Metaphorical measure expressions[1]

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Abstract. We present an analysis of measure phrases such as *heap/ounce of information* in which the measure expression receives a non-literal, metaphorical interpretation. We present evidence that these *metaphorical measure expressions*, as we call them, exhibit a puzzling incomplete countability pattern insofar as their grammatical reflexes fall between count and mass nouns. We show that nouns/NPs with such an incomplete countability pattern are predicted by, and are easily captured within, the theory of the count/mass distinction presented in Sutton and Filip (2019b, 2020).

Keywords: countability, measure phrases, plurality, indefinites, abstract nouns

1. Introduction

This paper addresses a set of data which have so far largely remained unexplored, and which exhibit a number of puzzling properties that seem to resist an analysis in terms of extant theories of the count/mass distinction. The data concern metaphorical or non-literal interpretations of measure expressions which arise especially clearly with entities that do not 'live' in the concrete domain, but rather in non-concrete, abstract domains. Some examples are: *heaps of assurances, a heap of knowledge, a whiff of insecurity, a sliver of hope*. Such metaphorical measure phrases are not odd outliers with low frequency of usage, but rather are common across registers. To our knowledge, there are only two recent studies that provide a systematic analysis of metaphorical measure phrases, namely Klockmann (2017) and de Vries and Tsoulas (2021b), and our analysis builds on both. We expand the empirical picture by considering not only large-quantity measure expressions like *heap* (as the latter do) but also small-quantity measure expressions like *iota*. Our analysis is couched within a mereological theory of countability.

1.1. Measure expressions for concrete entities

Nouns that function as measure expressions over denotations of concrete entities denote either standard or non-standard measures:

(1) a. standard measure expressions: *metre*, *foot*, *litre*, *gallon*, etc.
b. non-standard measure expressions: *glass*, *bucket*, *truckload*, *pallet*, *mouthful*, etc.

[1]This work has been supported by the grant awarded to Hana Filip by the German Research Foundation (Deutsche Forschungsgemeinschaft) for the project entitled *Individuation of eventualities and abstract things* (2020-24). Peter Sutton received funding from the Beatriu de Pinós postdoctoral fellowships programme, funded by the Secretary of Universities and Research (Government of Catalonia) and from the Horizon 2020 Programme of Research and Innovation of the European Union under the Marie Skłodowska-Curie grant agreement no 801370.

Measure expressions have a quantizing function (Krifka, 1989): namely, they take a cumulative argument (syntactically either MASS or PL COUNT) and return a measure phrase which is quantized, that is, it functions as a count expression. The head in a measure phrase can be pluralized, freely combined with numeral expressions, and the measure phrase (demarcated by square brackets in (2)) can also govern plural verb agreement:

(2) a. [Three crates of *sand*] were delivered to the store. MASS
 b. [Three crates of *books*] were delivered to the store. PL COUNT

1.2. Metaphorical measure expressions (MMEs)

We will use the term *metaphorical measure expressions* (MMEs) for measure expressions that are used to denote a non-literal amount of something. What is measured can be quantities in the concrete domain (3a, 4a, 5a), or in the abstract domain (3b, 4b, 5b), where there are no physical quantities to measure. Both standard measure expressions (e.g., *ton*, *ounce, mile*) and non-standard measure expressions (e.g., *heap*, *load*, *drop*, *sliver, whiff*) can be used in MMEs.

(3) a. Josie read {*a heap*|*heaps*} of *books* over the summer.
 b. Tony showered {*a heap*|*heaps*} of *assurances* on us.
(4) a. Pedro drank {*a heap*|*heaps*} of *water* after the procedure.
 b. Alex picked up {*a heap*|*heaps*} of *knowledge* in that class.
(5) a. Alex caught {*a whiff*|*whiffs*} of *chocolate* in the air.
 b. Alex detected {*a whiff*|*whiffs*} of *insecurity* in Billie.

In the concrete domain, measure expressions may be ambiguous between metaphorical and literal interpretations (e.g., *tonne of books*). Only non-literal interpretations are available in the abstract domain (*tonne of knowledge*). Some readers may find the examples in (5) improved by the presence of an exhaustive expression like *only*, or may find the plural cases degraded relative to the singular; we will return to these issues in depth in Section 4.2 and Section 4.3.

One striking semantic feature of MMEs is that they lack the quantizing function that literal uses of (standard and non-standard) measure expressions have. That is, they do not contribute the fundamental individuating notion of ‘a/one measurement unit’ to the meaning of the resultant measure phrase. As a result, they do not yield quantized sets, or in more intuitive terms, they do not return ‘bounded’ or ‘discrete’ quantities of what they measure. Instead, they introduce a vague quantity which is presented as contextually and/or subjectively large or small. For instance, *a heap of information* is understood as ‘a large quantity of information’ and *an iota of information* as ‘not very much information’. Given this vague quantity parameter, MMEs fall into two main semantic groups:

(6) a. large-quantity MMEs: *bunch*, *heap*, *load*, *mass*, *oodles*, *scad*, *ton*, *tonne*, …
 b. small-quantity MMEs: *bit*, *drop*, *glimmer*, *iota*, *ounce*, *shred*, *slither*, *sliver*, *speck*, *whiff*, …

Within these classes, some measure expressions like *scad* and *iota* seem to be dedicated to measuring abstract entities, and have no corresponding function for measuring entities in the concrete domain. For instance, while *an iota of information* is ‘not very much information’, there is no concrete non-standard measure that could be used to measure concrete physical stuff, e.g., ?*an iota of dust*.

Similarly, there are measure expressions such as *metre*, *foot* and *cup* that seem to be dedicated to measuring concrete entities, and cannot be (easily) used to measure abstract entities. We may speculatively suggest that this is because, in their concrete uses, they do not denote what we intuitively and readily would view as large or small quantities, unlike measure expressions such as *tonne* or *ounce*. Now, if it is correct that metaphorical uses of measure expressions denote small or large quantities, as we propose, then it would follow that ordinary measure expressions like *metre, foot* or *cup* which resist being interpreted as large or small quantities of concrete entities also resist being used as measure functions on denotations of abstract entities. This would be at least one working hypothesis that may be pursued in future research.

1.3. Counting metaphorical measure phrases

Syntactically speaking, all measure expressions, whether they denote measure functions over concrete or abstract entities, can be SG INDEFINITE COUNT (e.g., *a heap (of)*) or BARE PL (e.g., *heaps (of)*). Nominal arguments that denote what is measured, be it concrete or abstract, must be cumulative, i.e., either (bare) plural or mass:

measured entities	PL COUNT	MASS
concrete	(3a)	(4a), (5a)
abstract	(3b)	(4b), (5b)

As observed above, while concrete measure expressions form measure phrases that are syntactically count, this does not apply to MMEs that form *metaphorical measure phrases* (MMPs). Instead, they display an incomplete counting pattern: while they can be combined with the indefinite article (like count Ns) and be pluralized (like count Ns), they cannot be combined with numerals (unlike count nouns), as we see in (7–9).[2]

[2]There are apparent exceptions to this rule, cases where MMEs can be combined with the numeral *one*. For the most part, these appear to be cases where *one* is equivalent to the indefinite article and can be replaced with an indefinite article without any resulting oddity or infelicity. This accords with the well-known fact that the numeral denoting the number ‘one’ often patterns with the indefinite article. There are languages in which the two are homophonous, as in Italian (*uno, una*); and in some languages without an article system, the numeral for ‘one’ is used in at least some contexts in which the indefinite article is used in English (e.g., Slