`, `rice`, and `seed`) should be between those in a. and c:
`dust`/`pollen`/`sand` > `bean`/`cabbage`/`rice`/`seed` >
`furniture`/`kitchenware`/`jewelry`/`equipment`

**Hypotheses.** For each noun, the model outputs a score based upon the C1, C2, and C3 scores, and a weighting on C1-C3 (that is kept constant across all nouns). Our main hypotheses concern these weightings. First, the null hypothesis:

(5.30) Null Hypothesis: There are no values for $\omega_{C1}$–$\omega_{C3}$ that return scores that fulfil the success criteria.

The null hypothesis is admittedly fairly weak. To this, we add a positive hypothesis regarding an ordering of weightings over constraints:

(5.31) Ordering hypothesis: The ordering of $\omega_{C1}$–$\omega_{C3}$ values that return successful outcomes according to (5.29) will be: $\omega_{C1} > \omega_{C3} > \omega_{C2}$

To elaborate on this hypothesis, we believe that perceptual information (related to the relative size and discreteness of individuals that instantiate a given property) will tend to trump all when it comes to being a predictor of mass lexicalization. For instance, if for some N, the score $\mathbb{S}_{C1}(N)$ is high, based on the corpus modification occurrences, this should strongly predict that the property underpinning N always or at least highly probably will be lexicalized as mass crosslinguistically. Second, as indicated in our above discussion of C3, interacting with whole entities, including with parts of them after their integrity has been compromised, is something that we do on daily basis, and belongs to our earliest experiences with the world. For this reason, we think C3 will have to be weighted above C2, albeit below C1. The constraint C2 is the most abstract. It concerns entities being used together in relation to typical eventualities associated with properties. For this reason, we predict a low weighting for constraint C2.

**Model.** The weighted mean model is then a simple weighted sum of the scores for all constraints. Where weights $\omega_{C1}$, $\omega_{C2}$, $\omega_{C3}$ sum to 1:

(5.32) $\mathbb{S}(N) = \sum_{Cn \in \{C1,C2,C3\}} \omega_{Cn} \times \mathbb{S}_{Cn}(N)$

The code for the model can be found at `https://github.com/peter-sutton/objects-countability`, along with a python script in which one can check the output of the model given any set of weightings over the constraints.

### 5.3.2 Results: Runs of the model

Here we present the results from running the model with different parameter settings. First, as expected, if all constraints are weighted equally, we do not get a successful run. Properties like `chair` and `car` are ranked low, which is desired, however properties underpinning *functionally combinatorial* nouns are ranked too highly and granular properties are ranked too low.

(5.33) Ordering of scores with equally weighted constraints.
$\omega_{C1}, \omega_{C2}, \omega_{C3} = 0.33$:

potato > furniture > kitchenware > {equipment, jewelry} > dust > cabbage > {bean, sand} > pollen > pebble > apple > berry > gravel > rice > seed > grape > ball > chair > lentil > car

However, as we start to weigh C1 over C3 and C3 over C2, successful runs of the model start to emerge. With the weightings given in (5.34), we are close to meeting the success criteria, but properties such as `lentil` are ranked too low and properties such as `apple` and `potato` are ranked too high.

(5.34) Ordering of scores weighted where C1 has twice the weight of C3 and C3 has twice the weight of C2.
$\omega_{C1} = 0.57$, $\omega_{C2} = 0.14$, $\omega_{C3} = 0.29$:

dust > sand > pollen > potato > pebble > cabbage > bean > gravel > apple > berry > rice > furniture > {kitchenware, seed} > jewelry > equipment > grape > lentil > ball > chair > car

The most successful runs of the model were achieved with far heavier weightings where C1 is weighted 8-9 times that of C3, and where C3 is weighted twice that of C2:

(5.35) Ordering of scores weighted where C1 has 8-9 the weight of C3 and C3 has twice the weight of C2.
$\omega_{C1} = 0.85$, $\omega_{C2} = 0.05$, $\omega_{C3} = 0.1$:

`dust` > `sand` > `pollen` > `pebble` > `gravel` > `rice` > `potato` > `seed` > `berry` > `cabbage` > `bean` > `apple` > `furniture` > `grape` > `lentil` > `kitchenware` > {`jewelry`, `equipment`} > `ball` > `chair` > `car`

The numerical results for this run are given in figure 5.1. These results suggest that we have reason to reject the null hypothesis and confirm the ordering hypothesis. First, there are orderings of weights where $\omega_{C1} > \omega_{C3} > \omega_{C2}$ that result in successful runs. Second, as we see from the ordering resulting in equally balanced weightings in (5.33), the outcome is no longer a successful run.

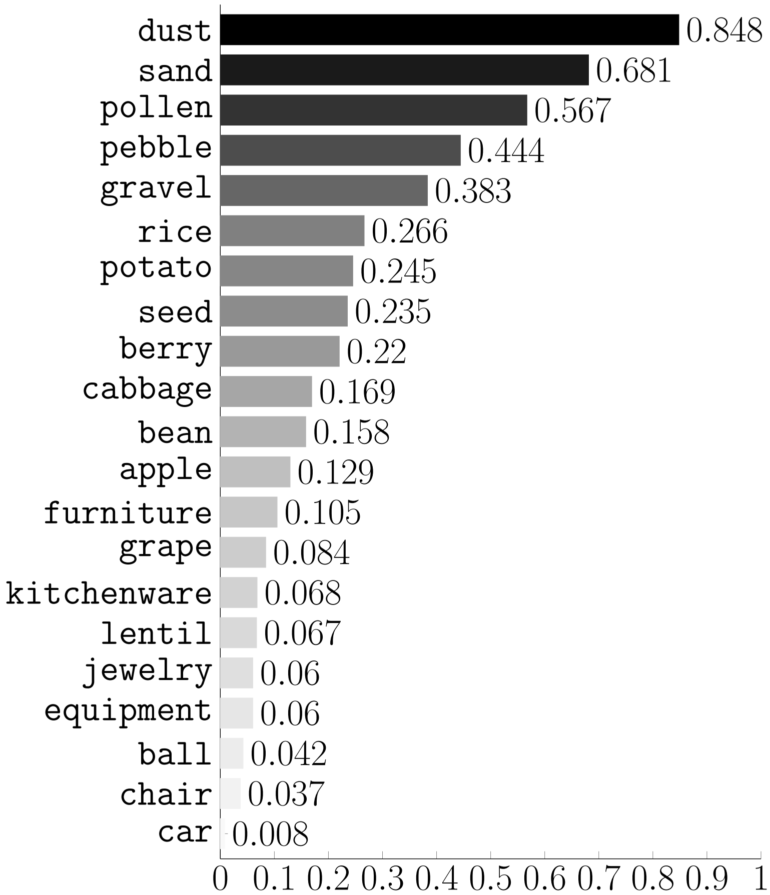
### 5.3.3 Discussion

Our weighted scoring model based on our perceptual-interactive constraints gives us some further reason to believe that the strongest predictor of mass lexicalization are perceptual properties of objects that instantiate the relevant properties, namely, how indistinguishable they are, as captured by C1. However, we were surprised regarding how dominant this effect is. Indeed, as can be seen from the C1 scores in Table 5.5, using C1 alone partly achieves our success criteria: properties denoting small granular entities like `dust` are rated highly, and properties underpinning canonical count nouns are rated low. What C1 scores alone do not manage to do is distinguish sufficiently between properties underpinning canonical count nouns and properties underpinning *functionally combinatorial* nouns. For this reason, it seems that we need the scores from our other constraints to get a more accurate picture.

That said, this pilot study requires follow up work in at least three respects. First, we ran this only on the basis of C1 and C3 scores derived from one English corpus, albeit a large one, and so replication studies using other English corpora as well as corpora from other languages should be undertaken to ensure that these results are not an artefact of the corpus we selected.

Second, our success criteria were based on data from relatively few languages. In order to have more confidence that our three perceptual-interactive constraints provide enough granularity to model the count/mass lexicalization

Figure 5.1: Results for a run of the model where C1 has 8-9 the weight of C3 and C3 has twice the weight of C2: $\omega_{C1} = 0.85$, $\omega_{C2} = 0.05$, $\omega_{C3} = 0.1$:




patterns of object-instantiated properties, a large scale crosslinguistic study should be undertaken to estimate the actual likelihood of object-instantiated properties being lexicalized as mass across languages, and then to see if the same weightings of scores taken from different corpora can approximate these values. If so, then this would be evidence that our three perceptual-interactive constraints genuinely do contribute to count/mass lexicalization patterns. If not, this would indicate that our model is at best incomplete.

Third, the allocation of C2, collective uses of instruments, scores on a rational and categorical basis, is non-optimal. We are sceptical that text corpus methods are apt for measuring whether a property satisfies C2, but there are other empirical means of estimating this. For *functionally combinatorial* nouns, truth value judgement experiments may be a more fruitful avenue. For instance, for *furniture* vs. *chairs*, we could collect true/false judgements from native speakers for test sentences such as the following:

(5.36) a. Furniture can be used jointly/collectively/together to furnish a space.
b. Chairs can be used jointly/collectively/together to seat a person.

Taking a step back from the specifics of the results, although we have taken only the first steps towards a deeper empirically grounded understanding of count/mass variation, these first steps are nonetheless important. The data concerning variation in count/mass lexicalization patterns is at first blush messy and chaotic. However, we suspected that there was indeed systematicity, albeit complex, in the data. The corpus study presented in this chapter, along with our weighted scoring model, go some way towards finding order in the chaos. Namely, there may be a number of factors that affect whether or not an object-instantiated property is ever lexicalized as mass, and if so, how frequently. Via our three perceptual-interactive constrains C1–C3, we endeavoured to identify three such factors. Our weighted scoring model furthermore provides some evidence that each of these factors is indeed relevant and a means of estimating the degrees to which properties satisfy two of these constraints. So, although fairly modest, this model makes progress in understanding the puzzling phenomenon of variation in count/mass lexicalization patterns and also helps more clearly define the next steps to be taken in an empirically grounded research programme for furthering this understanding.

### A sufficiently constrained theory

Our perceptual-interactive constraints C1–C3 predict where we should expect to find variation in count/mass lexicalization patterns: namely, (1) only for properties that are instantiated by objects, and (2) of these properties, only for those that satisfy at least one of C1–C3. Our account furthermore clarifies the relative contributions of perceptual and interactional factors in determining the likelihood of a property to be lexicalized as mass. In other words, our theory of count/mass lexicalization patterns is constrained in the right kind of way. To clarify what we mean by this, Chierchia (2015, p. 158) observes that “no known language that has some manifestation of the [count/mass] contrast is indifferent to the object/substance dichotomy, in the sense that it doesn’t care how its basic nouns are lexicalized” and that many theories (including his own earlier proposal in Chierchia (1998a) and the theories of Rothstein (2010) and Landman (2011)) problematically do “allow this type of interpretive freedom”.

Importantly, our object-centred contextualism does not suffer from this problem. We took the count/mass variation data as a centre-point for our theory in which objects play a central role. Recall that, our finely tuned understanding of *object* goes beyond that of ‘Spelke objects’ or Quinean objects and includes e.g., entities that united via their combined function (e.g., a saucepan and lid) and entities that do not move independently of others (e.g., an apartment in a block). We then proposed a package of perceptual-interactive constraints and used them to model comparatively how likely it is for an object-instantiated property to be lexicalized as mass. To our knowledge, the theory provided here is the most systematic attempt to handle the problem of constraining predictions regarding variation in count/mass lexicalization patterns allowing, of course, for the possibility that our system of perceptual-interactive constraints may have to be finessed.

## 5.4 Summary

Object-centred contextualism is the theory that the variation we find in count/mass lexicalization patterns is constrained to properties that (a) are instantiated by *objects* (in the specific sense that we have defined) and (b) that also display at least one of our three perceptual-interactive constraints *indistinguishability* C1, *collective fulfilment of a function* C2 and *object splitting* C3. Grammatical counting, on this view, is facilitated by context-indexed, object-centred quantizing functions. Sets of objects relative to a property are not always quantized and so we need these functions to operate on basic properties inside the lexicon to derive something grammatically countable. In this chapter, we have argued that non-countability arises as a result of the lexicalization of object-instantiated properties which are at least in part a result of the extent to which that core property satisfies at least one of the constraints C1–C3: satisfying any of these constraints licenses an object-neutral lexicalization of that property (modelled as the application of an object-neutral function), which amounts to lexicalization as a mass noun.

Furthermore, we have uncovered evidence for the efficacy of certain factors in predicting whether an object-instantiated property will be lexicalized as mass. Although we hypothesised that C1, indistinguishability, would be the most important factor, the results of our corpus study suggest the perhaps surprising result of just how important the size and homogeneity of objects that instantiate properties are in this regard.

# Chapter 6

# Extending the analysis

This volume has so far focused almost exclusively on variation in count/mass lexicalization patterns and the grammatical reflexes (canonical and non-canonical) of countability in number marking languages and, within these languages, only for concrete nouns that denote physical entities or stuff. These choices were justified. First, since we wished to investigate count/mass variation, number marking languages are the obvious choice since they tend to have clear grammatical reflexes of countability distinctions. Second, concentrating on concrete nouns made sense, in light of our main empirical observations. We observed a non-coincidental connection between whether a core property exhibits variation in its count/mass lexicalization patterns and whether nouns that lexicalize that property have non-canonical reflexes of countability. The most predominant of these non-canonical reflexes was for mass nouns and whether they are felicitous with stubbornly distributive predicates such as *round* and *small* which tend to quantify over objects.

In this chapter, we briefly overview extensions to our object-centred contextualist approach both to some languages that are not number-marking (Mandarin and Yudja), and to at least a subset of abstract nouns, namely those that denote propositions/informational entities (e.g., *information*). Indeed, a number of abstract nouns are polysemous between propositional and eventuality denoting senses e.g., *belief*, and *statement*, and we also provide an analysis of the eventuality-denoting senses of these nouns and the restrictions thereupon.

## 6.1 Beyond number marking languages

So far, our investigations into crosslinguistic variation relating to countability have been restricted in focus to whether core properties are *lexicalized* *as count or mass* across and within languages. However as mentioned in chapter 2, apart from variation in count/mass lexicalization patterns we also explore *morphosyntactic variation* in the grammatical reflexes of countability. Whereas lexicalization pattern variation relates to variation in the lexicalization of core properties as count or mass nouns across and within languages, morphosyntactic variation relates to variation in the morphosyntactic generalisations associated with the reflexes of the count and mass categories in the grammars of different languages. In number marking languages that also have a fully-developed article system like English or German, for instance, only mass nouns can be used without articles, 'bare', in argument positions. This is not the case in article-less languages, such as Finnish, and most Slavic languages, where both mass and count nouns freely occur 'bare' in argument positions.

We now extend our account of numeral constructions to two languages with very different morphosyntactic reflexes of countability to those of number-marking languages such as English: an obligatory classifier language, Mandarin, and a 'free numeral' language, Yudja.

### 6.1.1 Obligatory classifier languages: Mandarin

Moving beyond number marking languages, there is variation even when it comes to the 'signature property' of countability (Chierchia, 2010), namely straightforward compatibility with numeral constructions. As has been long observed, classifiers are obligatory in numeral constructions in Mandarin. This means that, prima facie, whether or not a noun requires an intervening classifier in numeral expressions cannot be used as a countability test. Classifiers in Mandarin fall into at least two classes: *count classifiers* and *massifiers* (Cheng & Sybesma, 1999). On a rough approximation, count classifiers are used for counting and massifiers are used for measuring (however, see Rothstein 2017 on why this is at best a rough approximation).

#### Three analyses of numeral constructions in Mandarin

The obligatory use of an intervening classifier in numeral constructions is widely held to be derived not from the features of the core property that underpins the interpretation of the noun, but rather from the semantic types of numerals and common nouns in obligatory classifier languages (see, e.g., Chierchia 2010, 2015; Krifka 1995).

A standard type-based analysis for English numeral constructions is given in (6.1). Common nouns express properties of type $\langle s, \langle e, t \rangle\rangle$, and numeral expressions have adjectival readings.[1]

(6.1) a. $[\![\text{two apples}]\!] : \langle s, \langle e, t\rangle\rangle = [\![\text{two}]\!]([\![\text{apples}]\!])$
b. $[\![\text{two}]\!] : \langle\langle s, \langle e, t\rangle\rangle, \langle s, \langle e, t\rangle\rangle\rangle$
c. $[\![\text{apples}]\!] : \langle s, \langle e, t\rangle\rangle$

There is less consensus for how to analyse Mandarin numeral constructions in terms of types. We do not wish to enter this debate here, but there are three main options. For each, we take as our running example the numeral construction in (6.2).

(6.2) san zhi mao
three CL cat
'three cats'

All three analyses treat Mandarin common nouns as denoting kinds, which, in order to skate over theoretical difference, we treat as entities of type $\kappa$.[2] All also assume that numeral constructions are interpreted as properties (of type $\langle s, \langle e, t\rangle\rangle$). The differences lie in the typing of numeral expressions and classifiers.

**Classifiers are for type shifting nouns:** This analysis, proposed somewhat tentatively in Chierchia 1998a, treats numerals in Mandarin just as they are in English. Since nouns denote kinds, classifiers are needed to shift the interpretation of the noun into a property. The composition of (6.2) is given, schematically in (6.3).

(6.3) a. $[\![\text{san zhi mao}]\!] : \langle s, \langle e, t\rangle\rangle = [\![\text{san}]\!]([\![\text{zhi}]\!]([\![\text{mao}]\!]))$
b. $[\![\text{san}]\!] : \langle\langle s, \langle e, t\rangle\rangle, \langle s, \langle e, t\rangle\rangle\rangle$
c. $[\![\text{zhi}]\!] : \langle \kappa, \langle s, \langle e, t\rangle\rangle\rangle$
d. $[\![\text{mao}]\!] : \kappa$

**Classifiers are for type shifting numerals:** Alternatively, as outlined in Krifka 1995, we can locate the obligatory requirement for classifiers in the numeral. On this view, numerals in Mandarin do not freely shift into being of an adjectival type, but instead only denote expressions of type $n$. The role of the classifier is to shift numerals into modifiers of kind denoting expressions (as well as encoding information about individuation criteria of application).

[1] Alternatively, one can treat numerals as predicative and evoke a rule for intersective function composition for attributive uses of adjectives, e.g., $\lambda P.\lambda Q.\lambda w.\lambda x.P_w(x) \wedge Q_w(x)$.

[2] On the idea that nouns in languages that allow for bare NPs denote kinds, see Gerstner-Link 1988. For an application to Mandarin, see Krifka 1995.

So combinations of classifiers and numerals in Mandarin are functions from kinds to properties, not property modifiers:

(6.4) a. $[\![\text{san zhi mao}]\!] : \langle s, \langle e, t\rangle\rangle = ([\![\text{san}]\!]([\![\text{zhi}]\!]))([\![\text{mao}]\!])$
b. $[\![\text{san}]\!] : n$
c. $[\![\text{zhi}]\!] : \langle n, \langle \kappa, \langle s, \langle e, t\rangle\rangle\rangle\rangle$
d. $[\![\text{mao}]\!] : \kappa$

**Classifiers are for type shifting nouns and building numeral constructions:** A highly related strategy is proposed in Chierchia (2015) (following Jiang (2012)). There it is proposed that, like Krifka's proposal, numerals are interpreted at type $n$. However, unlike in Krifka's proposal, classifiers combine first with nouns (kind denoting expressions), and output a function from numerals to properties. Thus, the sentence in (6.2) gets the structure in (6.5).

(6.5) a. $[\![\text{san zhi mao}]\!] : \langle s, \langle e, t\rangle\rangle = [\![\text{san}]\!]([\![\text{zhi}]\!]([\![\text{mao}]\!]))$
b. $[\![\text{san}]\!] : n$
c. $[\![\text{zhi}]\!] : \langle \kappa, \langle n, \langle s, \langle e, t\rangle\rangle\rangle\rangle$
d. $[\![\text{mao}]\!] : \kappa$

Although we do not wish to commit to any one of these three analyses, for the purposes of demonstration, we will implement the analysis in (6.5) in our semantics.

### Nominal countability distinctions in Mandarin

Given that Mandarin numeral constructions have mandatory intervening classifiers, and given that direct combination with numerals is a core property of count nouns in number-marking languages, one might wonder whether any nouns in Mandarin are count nouns. Indeed, Chierchia (1998a) proposed that all are mass, and Rothstein (2017), who treats kind denoting nouns as mass nouns also seems to make this claim (see also, e.g., Pires de Oliveira & Rothstein 2011 for related claims regarding Brazilian Portuguese).

However, such claims have been disputed (see especially Doetjes 1996, 1997, 2012). Here we briefly summarise the arguments in Doetjes 1997. First, as Doetjes (ibid.) points out, the distribution of the general unit classifier *ge* in Mandarin implies a countability distinction at the lexical level, since it can only be used with nouns that denote units, or that can be conceptualised as denoting units. Second, the classifiers *da* ('dozen', Mandarin) and *qun* ('flock', Mandarin) indicate a plurality of entities, but "do not indicate themselves what counts as an individual. This information must be provided by the noun" (ibid., p. 34). Third, the suffixes *–zi* and *–tou* cannot attach to substance denoting nouns (for a discussion of possible exceptions, see ibid., p.35). Doetjes concludes, based on these data, that common nouns in Mandarin encode a count/mass distinction. Cheng & Sybesma 1999, p. 515 also conclude, based on the distinction between count classifiers and 'massifiers' in Mandarin, that "the distinction between the two types of classifiers is made with explicit reference to two different types of nouns: nouns that come with a built-in semantic partitioning and nouns that do not—that is, count nouns and mass nouns". Indeed, there seems to be a growing consensus that obligatory classifier languages have a lexicalized count/mass distinction. See also Sudo 2017 and Chierchia 2015.[3]

Given these insights, we assume that there is a lexicalized count/mass distinction, at least in Mandarin Chinese and Japanese. In terms of our theory, this assumption means that there is a lexical distinction between nouns that tracks whether there is a quantized set of entities specified by the noun for counting. We concede, however, that the jury is still out as to whether the countability reflexes of classifier languages demarcate countability classes that differ from the notional object/substance distinction. (See Erbach et al. 2017 for some preliminary results with respect to Japanese.)

### An object centred contextualist semantics for Mandarin numeral constructions

The main technical challenges for an account of the Mandarin Chinese data within our semantic approach lie in modelling kind denoting expressions within a bi-partite lexical structure. We are thus faced with the challenge of correctly accounting for the semantics of count classifiers that interacts with this sort of lexical structure, and on a more theoretical level, we must also justify the counting base set for kind denoting nouns.

Following, e.g., Chierchia 2015, we will analyse kinds as type $\langle s, e \rangle$, a function from worlds to the supremum of the set of entities that instantiate a number-neutral property at that world ($\bigsqcup P$ is the supremum of the set $P$, if defined).[4] We assume that the extensions of Mandarin common nouns are kinds. This kind-denoting term is indexed to $\mathbf{dom}_c$, which selects the

[3] Chierchia (2015, p. 165) concludes that "it turns out to be wrong to claim that [...] [classifier languages] do not have a grammatical manifestation of the mass/count distinction." And Sudo (2017) distinguishes between nouns that have *countable denotations* and those that do not.

[4] See Sharvy 1980: $\bigsqcup P = \iota x[P(x) \wedge \forall y[P(y) \rightarrow y \sqsubset x]]$. This contrasts with $\sqcup P$, which is the sum of all members of $P$. If $P = \{x_1, x_2, ..., x_n\}$, then $\sqcup P = x_1 \sqcup x_2 \sqcup ... \sqcup x_n$.

contextual parameter that models nominal contextual domain restriction such that, for instance, *books* can be interpreted relative to a locations, such as 'on the shelf' (see chapter 4). The counting base will be a property that is instantiated by a set of objects that is or is not quantized (relative to a context and a world). A schema for a mass noun lexical entry is given in (6.6). Recall that 'ext' labels the extension, 'cbase' labels the counting base property.

(6.6) $$[\![[_{\mathrm{CN_{Mandarin}}}\ \mathrm{X_{mass}}]]\!]^{M,g} = \lambda c \lambda w \begin{bmatrix} \text{ext} & \bigsqcup \mathbf{dom}_c(\mathtt{P})(w) \\ \text{cbase} & \lambda y.\mathtt{P}(w)(y) \end{bmatrix}$$

The extension of Mandarin mass nouns is therefore type $e$ relative to a world, and their counting base set is not quantized, since it is, at each world, a number neutral set, $\mathtt{P}(w)$.

For countable nouns in Mandarin, as in English, the property in the extension field and the counting base field of the lexical entry is intersected with the set of objects (i.e., $\mathtt{P}_{obj}$). In the extension, in order for a kind to be formed from this set via $\bigsqcup$, the set of objects must be closed under sum. The counting base set for count nouns in Mandarin is the set of objects that instantiate the relevant property relative to a world. For the examples we discuss below, which involve count nouns that have a quantized set of objects in their denotations, the contextual parameter $\mathbf{qua}_c$ is not needed. Recall that $\mathbf{qua}_c$ only features in the lexical entries of nouns that denote non-quantized sets of objects on their own but syntactically behave like count nouns (e.g. *fence*), and so denote contextually-restricted quantized sets. The same would be true for such *interconnected* count nouns in Mandarin.

(6.7) $$[\![[_{\mathrm{CN_{Mandarin}}}\ \mathrm{X_{count}}]]\!]^{M,g} = \lambda c \lambda w \begin{bmatrix} \text{ext} & \bigsqcup {}^{*}\mathbf{dom}_c(\mathtt{P_{obj}})(w) \\ \text{cbase} & \lambda y.\mathtt{P}_{obj}(w)(y) \end{bmatrix}$$

This should suffice as a sketch at least of one possible analysis of Mandarin Chinese data. We also note that this proposal makes no prediction about whether the countability distinction in Mandarin diverges from the object-substance distinction, at least for concrete nouns.

The next challenge is how to map a kind-denoting nominal to a number neutral extension in our bi-partite semantics, i.e., to replicate the effect of Chierchia's (1998) 'up' and (for the sake of completeness) 'down' operators. Chierchia's operators are given below (with some notational variants):

(6.8) The 'up' operator (based on Chierchia 2015)

a. $^{\cup} : \langle\langle s, e\rangle, \langle s, \langle e, t\rangle\rangle\rangle$ – a function from kinds to properties.
b. $^{\cup} = \lambda k_{:\langle s,e\rangle}.\lambda w.\lambda x.x \sqsubseteq k_w$ if $k_w$ is defined, $\perp$ otherwise.

(6.9) The 'down' operator (based on ibid.)

a. $^{\cap} : \langle\langle s, \langle e, t\rangle\rangle, \langle s, e\rangle\rangle$ – a function from properties to kinds.

b. $^{\cap} = \lambda \mathcal{P}_{:\langle s,\langle e,t\rangle\rangle}.\lambda w.\bigsqcup P(w)$

The first issue that arises in replicating these operations in our semantics, is that we have a single domain assumption, and also do not assume more than one part relation (i.e., that there are not both plural and material part relations). This assumption generates the wrong predictions for the 'up' operator. As one would expect, for instance, if $\mathbf{cat}$ is the cat kind, then $\lambda x.x \sqsubseteq \mathbf{cat}_w$ contains all of the single cats and sums of single cats at $w$ (if any). However, problematically, given a single part relation, $\lambda x.x \sqsubseteq \mathbf{cat}_w$ also contains all of the parts of the single cats and sums thereof.

Fortunately, this is easily remedied in our bipartite semantics: nouns record counting base information, and the set of witnesses of a kind at a world just is the upward closure of the counting base set at that world. In the simplest of terms, given the schema in (6.7), kind denoting count nouns anyway still make accessible the property that generates the kind in the counting base.

Suppose that $\mathfrak{P}$ is a variable for a common noun denotation, and so is thus of type $\langle c, \langle s, \langle e, \langle t \times \langle e, t\rangle\rangle\rangle\rangle\rangle$ and $\mathfrak{K}$ is a variable for a kind-denoting common noun denotation of type $\langle c, \langle s, \langle e \times \langle e, t\rangle\rangle\rangle\rangle$ (a function from contexts and worlds to a pair of an entity and a (counting base) set). The 'up' operator for product type based noun denotations ($^{\cup\times}$) is straightforward to define:

(6.10) a. $^{\cup\times} : \langle\langle c, \langle s, \langle e \times \langle e, t\rangle\rangle\rangle\rangle, \langle c, \langle s, e\rangle\rangle\rangle$

b. $^{\cup\times} = \lambda\mathfrak{K}\lambda c\lambda w\lambda x.{}^{*}\text{cbase}(\mathfrak{K})(c)(w)(x) \wedge {}^{\cup}\text{ext}(\mathfrak{K})(c)(w)(x)$

if $\mathfrak{K}(w)$ is defined, $\perp$ otherwise.

In words, if the extension of a noun is a kind and its counting base set is a property, applying the 'up' operator returns a number neutral property generated from the counting base property via upward closure under sum (*), intersected with the set of entities that are instances of the kind, relative to whatever nominal domain restriction is in place. For example, if applied to a count noun lexical entry schema:

$$(6.11)\quad {}^{\cup\times}(\lambda c\lambda w \begin{bmatrix} \text{ext} & \bigsqcup{}^{*}\mathbf{dom}_c(\text{P}_{obj})(w) \\ \text{cbase} & \lambda y.\text{P}_{obj}(w)(y) \end{bmatrix})$$

$$= \lambda c\lambda w\lambda x.{}^{*}\text{P}_{obj}(w)(y) \wedge x \sqsubseteq {}^{*}\bigsqcup \mathbf{dom}_c(\text{P}_{obj})(w)$$

$$= \lambda c\lambda w\lambda x.{}^{*}\mathbf{dom}_c(\text{P}_{obj})(w)(y)$$

I.e., the application of $^{\cup\times}$ to the interpretation of a kind-denoting noun returns a context-indexed property for all entities in the denotation of the noun restricted to those relevant in the context.

The product-type based version of the 'down' operator can be far closer to Chierchia's, since, for a mereology with a single part relation there is an asymmetry between summation and part-hood when starting out with a quantized set. Summing a quantized set of entities will only yield a sum of entities, while taking the parts of sums of entities will yield both (sums of) entities and the parts of the entities in the quantized set. For example, the sum of the set of single cats will be a sum of cats, but the set of parts of this sum will not only be the set of single cats, but also, e.g., the parts of the single cats.

(6.12) a. $^{\cap\times} : \langle\langle s, \langle e, \langle t \times \langle e, t\rangle\rangle\rangle\rangle, \langle s, e\rangle\rangle$

b. $^{\cap\times} = \lambda\mathfrak{P}.\lambda w.\bigsqcup(\text{ext}(\mathfrak{P})(w))$

In words, if the interpretation of a noun, N, is the property of Ns and sums thereof, then applying the 'down' operator will yield the kind formed from that property via $\bigsqcup$.

We now have all that we need for an analysis of the sentence in (6.2) with the structure in (6.5). The derivation is given in (6.13)-(6.17):

The numeral expression *san* denotes a numeral 3 of type $n$, the noun *mao* ('cat') follows the schema for Mandarin count nouns given in (6.7). The interpretation of the classifier *zhi* applies to the interpretation of a kind-denoting noun. The output has the same counting base property as the interpretation of the noun (e.g., the property of single cats, in this instance). The extension of the noun is modified in two ways. First, it *zhi* forms a property from the kind via the 'up' operator, i.e., the number neutral property of for cats (relative to any contextual domain restriction. Second, this property is intersected with a cardinality function which adds a restriction that the entities it applies to have a cardinality of $n$ with respect to the counting base.

(6.13) $[\![\text{san}]\!]^{M,g} = 3$

(6.14) $[\![\text{mao}]\!]^{M,g} = \lambda c\lambda w \begin{bmatrix} \text{ext} & \bigsqcup{}^{*}\mathbf{dom}_{c}(\mathsf{cat}_{obj})(w) \\ \text{cbase} & \lambda y.\mathsf{cat}_{obj}(w)(y) \end{bmatrix}$

(6.15) $[\![\text{zhi}]\!]^{M,g} =$
$\lambda\mathfrak{K}\lambda n\lambda c\lambda w\lambda x \begin{bmatrix} \text{ext} & ^{\cup\times}(\mathfrak{K})(c)(w)(x) \wedge \mu_{\#}(x, \text{cbase}(\mathfrak{K}(c)(w)(x))) = n \\ \text{cbase} & \text{cbase}(\mathfrak{K}(c)(w)(x)) \end{bmatrix}$

This means that *zhi mao* 'zhi-CL cat' denotes a function from numerals $n$ to a character (a function from a context to a property). The instantiations of this property at each world is the set of sums of $n$ single cats. The counting base for this noun is the set of single cats in each world:

(6.16) $[\![\text{zhi mao}]\!]^{M,g} =$
$$\lambda n \lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & {}^{*}\mathbf{dom}_{c}(\mathsf{cat}_{obj})(w)(x) \wedge \mu_{\#}(x, \mathsf{cat}_{obj}(w)) = n \\ \text{cbase} & \lambda y.\mathsf{cat}_{obj}(w)(y) \end{bmatrix}$$

Finally *san zhi mao* 'three cats' denotes the sums of three single cats and the counting base for this numeral construction is the set of single cats:

(6.17) $[\![\text{san zhi mao}]\!]^{M,g} =$
$$\lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & {}^{*}\mathbf{dom}_{c}(\mathsf{cat}_{obj})(w)(x) \wedge \mu_{\#}(x, \mathsf{cat}_{obj}(w)) = 3 \\ \text{cbase} & \lambda y.\mathsf{cat}_{obj}(w)(y) \end{bmatrix}$$

### 6.1.2 A free numeral language: Yudja

Our analysis can also cover other cases of morphosyntactic count/mass variation such as that exhibited by languages like Yudja and Nez Perce which allow all nouns to be combined directly with numeral expressions. For instance, the Yudja example below is from Lima (2014a, pp. 540-1)

(6.18) a. CONTEXT: João cut his finger and three drops of blood fell on the floor: one near the river, one near the house and another near the school.

b. Txabïu apeta pe∼pe∼pe
three blood drip∼RED
'Three (drops of) blood dripped'

The interpretation of the direct combination of the numeral 'three' with 'blood' is determined by the context. I.e., in this example, the three clearly distinct and discrete quantities of blood are salient. Details of the analyses of such constructions vary, however there are some similarities between them. For instance, both Lima (2014b,a) and Chierchia (2015) assume that nouns are kind denoting in Yudja. Furthermore, for Yudja, Lima (2014a), Deal (2017), and Chierchia (2015) all assume an operator that applies at some point in the derivation of numeral constructions that allows contextually bounded entities in the denotations of substance nouns to be counted. For example, Chierchia (ibid.) proposes that Yudja has a generalised classifier that is typically morphologically null. In Mandarin, it is argued that numerals are only interpreted as type $n$ and that classifiers are needed to allow numerals to modify properties (see above). However, given that Yudja is not an obligatory classifier language, we see no need to restrict the interpretations of numerals in this way for this language. Following Lima (2014b), therefore, we allow numerals to be freely interpreted with an adjectival type, just as in number-marking languages like English. In other words, we have the following kind of derivation (again where $\kappa$ is whatever type one assumes for kinds):

(6.19)
a. $[\![\text{txabïu apeta}]\!] : \langle s, \langle e, t\rangle\rangle = [\![\text{txabïu}]\!]([\![\varnothing_{CL}]\!]([\![\text{apeta}]\!]))$
b. $[\![\text{txabïu}]\!] : \langle\langle s, \langle e, t\rangle\rangle, \langle s, \langle e, t\rangle\rangle\rangle$
c. $[\![\varnothing_{CL}]\!] : \langle \kappa, \langle s, \langle e, t\rangle\rangle\rangle$
d. $[\![\text{apeta}]\!] : \kappa$

In Chierchia's analysis, $[\![\varnothing_{CL}]\!]$ is analysed as an operator $\Delta$ that accesses the (stable) atoms of kinds built from stably atomic predicates and returns a contextually salient quantity for kinds that are not built from stable atoms:

(6.20) $$\Delta(k) = \begin{cases} AT^{\cup}(k), & \text{if } k \text{ is atomic} \\ quantity_n(k), & \text{otherwise} \end{cases}$$ (Chierchia, 2015, ex. 26b)

Using the terminology from Lima (2014b), one can distinguish between *notional count nouns* and *notional mass nouns* in Yudja. In Chierchia's analysis, *notional count nouns* in Yudja are counted in terms of their stable atoms and *notional mass nouns* in Yudja are counted in terms of salient quantities, as in Lima's example above.

### An object centred contextualist semantics for Yudja numeral constructions

*Notional count nouns* in Yudja (i.e., nouns that denote clearly demarcated individuated entities like cats will be analysed similarly to Mandarin: they denote kinds and specify a quantized set of entities for counting relative to context. *Notional mass nouns* in Yudja will be analysed slightly differently. An advantage of our bi-partite lexical structure is that we need not postulate a null classifier for counting constructions with in Yudja, unlike Chierchia's (2015) analysis of Yudja. Indeed, our contextualist semantics already arguably has the tools to account for notional mass nouns in Yudja. We will now outline how the $\mathbf{mod_c}$ contextual parameter, that models contextual domain restrictions, can be used to account for the main claim in Lima 2014a, p. 534 that "all nouns in Yudja are interpreted as count nouns".

In chapter 4, for number-marking language, we argued that the $\mathbf{mod_c}$ contextual parameter can only apply within the extension field of a lexical entry, since otherwise, contextual domain restriction would license mass-to-count shifts. The reason for this is that were we to allow $\mathbf{mod_c}$ to apply to the counting base property, this would predict that, given an appropriate context, any mass noun could be used felicitously in numeral constructions, contrary to fact. (Recall that e.g., *two furnitures* is infelicitous no matter what context it is used in. In chapter 4, we argued that this speaks against the view in Pelletier 2012 that all nouns have count and mass senses encoded in the lexicon.) This however suggests that there may be a way to use $\mathbf{mod_c}$ instead of Chierchia's (2015) $\textit{quantity}_n$ function.

Our $\mathbf{dom_c}$ is more general than Chierchia's $\textit{quantity}_n$. For one, $\mathbf{dom_c}$ can apply to any properties (quantized or not). Additionally, $\mathbf{dom_c}$ does not always result in a portion reading (e.g., with *books* being contextually restricted to only being those in some salient location such as on a shelf). However, in contexts where there are salient portions of stuff, $\mathbf{dom_c}$ can have a similar effect to Chierchia's $\textit{quantity}_n$ function in those contexts. Therefore, given Lima's (2014) claim that "all nouns in Yudja are interpreted as count nouns", in order to have a model that is in line with this claim, we tentatively suggest a rather simple analysis of concrete notional mass nouns in Yudja, given the contextual parameters that we already have at our disposal.[5] The extensions of notional mass nouns in Yudja should still, of course, be sensitive to contextual domain restrictions via $\mathbf{dom_c}$, however, we suggest that if $\mathbf{dom_c}$ also applies in to the counting base field of the lexical entries of these nouns, then we can account for Lima's claims and observations. Applying this proposal to a notional mass noun denoting stuff like *apeta* ('blood') in the above example, this would be implemented as in (6.21):

(6.21) $$[\![\text{apeta}]\!]^{M,g} = \lambda c \lambda w \begin{bmatrix} \text{ext} & \bigsqcup \mathbf{dom}_c(\texttt{blood})(w) \\ \text{cbase} & \lambda y.\mathbf{dom}_c(\texttt{blood})(w)(y) \end{bmatrix}$$

This proposal means that if there is a salient quantized set of portions/amounts of blood, then this set is accessible to grammatical counting operations.[6] If on the other hand, there is no such set, then the counting base set remains as a non-quantized number neutral property. This makes the prediction that, in contexts where there is no salient quantized set of portions/amounts of blood, numeral constructions will be judged infelicitous. Notional mass nouns in Yudja are, on this analysis, a bit like a highly constrained type of dual-life noun. In neutral contexts they are, by default, like regular kind-denoting mass nouns. However, when portions of the relevant stuff are salient in the context, these portions are made accessible to grammatical counting operations. Unlike dual life nouns, therefore, out-of-the-blue combinations of these nouns with numerals will be infelicitous, or else will

[5] We are unsure what the status of abstract nouns is in Yudja with respect to countability.

[6] We leave as an open question whether, following some suggestions in Lima (2014a), that we may need to make this condition stronger and require that the salient portions amounts are mereotopologically distinguished as well.

require some kind of accommodation.[7]

### 6.1.3 Summary

The morphosyntactic variation data for classifier languages such as Mandarin and languages such as Yudja are compatible with our object-centred contextualist approach by following the type-shifting proposed by, for example, Lima (2014a) and Chierchia (2015). In both cases, however, the explanation of countability with regard to the felicity of numeral constructions remains the same as with number marking languages. In context, for a noun to be felicitous in a numeral construction requires that it specifies a quantized set of entities for counting.

For Mandarin, we have assumed that the count/mass distinction is not greatly different than in number marking languages, only in Mandarin, nouns denote kinds. In Yudja, we have proposed that mass nouns are slightly different to mass nouns in obligatory classifier and number marking languages. They are kind denoting and, by default, mass, but the counting base set is sensitive to whether there are quantized portions of the relevant stuff in the context. Furthermore, our bipartite approach to the lexicon makes available an alternative analysis of numeral constructions in Yudja that does not presuppose the application of a morphologically null classifier.

## 6.2 Abstract nouns: a case study

In this section, we address the semantics of abstract common nouns, namely those nouns that do not denote (on at least one of their readings), concrete things or stuff. While there is less work on countability for abstract nouns than for concrete nouns, important progress has been made (see, e.g., Asher, 1993; Grimm, 2014, 2016; Katz & Zamparelli, 2012; Moltmann, 2013; Nicholas, 2010; Nicolas, 2002; Sutton & Filip, 2019, 2020, 2024; Tovena, 2001; Zamparelli, 2020).

Our focus in this section will be limited to a case study of what we call *informational nouns*, namely nouns that (on at least one of their readings) denote what could broadly be called *informational entities* such as propositions or facts, the contents of mental states, and contents of artefacts (like books

[7]In order to make this analysis work, we do need to make an additional assumption about numerals in Yudja, namely, that they include an application of the $^{\cup\times}$ operator such that the resulting extension of $n$ Ns will be a property, not a kind.

and legal writs), or speech acts. Examples of such nouns in English, which cut across the count/mass divide include:

(6.22) *allegation*, *assumption*, *belief*, *claim*, *criticism*, *evidence*, *fact*, *hypothesis*, *knowledge*, *opinion*, *point*, *proposal*, *report*, *statement*

Many of the above nouns are polysemous, however, we will not address polysemy here, as it is beyond the scope of this section (although, see recent work by one author (Chatzikyriakidis et al., 2025; Sutton, 2022, 2024c,a)). Our goal, here, is to show that our object-centred contextualist approach extends naturally to the informational sense of these nouns, all of which we will claim denote informational objects (or sums thereof). Some of the above nouns only denote informational objects, e.g., *fact* and *information*. However, many of them can also denote eventualities, for instance (mental) STATES as with *belief* and *knowledge*, and also (speech) EVENTS such as *report* and *statement*, where STATES and EVENTS are standard labels for aspectual classes (see e.g., summaries in Filip 2011.) We claim that the structure of these eventualities, specified in terms of their participants and identified/individuated in terms of temporal traces etc., have a bearing on their grammatical reflexes of countability.

In what follows, as an illustrative case in point for our contextualist object-centred theory, we will take a selection of the above English nouns, which cut across the mass/count divide and differ with respect to whether they may also denote eventualities (and if so, what aspectual class): namely, *belief*, *fact*, *information*, *knowledge*, and *statement*. We will also address cross-linguistic variation for informational abstract nouns in section 6.2.3.

### 6.2.1 The countability reflexes of informational nouns

We take as the primary indicator of whether a noun is an informational noun, that they are felicitous with at least some of the following predicates: namely, *true*, *false*, *misleading*, and *unfounded*, *uninformative*. Let us also note that some variation is generated by factors such as whether the noun carries a veridicality presupposition or whether it is typically used in the context of their being an agent/experiencer who is in some sense responsible or committed to the truth of the relevant informational entity.

(6.23) a. Alex's belief was true/false/unfounded.
b. All facts are true, otherwise they are not facts (there are no false facts).
c. Alex provided true/false/misleading information to Billie.

d. All knowledge is true and well founded, otherwise it is not knowledge.
e. Alex's statement was true/false/misleading/unfounded/ uninformative.

In English, *information* and *knowledge* are rigidly uncountable. For *knowledge*, for example, the only corpus examples we have found in which it is used in a canonically count syntactic environment come from philosophy articles or books, or commentaries on Buddhist scripture, but they are only a few. The other nouns all have at least one count sense that denotes informational entities. Some of the above nouns also have additional eventuality denoting sense, sometimes count (e.g., *statement*) and sometimes mass (e.g., *knowledge*). We take them in turn.

*Statement* can be used to denote, in addition to the content of what was stated (6.24a), the stating event (6.24b), and in some cases (6.24c), an artefact (especially in official legal contexts). All of these senses are countable.

(6.24) a. Alex's two statements were both false. Inf. object
b. Alex's two statements each lasted 5 minutes. Event
c. The two witness statements were left on the desk. Artefact

We have found no convincing evidence that *statement* has any uses in canonically mass syntactic environments.

*Belief* can also denote the informational entities (that which is believed) as in (6.25a), and this sense can be used in numeral constructions as in (6.25b).

(6.25) a. Alex's belief that it rained last night is true.
b. 'I have always had two basic beliefs about environmentalism', she says. 'Firstly, that it should be a part of the mainstream, not a niche issue. Secondly, that there are people in all areas of life who would like to do something...' (BNC, ED9)

However, it is not clear that all informational object readings of *belief* must be in count syntactic environments. In (6.26a), it is different variations in the content of beliefs that depart from the relevant accepted belief that seems to be at issue, while in (6.26b), *rejection of belief* relates to rejecting something like a credo consisting of a number of propositions (e.g., rejecting that divorce is wrong).

(6.26) a. The early church viewed deviations from accepted belief with distaste ... (BNC, B1J)
b. There were certainly other reasons for his rejection of belief at that age. (BNC, C8V)

In examples just given, *belief* was used with reference to religious belief. In addition, *belief* can be used to denote something like the mental state of holding a certain attitude, religious or other. Often, although not always, this is expressed by *belief in* constructions. Interestingly, these constructions can be used in environments that select for mass nouns, such as the bare occurrence in (6.27a), as well as in a canonically count context such as with indefinites as in (6.27b). However, *belief in* is highly marked in numeral constructions in which it is odd, and seems uninterpretable.

(6.27) a. It also reminds us of how recently belief in the supernatural was part of life. (BNC, BM6)
b. They share a belief in one God, who created and sustains the world. (BNC, AMT)
c. ??two beliefs in God and the the inevitability of progress

*Knowledge* is mass and is polysemous between an informational sense and a sense that denotes the mental state of the experiencer. In its informational sense, like the verb *know*, it can be used to relate to propositional knowledge (6.28a), and practical knowledge (how) as in (6.28b), but also to information that is independent of an experiencer as in (6.28c).

(6.28) a. Without the knowledge that the grains were initially uniform it would have been impossible to reconstruct the original population (BNC)
b. There is so much fund raising knowledge and experience amongst our volunteers. (BNC, H9S)
c. There is a vast store of knowledge in the world on every conceivable subject and this has been painstakingly recorded in textbooks, journals and a variety of other publications. (BNC, FEU)

The mental state denoting use of *knowledge* seems to be less prevalent in corpora, but can be found in examples such as (6.29), in which what Chang is denying is not a proposition (e.g., that there was a deal), but is denying that he was ever in a state of knowing such that the contents of this state contained information about the deal.

(6.29) Chang denied all knowledge of the deal. (BNC, HL5)

*Information*, in English, is not felicitous in count syntactic environments. It has an informational entity reading (6.30a), but can also be used to refer to an artefact, such as documents or a computer drive, that holds information as seen in (6.30b).

(6.30) a. We had to find out exactly where an object was stored, or on show, and record that information. (BNC, J29)
b. If the Other Side knows enough to be looking for Blagg, it could know enough to destroy or neutralise the information, whatever it may be, in his possession. (BNC, H86)

Finally, consider the informational object noun *fact* which only seems to denote propositions/informational objects and is also predominantly countable:

(6.31) a. From what I saw the other day, you already have a full biography of me down to the very last detail, even though you'd missed one or two relevant facts. (BNC, JXV)
b. ...the golden days of his journalistic apprenticeship in Yorkshire, where every fact was triple-checked... (BNC, ABG)

However, there are also many uses of *fact* in the bare singular in PP constructions. Predominant among these is the fixed expression *in fact*, however, the following constructions are also all attested in the BNC:

(6.32) a. issue/matter/point/question/statement of fact
b. based/founded on fact
c. accept/confirm/lay down/perceive/present/report/state as fact
d. indistinguishable from fact
e. mistaken for fact
f. the difference between fact and fiction/guesswork/hearsay

One reading for these data is that they refer to something like the totality of true propositions/informational entities. Somewhat like Wittgenstein's (1922) opening to the Tractatus, then, *Die Welt ist alles, was der Fall ist. Die Welt ist die Gesamtheit der Tatsachen, nicht der Dinge* ('The world is everything that is the case. The world is the totality of facts, not (of) things)', these uses of *fact* evoke something like *the state of the actual world* or *things as they really are.*

Arguably, then, these uses of *fact* could also be seen either as eventuality denoting readings (denoting the state of the actual world), or, equally, as something like the sum of all true propositions. We discuss these options further in the following.

With this overview of the empirical landscape for our selection of informational nouns, we will now develop an object-centred contextualist semantic analysis.

### 6.2.2 Plural sets and individuation schemas across semantic types

In order to extend our account to nouns that denote informational entities, we incorporate Schmitt's (2013; 2017) theory for a type of generalised mereological sum operation (we first explore this analysis in Sutton & Filip 2019, 2020). The innovative idea, here is to define a unified mereological sum ($\sqcup$) operation over different semantic types, such that, in addition to physical entities, one can talk of sums of properties, eventualities, propositions. For each domain of type $a$, $\mathcal{D}_a$, we have a bijection function $pl_a$ on the powerset of $\mathcal{D}_a$ to a plural structure, namely, the set of singularities and pluralities for that domain, $\mathbf{PL}_a$ (the inverse of $pl_a$ is $pl_a^{-1}$):

(6.33) $pl_a : (\mathcal{P}(\mathcal{D}_a)\backslash\varnothing) \rightarrow \mathbf{PL}_a$

Now, take an informational entity denoting noun such as *belief* or *information*. On the one hand, we want to be able to characterise its extension in terms of propositions of type $\langle s, t\rangle$. On the other hand, the denotation of *belief* and *information* seems to include pluralities of informational entities insofar as we can happily refer to e.g., *two beliefs*. This is where Schmitt's unified mereological sum operation is helpful, since it allows us to map any proposition onto a Boolean algebra. As an example, suppose we have three worlds in our domain: $w_1, w_2, w_3$. From this we can define three *atomic functions* of type $\langle s, t\rangle$ (i.e. propositions that are true in only one world), characterised by the singleton sets $\{w_1\}$, $\{w_2\}$, and $\{w_3\}$. The set of possible propositions is therefore $\mathcal{P}(\{\{w_1\}, \{w_2\}, \{w_3\}\})\backslash\varnothing$.

Using (6.33), we can define an algebra that is isomorphic to this powerset, i.e., $\mathbf{PL}_{\langle s,t\rangle}$. For example, for some $\mathbf{p}, \mathbf{q}, \mathbf{r}$, $pl_{\langle s,t\rangle}(\{w_1\}) = \mathbf{p}$, $pl_{\langle s,t\rangle}(\{w_2\}) = \mathbf{q}$, and $pl_{\langle s,t\rangle}(\{w_3\}) = \mathbf{r}$. I.e., we have the set $^*\{\mathbf{p}, \mathbf{q}, \mathbf{r}\}$. This set is the set of all informational entities and sums thereof that can be in the extension an informational noun, given the assumption that $\mathcal{W} = \{w_1, w_2, w_3\}$.

For instance, assuming for a moment a monopartite lexical entry for *information*, suppose the following extension for *information in the letter* in the actual world, $w_1$:

(6.34) $[\![\text{information in the letter}]\!]^{w_1}_{\langle\langle s,\, t\rangle,\, t\rangle,} = \{\{w_1, w_2\}, \{w_1, w_3\}\}$

We can then apply $pl_{\langle s,t\rangle}$:

(6.35) $pl_{\langle s,t\rangle}([\![\text{information in the letter}]\!]^{w_1}) = \{\mathbf{p} \sqcup \mathbf{q}, \mathbf{p} \sqcup \mathbf{r}\}$

Via $pl_a$, we therefore have, for a common noun that denotes propositions, a means of applying a mereological theory of countability to such nouns.

### 6.2.3 Objects in the informational domain

Given a domain of propositions/informational entities over which we can define mereological relations, and further given that some abstract nouns denote such entities, we may then ask in the context of our object-centred approach, what, if anything counts as an informational object? In other words, what, if anything, constitutes an object in the domain of propositions? Let us take, as our two examples, *belief*, which has a count sense in English (e.g., *two beliefs*) and *information*, a mass noun in English (#*two information(s)*). Suppose we have two properties underpinning the denotations of these nouns, namely `belief` and `info`.

Our answer to the question of what counts as an informational object, perhaps surprisingly, is that any proposition (excluding $\varnothing$, i.e. excluding $\perp$) can count as an object.[8] To justify this, let us take into account what kinds of things in the propositional/informational domain can be counted. While *one belief* may arguably seem to be restricted to simpler propositions (those that can be comprehended at any one time, say), this is not true of all informational nouns. We can count articles, stories and treaties, all of which relate to highly complex propositions. In principle, therefore, any amount of information that can constitute *one article/story/thesis* should be able to count as one informational object.[9]

The assumption that any amount of information should be able to count as one informational object equates to the assumption that there is no privileged set of propositions that count as informational objects. Importantly, within our object-centred account of countability, this makes three predictions when it comes to variation in count/mass lexicalization patterns.

First, we make predictions about whether informational properties will be lexicalized as count. While we do find variation in count/mass lexicalization patterns for informational nouns, as shown in Table 6.1 (partially reprinted from Sutton & Filip 2020), many informational nouns seem to be lexicalized as count, or at least have a count sense when denoting propositions as opposed to an eventuality (more on this below). Some examples of informational count nouns in English as given in (6.36).

(6.36) *assertion*, *claim*, *concern*, *hope*, *opinion*, *possibility*, *statement*, *suggestion*

Recall that, for concrete nouns, we have claimed that a necessary condi-

[8] Note that $\varnothing$ is excluded from $pl_a$ in (6.33).

[9] We set aside the non-propositional information that, say, articles may contain. For instance, questions posed in articles can be part of the information they contain (if those questions limit the set of worlds in which they can be true).

Table 6.1: Examples of cross- and intralinguistic variation in count/mass lexicalization patterns for informational nouns

| | Mass | Count (NOMINATIVE.PL) |
|---|---|---|
| `information` | *information* | *Information(en)* (German)<br>*tieto (tiedot)* (Finnish) |
| `evidence` | *evidence* | *Beweis(e)* (German)<br>*todiste(et)* (Finnish) |
| `knowledge` | *gnosi* (Greek, dual life)<br>*knowledge*, *Wissen* (German) | *gnosi(s)* (Greek, dual life) |

tion for a core property to be lexicalized as count is that it is instantiated by objects. If we then transpose this to abstract nouns that denote informational entities, this means that, in principle, any noun that denotes propositions/informational objects can be lexicalized as count!

Second, given that the set of propositional objects is not inherently quantized, we predict that counting with such nouns will be highly context sensitive in a manner akin to *fence*-like nouns, i.e., *interconnected* count nouns. That is to say that, rather than there being no 'objects' for counting, for informational nouns, there are, in a sense, too many objects for counting, since any proposition can count as an informational object. The further predication is, therefore, that when count, nouns like *Information-en* ('pieces of information', German, count) will be highly context sensitive when it comes to what counts as 'one'. This is indeed what we find. For instance, the example in (6.37a) is taken from the deTenTen20 corpus, but the minimally altered variant in (6.37b) is also acceptable (context: a reportage piece for a Cabaret show):

(6.37) a. Vielleicht **ist eine Information** für unsere treuen Besucher noch interessant: Alle Ensemblemitglieder sind davon überzeugt, sich persönlich von Jahr zu Jahr gesteigert zu haben und meinen, dennoch genug Potenziale zu verspüren, die noch gehoben werden können.

*__On piece of information__ is perhaps of interest to our loyal visitors: All cast members are satisfied that they have improved year on year, but nevertheless think that they still have enough potential for enhancement.*

b. Vielleicht **sind zwei Informationen** für unsere treuen Besucher noch interessant: Alle Ensemblemitglieder sind davon úberzeugt, sich persönlich von Jahr zu Jahr gesteigert zu haben und meinen, dennoch genug Potenziale zu verspüren, die noch gehoben werden

können.
***Two pieces of information*** *are perhaps of interest to our loyal visitors...*

Third, we make predictions about intralinguistic variation for informational nouns. First an observation. As discussed in Chapter 2, a common pattern we find for *interconnected* nouns is that we have a morphologically more simple count noun e.g., *fence* and a morphologically more complex mass noun derived from this noun e.g., *fencing*. However, when it comes to informational nouns, this pattern is much rarer. For instance, we have nothing like *beliefing* or *statementage* in addition to *belief* or *statement*. Why we find this non-parallelism between the concrete and abstract domains is, interestingly, predicted by our object-centred contextualist account. In the simplest of terms, this is because the set of objects that count as e.g., *one fence* is far more constrained than the set of informational objects that can count as e.g. *one belief*, such that for the latter, little or nothing is gained by a language having a derived mass noun in addition to a more morphologically simple count noun. Let us elaborate.

Take Rothstein's (2010) example of fencing around a square field. Where, in order, $a, b, c, d$ are sections of fencing corresponding to each side. Even in this simple scenario, the objects that can count as *one fence* are constrained on mereotopological and/or functional grounds. For instance while $a, b, c, d$ and $a \sqcup b \sqcup c \sqcup d$ may each easily count as *one fence* in an appropriate context, some sum entities formed from $a, b, c, d$ cannot. For instance, if $a$ and $c$ are on opposing sides of the field, we cannot think of a convincing context in which $a \sqcup c$ counts as *one fence*, likewise for $b \sqcup d$. If that is not sufficiently convincing, suppose that some other fencing $e$ is located on the other side of the world from $a, b, c$ and $d$. It seems highly implausible that any sums of $a, b, c$ or $d$ formed with $e$ could count as *one fence*. The reason for this is, plausibly, that non-contiguous portions of fencing cannot easily be conceptualised as functioning as 'one'. Contrast this with propositions/informational objects that could be the basis for counting *belief*. These are not spatially anchored like concrete objects and so there is no similar basis for ruling out sums of propositions to count as 'one'.

In terms of our theory, supposing that $\texttt{belief}_{obj}$ is the set of informational objects that instantiate $\texttt{belief}$, in principle, no proposition is excluded from this set. In contrast, as we have just outlined, some sums of entities are excluded from the set of *fence*-objects, $\texttt{fence}_{obj}$. What this predicts is that whereas, in terms of extension, a more cumulative flavour of meaning can be evoked when moving from e.g., *fence* to *fencing*, the same is not prima facie true were there some informational object denoting mass noun derived from *belief*. Therefore, we have at least some explanation for why we observe a non-parallelism between *interconnected* nouns in the concrete domain and *informational object* nouns in the abstract domain when it comes to whether morphologically derived mass nouns are attested.

In summary, not only have we shown how our theory can be applied to abstract nouns that denote informational objects, importantly, we have also derived three predictions about the count/mass lexicalization patterns of these nouns, based upon our claims about concrete nouns. Namely, that the properties underpinning these nouns should all, in principle, be able to lexicalized as count, and that, when count, they should display *fence*-like context sensitivity when it comes to counting, and finally, that we should not expect to find an abundance of informational object denoting mass nouns that are morphologically derived from informational object denoting count nouns.

### 6.2.4 Countability for informational nouns

#### *fact* and *information*

Let us start with informational nouns that do not have an associated eventuality, namely *fact* and *information*. (We set aside the artefact reading of *information* for now). In terms of lexical entries, our proposal for concrete nouns can be transferred over to informational object denoting nouns with minimal alterations. I.e., we can apply our functions for generating count and mass lexical entries for these nouns, via $\mathcal{Q}_c$ and $\mathcal{N}_c$, almost exactly as we would for concrete nouns. The one extra addition, is that we apply $pl_{\langle s,t\rangle}$ to the counting base set of both nouns (we abstract away from the veridicality presupposition for *fact* in our representations):

(6.38) $[\![[_{\text{CN}}\ \text{fact}]]\!]^{M,g} =$

$$\lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\texttt{fact}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathbf{qua}_c(pl_{\langle s,t\rangle}(\texttt{fact}_{obj})(w))(y) \end{bmatrix}$$

(6.39) $[\![[_{\text{CN}}\ \text{information}]]\!]^{M,g} =$

$$\lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\texttt{information})(w)(x) \\ \text{cbase} & \lambda y.pl_{\langle s,t\rangle}(\texttt{information}(w)))(y) \end{bmatrix}$$

Count and mass predicates can then be distinguished in terms of whether or not their counting base sets specify a quantized set of informational objects relative to the plural structure formed by $pl_{\langle s,t\rangle}$. As an example, suppose that there are two predicates of propositions of type $\langle\langle s, t\rangle, t\rangle$, $P$ and $Q$ such that $pl_{\langle s,t\rangle}(P) = \{\mathbf{p}, \mathbf{q}, \mathbf{r}\}$ and $pl_{\langle s,t\rangle}(Q) = \{\mathbf{p}, \mathbf{q}, \mathbf{r}, \mathbf{p} \sqcup \mathbf{q}\}$. $pl_{\langle s,t\rangle}(P)$ is quantized, but $pl_{\langle s,t\rangle}(Q)$ is not, and so $pl_{\langle s,t\rangle}(P)$ forms a counting base set for a count nouns and $pl_{\langle s,t\rangle}(Q)$ forms a counting base set for a mass noun.

This proposal does, however, mean that one would have to minimally adjust the interpretations of numerals when applied to abstract nouns insofar as there would have to be some applications of $pl_a$ and $pl_a^{-1}$ in the definition of the cardinality function. Nothing, in principle would, however, prevent being able to provide a single definition of such a function that applies equally to concrete and abstract entities.

However, we also need to accommodate the use of *fact* that we saw with e.g., *accept/confirm/lay down/perceive/present/report/state as fact*. It is not clear to us that *fact* has a fully fledged mass sense, given that some canonical mass constructions are not felicitous:

(6.40) a. #Alex didn't learn much fact.
b. #Fact is easy to come by in a library.

As we mentioned earlier, the non-count uses of *fact*, instead seem to evoke something like a Wittgensteinian totality of facts. We tentatively propose, therefore, that a shifting operation may be being applied, such that we end up with something like a singleton property in the sense of Chierchia (2010, 2015). That is to say that, when used in the bare singular in the above PPs for instance, the extension of *fact* is shifted from the set of informational entities that are true in the actual world to the singleton set of the sum of all such entities. Although tentative, this may be one way to capture the use of *fact* in which it has an approximate paraphrase of *the way things are/the way the world is*.

### *belief*, *knowledge* and *statement*

An obvious difference between *belief* and *statement* is that their associated eventuality types belong to different aspectual classes. *Statement* belongs to an EVENT aspectual class and *belief* to a STATE aspectual class. The EVENT and STATE aspectual classes along with the PROCESS aspectual class constitute the tripartite aspectual classification into which eventuality types are divided. The notion of EVENT is here used in this narrow sense, not to be confused either with 'eventuality' or event in the broad and often pretheoretical sense for all kinds of situations denoted by verbal or nominal predicates (see Filip 2020 and references therein). As a first pass, then, let us begin with a neo-Davidsonian analysis of the eventuality-denoting uses of these nouns, where CONTENTS is a type of THEME. We use $s$ as a variable for STATES and $e$ as a variable over EVENTS. We cannot adequately represent the polysemy of these nouns here, so instead, we will simply provide $\lambda$-terms for the eventuality and informational entity variables, and assume that one of these can be existentially closed to derive either reading. We also leave as unclosed a variable for the agent (AG) or experiencer (EXP) which may be filled in genitive constructions such as *Alex's belief/statement* (we set aside the artefact-denoting reading of *statement* here, however see Sutton 2022). A monopartite representation of *belief* and *statement* are given below.

(6.41) $[\![\text{belief}]\!] = \lambda w.\lambda x \lambda s.\lambda p.$
$[\texttt{belief}(w)(s) \wedge \textsc{exp}(w)(s,x) \wedge \textsc{contents}(w)(s,p)]$

(6.42) $[\![\text{statement}]\!] = \lambda w.\lambda x.\lambda e.\lambda p.$
$[\texttt{statement}(w)(s) \wedge \textsc{ag}(w)(e,x) \wedge \textsc{contents}(w)(e,p)]$

As with *fact*, we may assume that the contents of beliefs or statements may always be counted, facilitated by an application of $\mathbf{qua}_c$ to the counting base set. Recall, as explained in Chapter 4 some count noun lexical entries are additionally indexed to the quantizing contextual parameter (apply $\mathbf{qua}_c$). These nouns are count, but what counts as 'one' may vary depending on one's counting perspective, on context; on their own, out of context, they are non-quantized.

More complicated are eventuality-denoting readings. First, we may ask whether, like informational entities, eventualities denoted by nouns could be taken to constitute objects, and so be, in a sense, directly counted. While this might be a possible avenue, we instead build upon a suggestion in Grimm 2014 that counting constructions with eventuality denoting nouns can be analysed in terms of indirect counting of eventualities via counting participants, run times or locations of those eventualities. Hence, in a nutshell, our proposal amounts to the idea that we can either directly count informational entities (the contents of statements or beliefs) or indirectly count eventualities that are individuated in virtue of being anchored to their participants (i.e. to agents/experiencers), or locations, or to their run times.

For *statement*, the associated events can be located in space and time (which tends to be a relatively short interval), and have at least one agent. Consider the following examples with *two statements*. In order to rule out a reading in which the propositions are counted, we restrict the complement clauses to those containing atomic sentences (i.e., ones with no connectives etc.). For instance, in the examples in (6.43), *(that) spending will increase* cannot easily be understood as denoting two propositions. (For similar examples, see also Sutton & Filip 2019, 2020, 2024). In (6.43a), we have just one speaker (agent) Alex, so the two statements, or stating events, cannot be distinguished in terms of different agents. Also, background knowledge rules out that the single speaker Alex can make a statement in two different places at the same time. Hence, we cannot individuate the two statements in terms of two distinct locations alone, without also assuming that they were uttered at different times. The only way to individuate the two statements is with respect to different times, allowing for them to happen either in the same location or at two different ones. In fact, this is the only reading possible.

(6.43) a. Alex's two statements that spending will increase
b. Alex's and Billie's two statements that spending will increase
c. Alex and Billie's two statements that spending will increase

In (6.43b), extra readings are made available by the two separate (agents) denoted by the double genitive construction *Alex's and Billie's*. Now it is possible to individuate the two statements, the two stating events, in terms of their speakers (agents). That is to say that (6.43b) can refer to any situation in which Alex is the agent of one statement that spending will increase, and Billie of another. On this distributive interpretation, it is left underspecified whether or not the temporal traces of these speech act events overlap as well as whether they took place in the same location or at different locations. Of course, besides such distributive readings, there are also collective readings available. For instance, Alex and Billie jointly are the authors of both the statements, and the two speech acts might have been uttered by either of them taking collective responsibility for both statements, or by both Alex and Billie taking alternating turns. In this case, the two stating events, the two speech acts, will be distinguished in terms of their temporal traces. With the coordinated genitive in (6.43c), the collective reading seems preferable, and so similarly to (6.43a) the stating events can only be distinguished in terms of times, because Alex and Billie are jointly making the two statements. Distributive readings, as with (6.43b), are also possible.

The observations about the possible readings of the above examples suggest that we need an underspecified representation for what counts as 'one' eventuality in the denotation of nouns like *statement*, where what is underspecified is whether we are anchoring to agents, locations or temporal traces. (See Sutton & Filip 2024 for a discussion of how this implementation of anchoring differs from Grimm's (2014).) This choice, furthermore, can be narrowed down by the application of pragmatic reasoning in context.

We will now sketch at least some of the formal mechanisms for modelling this. Let us suppose that in world $w$, we have a set of eventualities $\texttt{statement}_w$. For simplicity, suppose this is the set $\{e_1, e_2, e_3\}$. We must then define whether any subset of this set is quantized. We propose to do this indirectly, via anchoring functions that, formally, are just functional (as opposed to relational) versions of the familiar thematic role functions:

(6.44) a. For all $e$, $\textsc{ag}(e) = x$ iff $x$ is the agent of $e$
b. For all $e$, $\textsc{exp}(e) = x$ iff $x$ is the experiencer of $e$ (if any)
c. For all $e$, $\tau(e) = t$ iff $t$ is the time interval of $e$ (if any)
d. For all $e$, $\textsc{loc}(e) = l$ iff $l$ is the location of $e$ (if any)
e. For 6.44a–6.44d, the result is undefined if the eventuality lacks the respective thematic role.

From this we can define quantization for a set of eventualities in the denotation of a common noun:

(6.45) Where $\Theta = \{\textsc{ag}, \textsc{exp}, \tau, \textsc{loc}\}$:
$QUA(E_{\langle v,t\rangle}, f)$ iff $f \in \Theta.\ QUA(\{y : e \in E, y = f(e)\})$
$E$ is a quantized set of eventualities relative to $f$ if the set of $f$-values (e.g., agents, time intervals or locations) is quantized.

In the nominal domain, therefore, we can count, for instance, *two statements*, as long as we find some appropriate anchoring relation which specifies a quantized set of entities (e.g., a quantized set of agents, temporal traces, or locations). For instance, even if the temporal traces of different stating events stand in a proper part relation, as long as we can identify AT LEAST ONE other quantized set to which we can anchor each such stating event, we can count them. So as we have seen in (6.43b), we can count the two stating events via anchoring them to a quantized set of two agents.

Taking the definition in (6.45), we may then assume that, for nominal eventuality denoting predicates, the contextually provided quantizing function $\mathbf{qua}_c$ applies to some predicate of eventualities in combination with a choice function that selects an anchor, either an agent, a location or a time interval (or a moment), and outputs a subset of this set of eventualities that is quantized just in case the relevant anchor is quantized, as well.

This in effect amounts to an account in which the kind of reasoning about how to count statements in examples like (6.43) is modelled in terms of reasoning about a choice of anchoring function. For (6.43a), for instance, as argued above, pragmatic factors suggest anchoring *two statements* to a quantized set of temporal traces. This predicts that if we remove the possibility of anchoring to a quantized set of temporal traces with a cardinality of at least two, we should get an infelicitous sentence, and this prediction is borne out in (6.46) where *simultaneous* and *at 14:03* rule out anchoring to such a quantized set of temporal traces:

(6.46) ?Alex's two simultaneous statements at 14:03 that spending will increase.

Now let us compare *statement* with *belief*. Although neither (6.47a) nor (6.47b) are easy to process, (6.47a) is less felicitous.

(6.47) a. ??Alex's two beliefs that spending will increase.
b. ?Alex's and Billie's two beliefs that spending will increase.

This contrasts with the examples in (6.48) which are perfectly felicitous. Both could be followed, for example, with *namely, that it will be good for employment and other parts of the economy.*

(6.48) a. Alex's two beliefs about the fact that spending will increase.
b. Alex's and Billie's two beliefs about the fact that spending will increase.

Arguably, the reason for the degraded judgements for the sentences in (6.47) is partly due to the nature of mental states, our way of conceptualising them, and partly to the properties of natural language predicates that we use to describe them. Prima facie, for (6.47a), we cannot individuate the beliefs in terms of their experiencer, because there is only one experiencer, namely Alex. Locations do not help either, since mental states, at least from a common-sense psychological perspective, are hardly locatable. That is, when it comes to their 'location', in our example (6.47a), the two relevant mental states both would be in Alex's mind or brain, and indeed we metaphorically do assert *You are on my mind, It is only in his mind, He has some twisted thoughts in his brain*, but such a 'location', if it can be called that, is a part of the experiencer, and for individuation purposes commensurate with that experiencer.

When it comes to individuation via temporal traces, generally states denoted by individual-level predicates (in the sense of Carlson 1977) like *believe, know, have blue eyes, be intelligent*, and by analogy also the corresponding nouns like *belief*, are taken to express non-temporal or "atemporal" properties that tend to be stable and hold of individuals more or less permanently and typically for a substantial part of their existence, possibly all of it (see e.g., Chierchia 1995). In this respect, they contrast with stage-level predicates like *be happy*, predicates that express temporary properties of individuals, as well as with dynamic eventualities like *jump, recover, run, state (sth)* that are generally locatable both in time and place (for more on states see e.g., Filip 2020 and references therein). The non-temporal or "atemporal" nature of (individual-level) states is also the reason why we do not distinguish mental states like beliefs in virtue of the times over which we hold them, all else being equal. For instance, if Alex believes something or holds a belief that $p$ is true, or if Alex is intelligent is true, such states hold of Alex at some interval, which most likely corresponds to most or all of his lifespan, and crucially also at any subinterval or moment of that interval (due to the homogeneity property of states). Therefore, it would be odd or uninformative to single out one particular subinterval or moment and assert the truth of Alex's belief at that interval or moment. For all these reasons, temporal traces as anchors are unsuitable for counting of states. With (6.47b), we have at least the ability to distinguish the beliefs in virtue of experiencers, which explains why (6.47b) is more felicitous than (6.47a).

In conclusion, the difference between counting with *statement* and counting with *belief* can be attributed, in large part, to the aspectual class of the underlying eventuality: EVENT for *statement* and STATE for *belief*. This is not to say that nouns that denote states cannot be lexicalized as count, and note that *belief* is predominantly a count noun. Nor does it mean that we cannot count states via anchoring to participants, as shown with (6.47b), albeit with a flavour of a mass-to-count coercion. The difference is, indeed, more subtle. We do differentiate, for instance, between locations and temporal traces when it comes to EVENTS in a way that we do not do when it comes to mental STATES. Stating EVENTS, speech acts, with one agent are spatiotemporally located, and the relevant locations and times can be used as anchors for counting of such EVENTS. In contrast, the mental states of a single experiencer are viewed as not being spatially located (ruling out locations as an anchor for multiple beliefs when there is one single experiencer), and, as argued above, temporal traces as anchors are unsuitable for counting of states.

### 6.2.5 Summary

In this section, we have laid out a means of extending our object-centred contextualist semantics to a limited class of abstract nouns, namely those denoting informational entities like *fact* and *information*, and, in addition, to those that can also denote eventualities like *belief* and *statement*.

We have argued that informational entities (propositions) count as OBJECTS with respect to the grammar of countability. This had some important consequences. For instance, that informational object denoting nouns would not, independently of context, have a quantized counting base set. All count informational object nouns, therefore, should display *fence*-like context sensitivity, a claim for which we provided evidence. However, they differ from *interconnected* count nouns, since what counts as an informational object, unlike with fences, and hedges etc., is not constrained by mereotopological factors, such as contiguity.

Finally, developing and building upon a suggestion in Grimm, 2014, we outlined a means of counting with the eventuality denoting sense of informational object nouns in terms of anchoring to participants, locations or times related to eventualities they denote. We also showed that the aspectual class of these eventualities has important consequences for what readings are available, depending on whether the sets of e.g., agents/experiencers, locations, and temporal traces are also quantized.

# Chapter 7

# Conclusions

The main question we set out to answer in this volume was:

> **What underpins the connection between variation in count/mass lexicalization patterns and the non-canonical reflexes of the count/mass distinction that we find across and within languages?**

Our exploration of the answers to the above question leads us to provide theoretical and empirical arguments for our *object-centred contextualist* account of countability. In a nutshell, count nouns specify a quantized set of objects for counting relative to context and mass nouns do not. (Our notion of *object* is broader than that of a 'Spelke object', see further below.) In cases where the set of objects that instantiate a core property expressed by a noun is not quantized (e.g., a property like `fence` denoted by the English *fence* or *fencing*), we argued that count lexicalizations of these properties (e.g., *fence*) include a *quantizing contextual parameter* that selects a quantized set of objects for counting in each context. This facilitates the kind of context sensitivity we see with respect to individuation for such count nouns.

For mass nouns with objects in their extensions, of which we discussed many, including object mass nouns (e.g., *furniture* and *kitchenware*), granular mass nouns (e.g., *gravel*, and *rice*), filament mass nouns (e.g., *bamboo* and *grass*) and *interconnected* mass nouns (e.g., *fencing* and *hedging*), we proposed that these objects are inaccessible to counting operations, because the set of entities in the counting base set of the relevant lexical entry is not quantized. We summarise the perceptual-interactive constraints on when properties that are instantiated by objects can be lexicalized as mass below.

Furthermore, as we observed, the very classes of mass nouns just mentioned, namely those with objects in their extensions, are the very mass nouns that are felicitous with stubbornly distributive predicates. This is not a characteristic feature shared by all mass nouns, but rather a non-canonical feature associated with the mass domain. While the lexical entries of these nouns do not specify a quantized set of objects that would sanction their use in numeral constructions, they still have objects, discrete individuated entities in their extensions, as is evidenced by the observation that they are accessible to modification by means of stubbornly distributive predicates. Indeed, we propose that while denoting objects is a necessary condition on countability, it is a sufficient condition on being felicitous with at least some stubbornly distributive predicates (other lexical constraints notwithstanding). It is not a necessary condition, given that there are (mass) nouns such as *pollen* (that express properties such as `pollen`) that are infelicitous with stubbornly distributive predicates, despite being instantiated by objects.

Among the key explanatory factors that motivate why some properties that are instantiated by objects can be lexicalized as mass are, as we argue, three perceptual-interactive constraints: namely INDISTINGUISHABILITY, COLLECTIVE USES OF INSTRUMENTS and OBJECT SPLITTING. As we showed, these properties not only underpin and help explain the phenomenon of variation in count/mass lexicalization patterns, but also contribute to the explanation of why some non-canonical reflexes of countability arise. In particular, for nouns like *fence*, one reason why they do not specify a quantized set of objects independently of a context, is because *fence* objects when connected together can be used to enclose a single area such that the whole amount of enclosing fencing can, viewed from an appropriate counting perspective, also count as *a fence*. (I.e., its core property `fence` satisfies our COLLECTIVE USES OF INSTRUMENTS constraint.) Or, to take another example, an interconnected system of man-made waterways can count as *one canal* or, viewed from another counting perspective (and even in the same context), as *many canals*. For mnemonic purposes we coined the label *interconnected count nouns* for this class of nouns. *interconnected* count nouns like *fence* and *canal* denote non-quantized set of objects, and, as we argue, this is precisely what motivates why they can be straightforwardly used in the singular in the pseudopartitive measure construction, such as *2 km of fence/canal*. Such count nouns thus exhibit a behaviour that is not canonically syntactically count, in contrast to prototypical count nouns like *baby*, which, as is well known, cannot be straightforwardly used in the pseudopartitive measure construction, as we see in *#six pounds of new-born baby*.

Here, rather than summarise our theory as a whole, which we already did in chapter 1, we will highlight what we take to be the main empirical, theoretical, and methodological contributions we have made. We take them in turn in section 7.1. In section 7.2 we lay out what might be the most fruitful directions for future research building on the line of research staked out in this book.

## 7.1 Contributions

### 7.1.1 Empirical contributions

Among the main novel empirical contributions is our focus on data with granular and filament nouns, adduced and discussed in chapter 2. In particular, we draw attention to their use with stubbornly distributive predicates. Although some recognition of the use of stubbornly distributive predicates with granular and filament mass has been made (e.g., Grimm 2012, p. 7), no comprehensive study of these data has, to our knowledge, previously been undertaken. To this end, we collected data, primarily from Czech, English, Finnish and German, attesting the use of granular and filament nouns with stubbornly distributive predicates. Below are two examples repeated from chapter 2.

(2.63) Below temperatures of about -6°c it becomes pointless salting the roads, as even salt water freezes, so they put down grit. **This grit is much larger** and heavier than anything I have seen in England and I dread to think what it does to paintwork. [ukWaC]

(2.70) but this is the first square bamboo stick I've seen! And before you start wondering whether the bamboo growers had some fiendish method of making it grow this way, I can reveal (having done some work on the tip of this stick) that it's simply **round bamboo** that has been worked down to a square cross-section, probably using a sharp scraper. [ukWaC]

We also undertook a corpus study that provided evidence, for Czech and English, that granular and filament nouns are as routinely used with stubbornly distributive predicates as object mass nouns. A key, and a new, empirical observation that we made is that there is a tight connection between variation in count/mass lexicalization patterns and non-canonical grammatical reflexes of countability. For instance, a felicitous use of a mass noun with stubbornly distributive predicates is not a characteristic feature shared by all mass nouns, but rather a non-canonical feature of only some mass nouns. Another example of non-canonical grammatical reflexes of countability is the use of certain count nouns in the pseudo-partitive measure construction. We made the following two observations:

> **If a noun has non-canonical reflexes of countability, then it is highly likely that the core property underpinning this noun displays variation in its count/mass lexicalization patterns**.

> **If a core property displays variation in its count/mass lexicalization patterns, then at least some of the lexicalizations of this property (usually the mass lexicalizations) will have non-canonical grammatical reflexes of countability.**

We identified three notional classes of nouns, and the core properties that these nouns lexicalize, that evidence these observations, namely *functionally combinatorial* nouns (a class that subsumes object mass nouns), *granular and filament* nouns, and *interconnected* nouns.

Finally, we observed that one common feature of all of these nouns is that they have objects in their extensions, i.e., the core properties that they lexicalize are instantiated by objects, in our sense of this term, most importantly: namely, we defined a notion of *object* that is relevant for grammatical counting operations and which tracks what is conceived of as one entity. This notion is broad and general enough to include more entities than just what is standardly understood as Spelke objects. For instance, for us, *objects* includes cups and balls, but also shelves in a bookcase (that may be connected together and so do not move independently of one another), rooms in a house (which are connected, but are not typically movable at all), and also mortars and pestles (that are not mereotopologically connected at all, but do, together, serve a single function, and hence are often viewed as a single unit). We also emphasised that entities that are small and even indistinguishable from one another relative to our perceptual acuity count as objects in our sense, even if they are not taken to be prototypical examples of Spelke objects. These included grains of sand and pollen, and blades of grass. (For a different view see Grimm (2014), who characterises granulars like *pollen* as clusters of Maximally Strongly Self-Connected entities.)

Our study of the lexicalization patterns of the core properties like `furniture`, `kitchenware`, `sand`, `grass`, and `fence`, as attested across a large swath of data that we collected, led us to the following empirical generalisations: namely, a (concrete) core property that is lexicalized as either count or mass must be instantiated by objects, and a noun must denote objects if it has non-canonical reflexes of countability, be it in the mass or count domain. I.e., we do not find count/mass lexical variation underpinned by properties of substances (e.g., `water`), and neither do we find non-canonical reflexes of countability for substance denoting mass nouns, in number marking languages at least.

This still left us with the question of why only some properties that are instantiated by objects are ever lexicalized as mass. We addressed this question by proposing a system of perceptual-interactive constraints, which will be elaborated upon below under our theoretical contributions.

### 7.1.2 Theoretical contributions

As already highlighted by the name for our account, objects play a central role in the theory. Indeed, it is one of our central claims, and theoretical contributions, that the notion of *object*, used in our specific technical sense, should play a more central role in theories of countability.

This was motivated by both the count/mass lexical variation data, and the empirical evidence for the broader than previously acknowledged selectional restrictions for stubbornly distributive predicates. We argued that the dividing line between properties that show variation in their count/mass lexicalization patterns, on the one hand, and those that do not, on the other hand, does not align with the distinctions that are central to many state-of-the-art theories of countability, including whether a core property is stably atomic in the sense of Chierchia (2010), or whether a mass noun that lexicalizes that property is *neat* in the sense of Landman (2011). Likewise, we argued that the dividing line between nouns that have non-canonical reflexes of countability, on the one hand, and those that do not, on the other hand, and the properties that they denote, also does not align with such distinctions. For instance, whether a mass noun is felicitous with a stubbornly distributive predicate seems to be independent of whether the noun is *neat* mass or *mess* mass in the sense of Landman (ibid.). What does align neatly with the empirical data, however, as we propose, is whether a noun has objects, in our technical sense, in its extension, or whether the core property the noun lexicalizes is instantiated by such objects.

We propose that the context-sensitivity of common nouns, which includes both general contextual domain restrictions and the kind of context-sensitivity with respect to what counts as *one* (as shown by *interconnected* count nouns such as *fence*, for instance), can be modelled within a single contextualist model. Our contextualist model builds upon and further develops that originally proposed by Kaplan (1989) to model indexical and demonstrative expressions. Indeed, one of the contributions we have made regarding the development of semantic frameworks is encoding a Kaplanian contextualist semantics in a modest extension of Gallin's $\mathrm{TY}_2$ logic, something previously only done, to our knowledge in Montague Grammar (e.g., Bennett 1978). The extensions were twofold: first, we needed product types in order to model Kaplanian contexts as tuples of constants, and, second, we needed to separate types for worlds and times, unlike Gallin who has a single type $\boldsymbol{s}$ for world-time pairs, because times of, e.g., utterance, but not possible worlds are a value of at least one of the Kaplanian contextual parameters. The result was a compositional semantics based upon a $\mathrm{TY}_{3\times}$ logic.

We also provided a formal characterisation of two contextual parameters that we argued should be added to the standard Kaplanian ones (e.g., time, location, speaker etc.). One contextual parameter that we added governs nominal contextual domain restriction (following Stanley 2002; Stanley & Gendler Szabó 2000). This we formalised as $\mathbf{mod_c}$, a function that intersects the property with some other salient restriction (e.g., the property of being on the shelf for *books*). The other parameter, we argued, was needed to govern variation in individuation criteria, such as that displayed by *interconnected* count nouns like *fence* and *hedge*: namely, our *quantizing contextual parameter*, $\mathbf{qua_c}$. This, we proposed, applies to a core property that is instantiated by objects and yields a property that is instantiated by a quantized set of objects at each world (if instantiated at all in that world), and so it allows us to capture the observation that the extensions of some count nouns vary with context with respect to what counts as *one*.

Our contextualist semantics, we argued, differs in some key respects from the theoretically full-fledged contextualist approach in the count/mass literature, which was first worked out by Rothstein 2010. In particular, unlike in ibid., our approach does not necessitate a type distinction between the interpretations of count and mass nouns (all nouns denote Kaplanian characters). Furthermore, the contextual parameter that we proposed for governing individuation, namely, our *quantizing contextual parameter* $\mathbf{qua_c}$, is a property modifier that assures that the set of single objects denoted by each count noun in a sentence be quantized, even if the union of all such sets was not. In contrast, in ibid., similar intuitions about what counts as *one* from 'a particular counting perspective' (in her terms) in a given context constitutes a subset of the nominal domain, and it is captured by means of *context* $\mathbf{k}$ in the lexical entries of count nouns, which is intersected with the number-neutral extension of the noun.

We also provided novel arguments for a bipartite approach to the lexicon, namely where lexical entries record both what is in the extension of a noun at a world and in a context, and what counts as 'one' for that noun (the counting base set) at that world and context.

One argument we provided was based upon variation in count/mass lexicalization patterns, and the other was based on the need to keep general contextual domain restriction (our $\textbf{mod}_c$) separated in its effects from the contextual parameter governing individuation conditions (our *quantizing contextual parameter*, $\textbf{qua}_c$). We furthermore showed how a bipartite approach to the lexicon is compatible with compositional semantics as showed by our applications to plural morphology, numeral constructions, and to combining nouns with stubbornly distributive predicates. Extending this approach beyond number marking languages, we then accounted for numeral constructions in both Mandarin Chinese (an obligatory classifier language) and to Yudja (a 'free numeral' language).

Given that objects play such a central role in our theory, it was incumbent upon us to address abstract nouns. Our object-centred contextualist approach, we showed, makes predictions regarding context sensitivity when counting with nouns that denote informational entities like *belief, statement, fact, proposition,* and *information*. We argued that, grammatically speaking, informational entities such as propositions are treated as objects. However, there is nothing akin to a bounded Spelke object in the informational domain, and as a result, what counts as, say, *one fact* or *one piece of information* will be sensitive to one's counting perspective in a way comparable to concrete *interconnected* count nouns like *fence*. This prediction seems to be borne out. For informational nouns that can also denote eventualities such as *statement*, we took the intuitive notion of ANCHORING in Grimm 2014, and developed a formal account of anchoring that makes firm predictions about on what basis eventuality-denoting nouns can be counted, and links the semantics of eventuality-denoting nominals to the literature on thematics roles, as well as earlier insights from Davidson and Krifka. We showed that subtle countability distinctions arise for eventuality denoting nouns based upon the aspectual class of the underlying eventuality, its thematic role structure, and general pragmatic reasoning. We hope that the modest amount of progress made here will provide a fruitful avenue for further research.

Finally, we have provided a means of getting a theoretical handle on the vexing phenomena of count/mass variation and the constraints upon it. We proposed three such perceptual-interactive constraints (that bear relations to those proposed by Wierzbicka 1988), namely INDISTINGUISHABILITY, COLLECTIVE USES OF INSTRUMENTS and OBJECT SPLITTING. We argued that for a core property to be lexicalized as a count noun (in some languages at least) requires that this core property be instantiated by objects, and that it satisfies at least one of these perceptual-interactive constraints. We then refined this view via the development of a weighted scoring model over these constraints so as to be able to also predict the relative propensity for an object-instantiated core property to be lexicalized as mass if it satisfies at least one of the constraints. This allowed us to explain, for instance, why `pollen` and `sand` are seldom if ever lexicalized as count nouns, despite being instantiated by objects.

### 7.1.3 Methodological contributions

Methodologically, the main contributions of this volume concern the integration of corpus linguistic methods to support and inform our theoretical work on countability. This builds on the relatively limited amount of similar work done in the domain of countability, including Grimm 2014, 2016, Kulkarni et al. 2016, Zamparelli 2020, and work on the Bochum English Countability Lexicon (BECL) Husić 2020; Kiss et al. 2014. In chapter 2, we argued, based upon a corpus study in Czech and English, that, when it comes to the mass domain, granular and filament mass nouns are as deserving of attention as object mass nouns when it comes to their non-canonical countability reflexes, given their perhaps surprising compatibility with stubbornly distributive predicates, which indicates that they also take their denotation from the domain endowed with discrete objects.

In chapter 5, we develop tools based on techniques used in distributional semantics to probe our hypotheses regarding the cognitive-level features of properties underpinning concrete common nouns. For instance, our INDISTINGUISHABILITY perceptual-interactive constraint emphasises that entities in the extensions of nouns are conceived of as homogeneous, small, and often occur in clusters. Adapting tools from distributional semantics, we developed a means of using a corpus to estimate the extent to which properties satisfy this constraint, by looking at the distributions of the nouns that lexicalize these properties have with particular modifiers that evoke INDISTINGUISHABILITY. These included modifiers like *indistinguishable* or those that occur in the pseudo-partitive measure construction with measure constructions like *heap (of rice/chairs)*, *dusting (of sugar)*, and verbal predicates such as *scattered (the rice/furniture across the floor)*. Based upon this distributional semantics method for estimating the extent to which properties satisfy our three perceptual-interactive constraints, we presented preliminary work for how this can be used to extrapolate an ordering over properties that ranks them in terms of their propensity to be lexicalized as mass across and within languages. To our knowledge, this is the first empirically grounded attempt to do so.

## 7.2 Future directions

While we think that this volume has made a reasonable amount of progress with respect to the questions we sought to answer, much remains to be done, including along avenues that are now more salient given our novel empirical insights and consequently innovative theoretical positions we argued for. We take these briefly in turn.

**Developing and refining the perceptual-interactive constraints.** We propose three perceptual-interactive constraints, namely, INDISTINGUISHABILITY, COLLECTIVE USES OF INSTRUMENTS, and OBJECT-SPLITTING, as playing a key role in motivating variation in count/mass lexicalization patterns. We hope they will be useful in the characterisation of count/mass theories in the future. However, we do not rule out that future research will lead to their sharpening, and perhaps better formulation, nor that more than three perceptual-interactive constraints may be needed for a fuller picture.

**Further developing corpus methodologies.** As mentioned above, we contributed to a fairly small range of previous corpus-based analyses of the count/mass distinction. There is a large potential for furthering our understanding of the theory of countability in natural language semantics by means of the tools of corpus linguistics, as well as techniques and evaluation (statistical) methods associated with it, including those leaning on distributional semantics developed here. For instance, using large corpora for multiple languages has proven fruitful in getting a better picture of variation with respect to count/mass lexicalization patterns, not only when it comes to classes of concrete nouns explored here, but also abstract nouns.

**Extending the account to a fuller array of abstract nouns.** Our immediate future goals include extending our analysis to a wider range of abstract nouns, focusing on those that denote eventualities and further examining the effect of aspectual class on count/mass variation. In particular, one topic in need of further investigation is what constraints there are on anchoring eventualities to participants, time intervals and locations, and whether there is a variation in anchoring parameters within and across languages, and if so, what effect, if any, they have on variation in the count/mass lexicalization.

**Accounting for polysemy.** Another issue that arises, especially for abstract nouns, is polysemy. Most work on countability for polysemous nouns has focused entirely on count nouns and sense selection. For instance, when *two books* is used to count physical things, informational things or both (see, e.g., Asher, 2015; Chatzikyriakidis & Luo, 2018; Chatzikyriakidis et al., 2025; Chatzikyriakidis & Luo, 2015; Gotham, 2014, 2017, 2021; Liebesman & Magidor, 2017, 2019; Pustejovsky, 1995). What still is to be done is the integration of accounts of polysemous nouns within a theory of countability. This arguably will require a richer semantic theory than the one we have assumed in this volume. Our bipartite lexical entries are effectively very simple frames with two 'attributes': namely, the counting base and the extension. A promising avenue for analysing countability for polysemous nouns is therefore to make use of more richly typed frame-based semantics such as Type Theory with Records (Cooper, 2012, 2023). For applications to polysemy, see Cooper 2007, 2011; Sutton 2022, 2024a.

**Accounting for dual life nouns.** Relatedly, much is still to be done on the semantics of dual life nouns like *stone, paper, cake, rope* in English. Indeed, it is an open question whether such nouns are polysemous, and so can be analysed within frameworks that cover polysemous nouns, or, as proposed by Chierchia (2010), dual life nouns are analysed in terms of covert operators. For instance, that *rope* denotes rope stuff, but salient partitions can be extracted from this denotation in context to get the count sense of *rope*.

# Appendix A

# List of definitions

## A.1 Objects and properties

We define a broad conception of a set of objects, $O^+$, that includes Spelke objects, as well as non-cohesive objects and connected objects:

(4.9) **Objects (final version):**
$\mathcal{I}(O^+)(w) \subseteq D_e$ such that:
$\forall x.x \in O^+_w \leftrightarrow$ *$x$ is a Spelke object or*
*$x$ is a physical entity that fulfils some functional role.*

This set of objects is used to define properties that have objects in their extensions:

(4.18) **Object extensional property.**
$\mathtt{P} : \langle s, et \rangle$ *is object-extensional iff:* $\exists w.\exists X.X \subseteq O^+_w \wedge X \subseteq \mathtt{P}_w$

For a property, $\mathtt{P}$, that, in our broad sense, has objects in its extension, we use $\mathtt{P}_{obj}$ as a convenient abbreviation for the property *of* those objects (i.e., at each world, the extension of $\mathtt{P}$, intersected with the set of objects):

(4.19) $\mathtt{P}_{obj} =_{def} \lambda w.\lambda x.\mathtt{P}(w)(x) \wedge O^+(w)(x)$

## A.2 Mereological definitions

Classical Extensional Mereology (CEM) is the formal theory of parts and sums. For an overview of the developments of CEM, see, for instance, Champollion & Krifka 2016 and references therein.

The sum operation for type $\tau$, $\sqcup_\tau$, is a complete, commutative, idempotent, and associative operation between two entities of type $\tau$ (Krifka, 1989, p. 77)

(We drop typing subscripts below).

(A1) $\forall x \forall y[(\exists P \exists P'[P(x) \wedge P'(y)]) \rightarrow \exists z[x \sqcup y = z]]$ (Completeness)
$\forall x \forall y[x \sqcup y = y \sqcup x]$ (Commutativity)
$\forall x \forall y[x \sqcup x = x]$ (Idempotency)
$\forall x \forall y \forall z[(x \sqcup y) \sqcup z = x \sqcup (y \sqcup z)]$ (Associativity)

From this, the part relation, $\sqsubseteq$, the proper part relation, $\sqsubset$, and overlap $\circ$ relation can be defined (Krifka, 1989).

(A2) $\forall x \forall y[x \sqsubseteq y \leftrightarrow x \sqcup y = y]$ (Part)
$\forall x \forall y[x \sqsubset y \leftrightarrow x \sqsubseteq y \wedge x \neq y]$ (Proper part)
$\forall x \forall y[x \circ y \leftrightarrow \exists z[z \sqsubseteq x \wedge z \sqsubseteq y]]$ (Overlap)

A quantized predicate of type $\langle e, t \rangle$:

(3.15) $QUA(P) \leftrightarrow \forall x.\forall y.P(x) \wedge P(y) \rightarrow \neg x \sqsubset y$ (ibid.)

A disjoint predicate of type $\langle e, t \rangle$:

(3.16) $DIS(P) \leftrightarrow \forall x.\forall y.P(x) \wedge P(y) \wedge x \neq y \rightarrow \neg x \circ y$
(e.g. Landman, 2011)

The set of relative atoms for a predicate of type $\langle e, t \rangle$:

(4.76) $AT(P) = \lambda x[P(x) \wedge \forall y[P(y) \wedge y \sqsubseteq x \rightarrow x = y]]$

An object atomic property relative to a world (see Krifka 1989 for a similar formulation):

(4.77) $\mathtt{P}$ is *object atomic at* $w$ iff $\exists X[X \subseteq O^{+} \wedge AT(\mathtt{P}_w) = X]$

## A.3 Contexts

(4.25) **Kaplanian contexts enriched with a contextual domain restriction parameter and a quantizing contextual parameter** are tuples of type $e \times e \times i \times \langle\langle s, et \rangle, \langle s, et \rangle\rangle \times \langle\langle s, et \rangle, \langle s, et \rangle\rangle$ of the form $\langle c_{utt}, c_{add}, c_{time}, c_{dom}, c_{qua} \rangle$.

Where '$c_{utt}$' is an utterer, '$c_{add}$' an addressee, and the index governing nominal domain restriction, $c_{dom}$ is defined as follows:

(4.22) $c_{dom} := \lambda P_{\langle s,et \rangle}.\lambda w.\lambda x.\mathtt{P}(w)(x) \wedge \mathtt{Q}(w)(x)$ such that:
a. There is a $w' \in \mathcal{D}_s$ where $\mathtt{P}(w') \cap \mathtt{Q}(w') \neq \varnothing$ and

b. $\mathtt{Q}$ is salient/relevant to $\mathtt{P}$.

To define the *quantizing contextual parameter*, $c_{qua}$, we first define the maximally quantized subset relation $\subseteq_{max.QUA}$, and therewith a *maximally quantizing function* $f_{qua}$:

(4.26) $$P \subseteq_{max.QUA} Q \leftrightarrow \; P \subseteq Q \wedge QUA(P) \wedge \forall X \subseteq Q[X \supseteq P \wedge QUA(X) \rightarrow X = P]$$

(4.27) $f_{qua} : \langle\langle s, et\rangle, \langle s, et\rangle\rangle$ is a maximally quantizing function iff: for all $\mathtt{P} : \langle s, et\rangle$, and for all $w$, $f_{qua}(\mathtt{P})(w) \subseteq_{max.QUA} \mathtt{P}(w)$

(4.28) $c_{qua} := \lambda P_{\langle s,et\rangle}.\lambda w.\lambda x.f_{qua}(\mathtt{P})(w)(x)$ such that $f_{qua}$ is a maximally quantizing function

We make use of the following abbreviations for the type of enriched Kaplanian contexts and the projection functions to access the indices in these contexts:

(4.31) **Type abbreviation convention (contexts):**
$e \times e \times i \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle \times \langle\langle s, et\rangle, \langle s, et\rangle\rangle \mapsto c$

(4.32) **Context projection functions.**
For a context $c$ of type $e \times e \times i \times \langle\langle s, et\rangle, \langle s, \langle et\rangle\rangle\rangle \times \langle\langle s, et\rangle, \langle s, \langle et\rangle\rangle\rangle$:

a. $\mathbf{utt}_c =_{def} \pi_1(c)$
b. $\mathbf{add}_c =_{def} \pi_1(\pi_2(c))$
c. $\mathbf{time}_c =_{def} \pi_1(\pi_2(\pi_2(c)))$
d. $\mathbf{dom}_c =_{def} \pi_1(\pi_2(\pi_2(\pi_2(c))))$
e. $\mathbf{qua}_c =_{def} \pi_2(\pi_2(\pi_2(\pi_2(c))))$

## A.4 Lexical entries

### A.4.1 Mono-partite lexical entries

(4.34) Object-centred Quantizing Function (mono-partite lexical entries):

$$\mathcal{Q}_c = \begin{cases} \lambda \mathtt{P}\lambda c\lambda w\lambda x[\mathbf{dom}_c(\mathtt{P}_{obj})(w)(x)] & \text{if } \mathtt{P}(w) \cap O^+(w) \neq \varnothing, \text{ and } QUA(\mathtt{P}_{obj}(w)) \\ \lambda \mathtt{P}\lambda c\lambda w\lambda x[\mathbf{qua}_c(\mathbf{dom}_c(\mathtt{P}_{obj}))(w)(x)] & \text{if } \mathtt{P}(w) \cap O^+(w) \neq \varnothing, \text{ and } \neg QUA(\mathtt{P}_{obj}(w)) \\ \bot & \text{otherwise.} \end{cases}$$

(4.40) Object-neutral Function (mono-partite lexical entries):

$$\mathcal{N}_c \quad = \quad \lambda \mathtt{P}.\lambda c \lambda w \lambda x[\mathbf{dom}_c(\mathtt{P})(w)(x)]$$

## A.4.2 Bipartite lexical entries

(4.45) Bipartite lexical entry schema:

$$\lambda c \lambda w \lambda x \left\langle \mathtt{P}(w)(c)(x),\ \lambda y.\mathtt{Q}(w)(c)(y) \right\rangle \qquad : \langle c, \langle s, \langle e, \langle t \times et\rangle\rangle\rangle\rangle$$

Where $\mathtt{P}$ is the nominal property and $\mathtt{Q}$ is the property of what counts as one $\mathtt{P}$. The lexical entry schema for common nouns that are interpreted at type $\langle c, \langle s, \langle e, \langle t \times et\rangle\rangle\rangle\rangle$

In order to aid readability, we introduce the following notational conventions. First, we re-write (4.45) in matrix format, where 'ext' and 'cbase' label the extension and counting base fields respectively:

(4.46) Bi-partite lexical entry schema (alternative notation):

$$\lambda c \lambda w \lambda x \begin{bmatrix} \text{ext} & \mathtt{P}(w)(c)(x) \\ \text{cbase} & \lambda y.\mathtt{Q}(w)(c)(y) \end{bmatrix}$$

Where $\mathtt{P}$ is the nominal property and $\mathtt{Q}$ is the property of what counts as one $\mathtt{P}$.

We then use the labels 'ext' and 'cbase' in lieu of the projection functions $\pi_1$ and $\pi_2$, respectively:

(4.47) a. $\pi_1(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = \text{ext}(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = p$

b. $\pi_2(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = \text{cbase}(\begin{bmatrix} \text{ext} & p \\ \text{cbase} & Q \end{bmatrix}) = Q$

(4.48) Object-centred Quantizing Function (bipartite lexical entries):

$$\mathcal{Q}_c = \begin{cases} \lambda \mathtt{P} \lambda c \lambda w \lambda x. \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathtt{P}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathtt{P}_{obj}(w)(y) \end{bmatrix} & \text{if } \mathtt{P}_{obj}(w) \neq \varnothing, \text{ and } QUA(\mathtt{P}_{obj}(w)) \\ \lambda \mathbf{P} \lambda c \lambda w \lambda x. \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathtt{P}_{obj})(w)(x) \\ \text{cbase} & \lambda y.\mathbf{qua}_c(\mathtt{P}_{obj})(w)(y) \end{bmatrix} & \text{if } \mathtt{P}_{obj}(w) \neq \varnothing, \text{ and } \neg QUA(\mathtt{P}_{obj}(w)) \\ \perp & \text{otherwise.} \end{cases}$$

(4.51) Object-neutral Function (bipartite lexical entries):

$$\mathcal{N}_c = \lambda \mathrm{P} \lambda c \lambda w \lambda x. \begin{bmatrix} \text{ext} & \mathbf{dom}_c(\mathrm{P})(w)(x) \\ \text{cbase} & \lambda y.\mathrm{P}(w)(y) \end{bmatrix}$$

# A.5 Extensions to the system

## A.5.1 Non-number-marking languages

(6.8) The 'up' operator (based on Chierchia 2015)

a. $^{\cup} : \langle\langle s, e\rangle, \langle s, \langle e, t\rangle\rangle\rangle$ – a function from kinds to properties.
b. $^{\cup} = \lambda k_{:\langle s,e\rangle}.\lambda w.\lambda x.x \sqsubseteq k_w$ if $k_w$ is defined, $\perp$ otherwise.

(6.9) The 'down' operator (based on ibid.)

a. $^{\cap} : \langle\langle s, \langle e, t\rangle\rangle, \langle s, e\rangle\rangle$ – a function from properties to kinds.
b. $^{\cap} = \lambda \mathcal{P}_{:\langle s,\langle e,t\rangle\rangle}.\lambda w.\bigsqcup P(w)$

With which, we define 'up' and 'down' operators that apply to bipartite lexical entries (that have a product type), hence, $^{\cup\times}$ and $^{\cap\times}$:

(6.10) a. $^{\cup\times} : \langle\langle c, \langle s, \langle e \times \langle e, t\rangle\rangle\rangle\rangle, \langle c, \langle s, e\rangle\rangle\rangle$
b. $^{\cup\times} = \lambda \mathfrak{K} \lambda c \lambda w \lambda x.{}^{*}\text{cbase}(\mathfrak{K})(c)(w)(x) \wedge {}^{\cup}\text{ext}(\mathfrak{K})(c)(w)(x)$
if $\mathfrak{K}(w)$ is defined, $\perp$ otherwise.

(6.12) a. $^{\cap\times} : \langle\langle s, \langle e, \langle t \times \langle e, t\rangle\rangle\rangle\rangle, \langle s, e\rangle\rangle$
b. $^{\cap\times} = \lambda \mathfrak{P}.\lambda w.\bigsqcup(\text{ext}(\mathfrak{P})(w))$

## A.5.2 Abstract nouns:

Schmitt (2013) defines a plural structure for a domain of any type $a$:

(6.33) $pl_a : (\mathcal{P}(\mathcal{D}_a)\backslash\varnothing) \rightarrow \mathbf{PL}_a$ (ibid.)

For abstract nouns that denote eventualities (on at least one of their senses), the following functions access participants, locations, and times (if applicable):

(6.44) $\Theta = \{\text{AG}, \text{EXP}, \tau, \text{LOC}\}$ such that:

a. For all $e$, $\text{AG}(e) = x$ iff $x$ is the agent of $e$
b. For all $e$, $\text{EXP}(e) = x$ iff $x$ is the experiencer of $e$ (if any)
c. For all $e$, $\tau(e) = t$ iff $t$ is the time interval of $e$ (if any)
d. For all $e$, $\text{LOC}(e) = l$ iff $l$ is the location of $e$ (if any)
e. For 6.44a–6.44d, the result is undefined if the eventuality lacks the respective thematic role.

From which we define when a nominal predicate of eventualities is quantized relative to a participant, location or time:

(6.45) Where $\Theta = \{\text{AG}, \text{EXP}, \tau, \text{LOC}\}$:
$QUA(E_{\langle v,t \rangle}, f)$ iff $f \in \Theta. QUA(\{y : e \in E, y = f(e)\})$
$E$ is a quantized set of eventualities relative to $f$ if the set of $f$-values (e.g., agents, time intervals or locations) is quantized.

# Appendix B

# Results: stubbornly distributive predicate corpus study

## B.1 NLP code for English

The following code uses the spaCy package for Python. `nlp_obj` is an object that has be processed using this package via `nlp()`.

```
def parse_list_func(nlp_obj):
  parse_list = []
  for token in nlp_obj:
        token_text = token.text
        token_lemma = token.lemma_
        token_pos = token.pos_
        token_dep = token.dep_
        token_head = token.head.lemma_
        token_head_index = token.head.i
        token_index = token.i
        parse_list.append([token_text, token_lemma, token_pos,
        token_head,token_dep, token_head_index,token_index])
   return parse_list
```

For each parsed string, the function returns a list with the same number of items as in the string. For each of these items, the function returns a list of length 7 containing the lexical item (e.g., *cats*), the lemma for the item (e.g., *cat*), the POS tag, the dependency relation that item has (e.g., *dobj* for *cats* in *likes cats*), the item on which it depends, the position in the string of the item on which it depends, and the position in the string of the item itself (e.g., in *Alex likes cats*, token.i = 2 and token.head.i = 1).

This program defines adjectival modification as follows: the modifier lemma is in the parse, has amod dependency and the head number index is for a noun in the noun list:

```
def find_mod(nlp_obj):
    parse_list = parse_list_func(nlp_obj)
    matches_str = matcher(nlp_obj)

    noun_pos_dict = {}
    for ent in noun_list:
        noun_pos_dict[ent] = []

   noun_mods_dict = {}
    for ent in noun_list:
        noun_mods_dict[ent] = []

    mods_pos_dict = {}
    for item in mod_list:
        mods_pos_dict[item] = []

    for tup in matches_str:
        for ent in noun_list:
            if nlp_obj.vocab.strings[tup[0]] == ent:
                noun_pos_dict[ent].append(tup[1])

    for tup in matches_str:
        for ent in mod_list:
            if nlp_obj.vocab.strings[tup[0]] == ent:
mods_pos_dict[ent].append(tup[1])

    for item in parse_list:
        if item[1] in mod_list and item[-4] in noun_list and item[-3]
== 'amod':
            mod_pos = item[-1]
            noun = item[-4]
            noun_mods_dict[noun].append(nlp_obj[mod_pos].lemma_)
    return noun_mods_dict
```

## B.2 Noun frequencies for Czech and English

Table B.1: Estimated frequencies of noun lemmas for the relevant sense of the noun in the enTenTen20 corpus. The margin of error is calculated based upon the standard error of a random sample of 100 or 300 sentences containing the noun and annotated by hand for whether this was the relevant sense. Test statistic: MoE $= z.\sqrt{\frac{p(1-p)}{n}}$ for proportion $p$ and sample size $n$ with critical value $z$ calculated for a 99% confidence interval. Where we found no false hits in a sample size of 100, we report the margin of error as less than 2.56%.

| Noun | Estimated Frequency | Margin of Error (%) | Sample accuracy (size) |
|---|---|---|---|
| air | 3853051 | 7.12 | 193 (300) |
| ammunition | 281542 | 3.14 | 286 (300) |
| asparagus | 63474 | 5.06 | 260 (300) |
| ball | 2282042 | 6.58 | 220 (300) |
| bamboo | 162132 | 7.06 | 197 (300) |
| bridge | 1587485 | 6.19 | 233 (300) |
| car | 9033605 | 3.53 | 282 (300) |
| celery | 63470 | 5.99 | 239 (300) |
| chair | 1196149 | 7.38 | 132 (300) |
| clover | 51475 | 5.36 | 254 (300) |
| crockery | 19016 | 3.44 | 283 (300) |
| custard | 40779 | 3.34 | 284 (300) |
| cutlery | 42025 | 4.18 | 274 (300) |
| dog | 4042325 | 3.71 | 280 (300) |
| equipment | 4018708 | 2.67 | 290 (300) |
| flat | 154555 | 7.44 | 149 (300) |
| footwear | 151826 | 2.54 | 291 (300) |
| furniture | 964879 | 2.08 | 294 (300) |
| garlic | 330172 | 3.88 | 278 (300) |
| gas | 3471930 | 5.31 | 255 (300) |
| glassware | 34262 | 2.67 | 290 (300) |
| gold | 1728670 | 6.44 | 225 (300) |
| grass | 950039 | 6.57 | 93 (100) |
| gravel | 244724 | 1.90 | 295 (300) |
| grit | 50989 | 7.37 | 130 (300) |
| hay | 176679 | 5.41 | 253 (300) |
| jewellery | 222917 | 1.90 | 295 (300) |
| livestock | 408620 | <2.56 | 100 (100) |
| luggage | 238007 | 1.90 | 295 (300) |
| mud | 402019 | 5.41 | 253 (300) |
| oil | 5680405 | 2.08 | 294 (300) |
| pasta | 267274 | 2.08 | 294 (300) |
| pen | 566409 | 6.41 | 226 (300) |
| pollen | 148560 | 3.61 | 98 (100) |
| poultry | 146925 | 7.25 | 183 (300) |
| rice | 728359 | 5.06 | 260 (300) |
| rubble | 106185 | 7.37 | 91 (100) |
| sand | 981935 | 5.83 | 243 (300) |
| shampoo | 174772 | 3.61 | 98 (100) |
| shirt | 867420 | 3.61 | 98 (100) |
| steel | 1737681 | 5.05 | 96 (100) |
| wheat | 370468 | 6.72 | 214 (300) |

Table B.2: Estimated frequencies of Czech noun lemmas for the relevant sense of the noun in the csTenTen17 corpus. The margin of error is calculated based upon the standard error of a random sample of 100 or 300 sentences containing the noun and annotated by hand for whether this was the relevant sense. Test statistic: MoE $= z.\sqrt{\frac{p(1-p)}{n}}$ for proportion $p$ and sample size $n$ with critical value $z$ calculated for a 99% confidence interval. Where we found no false hits in a sample size of 100, we report the margin of error as less than 2.56%.

| Noun | Estimated Frequency | Margin of Error (%) | Sample accuracy (size) |
|---|---|---|---|
| auto | 3798310 | <2.56 | 100 (100) |
| bambus | 31632 | 3.61 | 98 (100) |
| bláto | 67282 | 1.71 | 296 (300) |
| byt | 2526144 | <2.56 | 100 (100) |
| chřest | 24938 | <2.56 | 100 (100) |
| drůbež | 54217 | 2.56 | 99 (100) |
| jablko | 212710 | 5.05 | 96 (100) |
| košile | 207390 | <2.56 | 100 (100) |
| kukuřice | 83393 | <2.56 | 100 (100) |
| most | 667458 | 6.63 | 218 (300) |
| munice | 82592 | 2.56 | 99 (100) |
| míč | 641766 | <2.56 | 100 (100) |
| nábytek | 672318 | <2.56 | 100 (100) |
| nádobí | 213056 | <2.56 | 100 (100) |
| obuv | 259255 | 2.56 | 99 (100) |
| ocel | 359688 | 0.86 | 299 (300) |
| olej | 1113258 | <2.56 | 100 (100) |
| pero | 101030 | 7.36 | 128 (300) |
| pes | 1973676 | 3.14 | 286 (300) |
| plyn | 776891 | 2.56 | 99 (100) |
| pudink | 29470 | <2.56 | 100 (100) |
| pyl | 39761 | 2.56 | 99 (100) |
| písek | 282423 | 3.61 | 98 (100) |
| příbor | 38121 | 3.61 | 98 (100) |
| pšenice | 66481 | <2.56 | 100 (100) |
| rýže | 171692 | <2.56 | 100 (100) |
| sláma | 61996 | 9.2 | 85 (100) |
| suť | 29019 | <2.56 | 100 (100) |
| tekutina | 216522 | <2.56 | 100 (100) |
| tráva | 366704 | 5.05 | 96 (100) |
| vybavení | 1097304 | <2.56 | 100 (100) |
| vzduch | 1162591 | <2.56 | 100 (100) |
| zlato | 590502 | 6.99 | 92 (100) |
| šampon | 124227 | <2.56 | 100 (100) |
| šindel | 22902 | <2.56 | 100 (100) |
| šperk | 281115 | 2.4 | 292 (300) |
| šrot | 41553 | 3.61 | 98 (100) |
| štěrk | 56813 | <2.56 | 100 (100) |
| židle | 367149 | 3.96 | 277 (300) |

Table B.3: Stub scores for English (enTenTen20 corpus). Scores are calculated from the product of the estimated percentage of occurrence based on a cleaned sample and the total noun frequency for the relevant sense and Stub entropy. Stub entropy is a measure of variation with respect to which stubbornly distributive predicates are used with the noun.

| Noun | Stub frequency | Stub percentage | Stub Entropy | Stub Score |
|---|---|---|---|---|
| air | 7 | 0.0002 | 1.45 | 0.0003 |
| ammunition | 152 | 0.054 | 1.46 | 0.0791 |
| asparagus | 83 | 0.1308 | 1.84 | 0.2406 |
| ball | 29254 | 1.2819 | 1.33 | 1.7045 |
| bamboo | 229 | 0.1412 | 1.89 | 0.2662 |
| bridge | 17295 | 1.0894 | 1.41 | 1.532 |
| car | 48939 | 0.5417 | 1.15 | 0.6233 |
| celery | 30 | 0.0473 | 1.76 | 0.0834 |
| chair | 7127 | 0.5958 | 1.45 | 0.8638 |
| clover | 72 | 0.1399 | 1.55 | 0.2166 |
| crockery | 16 | 0.0841 | 0.92 | 0.0774 |
| custard | 5 | 0.0123 | 1.12 | 0.0138 |
| cutlery | 31 | 0.0738 | 1.27 | 0.0939 |
| dog | 60020 | 1.4848 | 1.22 | 1.8087 |
| equipment | 6157 | 0.1532 | 1.01 | 0.1547 |
| flat | 3753 | 2.4283 | 1.1 | 2.6804 |
| footwear | 42 | 0.0277 | 1.78 | 0.0494 |
| furniture | 1777 | 0.1842 | 1.21 | 0.2224 |
| garlic | 44 | 0.0133 | 1.34 | 0.0178 |
| gas | 11 | 0.0003 | 1.52 | 0.0005 |
| glassware | 32 | 0.0934 | 1.38 | 0.1288 |
| gold | 472 | 0.0273 | 0.94 | 0.0256 |
| grass | 14518 | 1.5282 | 0.65 | 0.9911 |
| gravel | 777 | 0.3175 | 0.97 | 0.3092 |
| grit | 107 | 0.2098 | 1.3 | 0.2723 |
| hay | 73 | 0.0413 | 1.04 | 0.0431 |
| jewellery | 108 | 0.0484 | 1.36 | 0.0658 |
| livestock | 1398 | 0.3421 | 0.79 | 0.2699 |
| luggage | 600 | 0.2521 | 1.11 | 0.2805 |
| mud | 6 | 0.0015 | 1.6 | 0.0024 |
| oil | 16 | 0.0003 | 1.45 | 0.0004 |
| pasta | 749 | 0.2802 | 1.55 | 0.435 |
| pen | 2795 | 0.4935 | 1.62 | 0.7991 |
| pollen | 63 | 0.0424 | 1.67 | 0.0709 |
| poultry | 93 | 0.0633 | 1.16 | 0.0737 |
| rice | 256 | 0.0351 | 1.53 | 0.0537 |
| rubble | 140 | 0.1318 | 1.21 | 0.1589 |
| sand | 103 | 0.0105 | 1.31 | 0.0137 |
| shampoo | 32 | 0.0183 | 1.47 | 0.0269 |
| shirt | 2988 | 0.3445 | 1.44 | 0.4967 |
| steel | 253 | 0.0146 | 1.17 | 0.017 |
| wheat | 112 | 0.0302 | 1.86 | 0.0561 |

Table B.4: Stub scores for Czech (csTenTen17 corpus). Scores are calculated from the product of the estimated percentage of occurrence based on a cleaned sample and the total noun frequency for the relevant sense and Stub entropy. Stub entropy is a measure of variation with respect to which stubbornly distributive predicates are used with the noun.

| Noun | Stub frequency | Stub percentage | Stub Entropy | Stub Score |
|---|---|---|---|---|
| auto | 27796 | 0.7318 | 0.86 | 0.6257 |
| bambus | 104 | 0.3288 | 1.59 | 0.5237 |
| bláto | 0 | 0.0 | 2.4 | 0.0 |
| byt | 34041 | 1.3475 | 0.56 | 0.7589 |
| chřest | 11 | 0.0441 | 1.69 | 0.0745 |
| drůbež | 234 | 0.4316 | 1.39 | 0.6013 |
| jablko | 2071 | 0.9736 | 0.78 | 0.7585 |
| jetel | 3 | 0.0064 | 1.4 | 0.009 |
| košile | 1604 | 0.7734 | 0.86 | 0.6618 |
| kukuřice | 51 | 0.0612 | 1.23 | 0.0752 |
| míč | 5293 | 0.8248 | 0.87 | 0.7168 |
| most | 8635 | 1.2937 | 1.02 | 1.3168 |
| munice | 49 | 0.0593 | 1.5 | 0.0893 |
| nábytek | 1370 | 0.2038 | 0.9 | 0.1827 |
| nádobí | 407 | 0.191 | 1.28 | 0.2454 |
| obuv | 149 | 0.0575 | 1.23 | 0.0707 |
| ocel | 267 | 0.0742 | 1.69 | 0.1251 |
| olej | 0 | 0.0 | 2.4 | 0.0 |
| pero | 921 | 0.9116 | 1.38 | 1.2608 |
| pes | 27432 | 1.3899 | 0.76 | 1.0605 |
| písek | 289 | 0.1023 | 0.73 | 0.0745 |
| plyn | 0 | 0.0 | 2.4 | 0.0 |
| příbor | 94 | 0.2466 | 1.33 | 0.3269 |
| pšenice | 12 | 0.0181 | 1.32 | 0.0239 |
| pudink | 15 | 0.0509 | 1.2 | 0.0611 |
| pyl | 5 | 0.0126 | 1.19 | 0.0149 |
| rýže | 168 | 0.0978 | 1.19 | 0.116 |
| šampon | 0 | 0.0 | 0.84 | 0.0 |
| šindel | 23 | 0.1004 | 1.71 | 0.172 |
| sláma | 141 | 0.2274 | 0.77 | 0.1752 |
| šperk | 1509 | 0.5368 | 1.11 | 0.5939 |
| šrot | 31 | 0.0746 | 1.06 | 0.0791 |
| štěrk | 1058 | 1.8622 | 0.27 | 0.5017 |
| suť | 195 | 0.672 | 0.89 | 0.6001 |
| tekutina | 0 | 0.0 | 2.4 | 0.0 |
| tráva | 857 | 0.2337 | 1.39 | 0.3243 |
| vybavení | 1327 | 0.1209 | 0.76 | 0.0918 |
| vzduch | 0 | 0.0 | 2.4 | 0.0 |
| zavazadlo | 2320 | 1.7122 | 0.88 | 1.5117 |
| židle | 549 | 0.1495 | 1.17 | 0.1749 |
| zlato | 4 | 0.0007 | 0.96 | 0.0007 |

# Appendix C

# Results: constraints corpus study

## C.1 NLP code

### C.1.1 Code for extracting C-relevant constructions

```
def parse_list_func(nlp_obj):
      parse_list = []
      for token in nlp_obj:
            token_text = token.text
            token_lemma = token.lemma_
            token_pos = token.pos_
            token_dep = token.dep_
            token_head = token.head.lemma_
            token_head_index = token.head.i
            token_index = token.i
            parse_list.append([token_text, token_lemma, token_pos,
               token_head,token_dep, token_head_index,token_index])
      return parse_list

def find_mod(nlp_obj):
      parse_list = parse_list_func(nlp_obj)
      matches_str = matcher(nlp_obj)

      noun_pos_dict = {}
      for ent in noun_list:
            noun_pos_dict[ent] = []

      noun_mods_dict = {}
      for ent in noun_list:
            noun_mods_dict[ent] = []

      mods_pos_dict = {}
      for item in mod_list:
            mods_pos_dict[item] = []
```

```
        for tup in matches_str:
            for ent in noun_list:
                if nlp_obj.vocab.strings[tup[0]] == ent:
                    noun_pos_dict[ent].append(tup[1])

        for tup in matches_str:
            for ent in mod_list:
                if nlp_obj.vocab.strings[tup[0]] == ent:
                    mods_pos_dict[ent].append(tup[1])

#Adj mod:  If mod lemma is in parse, has amod dependency and the head number
index is for a noun in the noun list
        for item in parse_list:
            if item[1] in mod_list and item[-4] in noun_list and item[-3]
              == ‘amod’:
                mod_pos = item[-1]
                noun = item[-4]
                noun_mods_dict[noun].append(nlp_obj[mod_pos].lemma_)

#PP mod:  If Subj NP depends on a modifier in the PP:
        for item in parse_list:
            if item[1] in mod_list and item[-3] == ‘pobj’:
                mod_pos = item[-1]
                mod_head_pos = item[-2]
                head_mod_head_pos = parse_list[mod_head_pos][-2]
                for item2 in parse_list:
                    if item2[1] in noun_list and item2[-2] == head_mod_head_pos:
                        mod_pos = item[-1]
                        noun_lab = item2[1]
                        noun_mods_dict[noun_lab].append(nlp_obj[mod_pos].lemma_)
# And if N is in a PP (e.g.  mound of sand)
                for item4 in parse_list:
                    for item3 in parse_list:
                        if item4[1] in mod_list and item4[-2] ==
                          head_mod_head_pos and item3[1] in noun_list
                          and item3[-3] == ‘pobj’:
                            sub_mod_pos = item4[-1]
                            noun_head_pos = item3[-2]
                            head_noun_head_pos = parse_list[noun_head_pos][-2]
                            if head_noun_head_pos == sub_mod_pos:
                            noun_lab = item3[1]
                            noun_mods_dict[noun_lab].append(nlp_obj[mod_pos].lemma_)

#PP N with mod as head e.g.  mound of sand:
        for item in parse_list:
            if item[1] in noun_list and item[-3] == ’pobj’:
                prep_pos = item[-2]
                head_pos = parse_list[prep_pos][-2]
                for ent1 in mods_pos_dict:
```

```
                    for m in mods_pos_dict[ent1]:
                         if head_pos == m:
                              noun_mods_dict[item[1]].append(nlp_obj[m].lemma_)

#V mod:  If NP depends on mod (e.g.  sand piled up):
      for item in parse_list:
           for ent1 in mods_pos_dict:
                for m in mods_pos_dict[ent1]:
                     if item[1] in noun_list and item[-2] == m:
                          noun_dep_pos = m
                          noun_mods_dict[item[1]].append(nlp_obj[m].lemma_)
 #V mod if the N is headed by a mod PP (e.g.  mound of sand piled up)
                     if item[1] in mod_list and item[-2] == m and item[-3]
                        != ‘‘ROOT":
                          head_dep_pos = m
                          head_pos = item[-1]
                          for item2 in parse_list:
                               if item2[-3] == ‘‘pobj":
                                    noun_head_pos = item2[-2]
                                    head_noun_head_pos = parse_list[noun_head_pos][-2]
                                    if head_noun_head_pos == head_pos
                                       and item2[1] in noun_mods_dict:
                                          noun_mods_dict[item2[1]].append(nlp_obj[m].lemma_)

      return noun_mods_dict
```

### C.1.2 Monte Carlo Simulation Code

```
dst = distance.cosine(pred_vec, obs_vec)
# where pred_vec, obs_vec are list for the predicted and observed vectors.
n = 5000000
m = 300
cos_results = []
cos_mus = []
cos_runtimes = []
# b is a list, the predicted or measured vector that will be randomly shuffled
b = []

# Outer loop
for its in range(0,m):
      l = []
# Inner loop
      for x in range(0,n):
           random.shuffle(b)
           dst_comp = distance.cosine(pred_vec,b)
           if dst_comp <= dst:
                l.append(dst_comp)
      cos_prob = len(l)/n
      cos_results.append(l)
```

```
cos_mus.append(cos_prob)
cos_runtimes.append(run_time)
```

## C.2 Tables of Results

Table C.1: Estimated frequencies of noun lemmas for the relevant sense of the noun in the enTenTen20 corpus. The margin of error is calculated based upon the standard error of a random sample of 150 or 300 sentences containing the noun and annotated by hand for whether this was the relevant sense. Test statistic: MoE $= z.\sqrt{\frac{p(1-p)}{n}}$ for proportion $p$ and sample size $n$ with critical value $z$ calculated for a 99% confidence interval.

| Noun | Estimated Frequency | Margin of Error (%) | Sample accuracy (size) |
|---|---:|---:|---:|
| apple | 591774 | 8.81 | 116 (150) |
| ball | 2282042 | 6.58 | 220 (300) |
| bean | 561180 | 7.44 | 128 (150) |
| berry | 274753 | 3.61 | 98 (100) |
| cabbage | 117557 | 6.57 | 93 (100) |
| car | 9033605 | 3.53 | 282 (300) |
| chair | 1196149 | 7.38 | 132 (300) |
| dust | 924571 | 6.12 | 94 (100) |
| equipment | 4018708 | 2.67 | 290 (300) |
| furniture | 964879 | 2.08 | 294 (300) |
| grape | 377256 | 7.44 | 128 (150) |
| gravel | 244724 | 1.9 | 295 (300) |
| jewelry | 456398 | 3.61 | 98 (100) |
| kitchenware | 11043 | 6.12 | 94 (100) |
| lentil | 59802 | 6.12 | 94 (100) |
| pebble | 84542 | 9.3 | 110 (150) |
| pollen | 148560 | 3.61 | 98 (100) |
| potato | 666523 | 7.84 | 125 (150) |
| rice | 728359 | 5.06 | 260 (300) |
| sand | 981935 | 5.83 | 243 (300) |
| seed | 1428513 | 9.44 | 108 (150) |

Table C.2: Results for C1 (Indistinguishability) based upon the enTenTen20 corpus. This includes the estimated frequency of C1-RELEVANT CONSTRUCTIONS, the estimated probability of C1-RELEVANT CONSTRUCTIONS calculated based on the results in Table C.1, C1 entropy scores, the entropy adjusted score, and then the C1 Score, which is the Entropy adjusted score scales to the range $[0, 1]$.

| Noun | Frequency C1-REL. CONSTR. | Probability C1-REL. CONSTR. | C1 Entropy | C1 Entropy Adjusted Score | C1 Score |
|---|---|---|---|---|---|
| dust | 55649 | 0.06019 | 1.047 | 6.299 | 0.998 |
| sand | 12406 | 0.01263 | 1.269 | 1.603 | 0.799 |
| pollen | 1398 | 0.00941 | 1.146 | 1.078 | 0.66 |
| pebble | 672 | 0.00795 | 0.879 | 0.699 | 0.503 |
| gravel | 1916 | 0.00783 | 0.764 | 0.598 | 0.45 |
| rice | 2258 | 0.0031 | 1.208 | 0.375 | 0.312 |
| seed | 10057 | 0.00704 | 0.46 | 0.324 | 0.276 |
| berry | 1689 | 0.00615 | 0.43 | 0.264 | 0.232 |
| potato | 1654 | 0.00248 | 0.799 | 0.198 | 0.18 |
| cabbage | 154 | 0.00131 | 0.83 | 0.109 | 0.103 |
| bean | 548 | 0.00098 | 1.095 | 0.107 | 0.101 |
| apple | 651 | 0.0011 | 0.795 | 0.087 | 0.084 |
| grape | 2942 | 0.0078 | 0.112 | 0.087 | 0.083 |
| lentil | 58 | 0.00098 | 0.84 | 0.082 | 0.079 |
| furniture | 1044 | 0.00108 | 0.619 | 0.067 | 0.065 |
| ball | 953 | 0.00042 | 1.01 | 0.042 | 0.041 |
| chair | 893 | 0.00075 | 0.515 | 0.038 | 0.038 |
| kitchenware | 3 | 0.00027 | 0.677 | 0.019 | 0.018 |
| jewelry | 130 | 0.00028 | 0.421 | 0.012 | 0.012 |
| equipment | 859 | 0.00021 | 0.527 | 0.011 | 0.011 |
| car | 878 | 0.0001 | 0.724 | 0.007 | 0.007 |

Table C.3: Results for C3 (Object Splitting) based upon the enTenTen20 corpus. This includes the estimated frequency of C3-RELEVANT CONSTRUCTIONS, the estimated probability of C3-RELEVANT CONSTRUCTIONS calculated based on the results in Table C.1, C3 entropy scores, the entropy adjusted score, and then the C3 Score, which is the Entropy adjusted score scales to the range $[0, 1]$.

| Noun | Frequency C3-REL. CONSTR. | Probability C3-REL. CONSTR. | C3 Entropy | C3 Entropy Adjusted Score | C3 Score |
|---|---|---|---|---|---|
| potato | 20559 | 0.03084 | 0.805 | 2.484 | 0.917 |
| cabbage | 3067 | 0.02609 | 0.638 | 1.664 | 0.811 |
| bean | 7296 | 0.013 | 0.965 | 1.254 | 0.715 |
| apple | 17081 | 0.02886 | 0.304 | 0.879 | 0.585 |
| berry | 940 | 0.00342 | 0.743 | 0.254 | 0.224 |
| pebble | 161 | 0.0019 | 0.983 | 0.187 | 0.17 |
| grape | 765 | 0.00203 | 0.708 | 0.144 | 0.134 |
| ball | 2232 | 0.00098 | 0.724 | 0.071 | 0.068 |
| pollen | 153 | 0.00103 | 0.661 | 0.068 | 0.066 |
| chair | 2058 | 0.00172 | 0.3 | 0.052 | 0.05 |
| kitchenware | 4 | 0.00036 | 0.724 | 0.026 | 0.026 |
| sand | 336 | 0.00034 | 0.594 | 0.02 | 0.02 |
| car | 2378 | 0.00026 | 0.677 | 0.018 | 0.018 |
| lentil | 168 | 0.00281 | 0.026 | 0.007 | 0.007 |
| rice | 2901 | 0.00398 | 0.016 | 0.006 | 0.006 |
| seed | 7002 | 0.0049 | 0.01 | 0.005 | 0.005 |
| furniture | 1228 | 0.00127 | 0.019 | 0.002 | 0.002 |
| equipment | 0 | 0.0 | – | 0.0 | 0.0 |
| dust | 0 | 0.0 | – | 0.0 | 0.0 |
| gravel | 0 | 0.0 | – | 0.0 | 0.0 |
| jewelry | 0 | 0.0 | – | 0.0 | 0.0 |

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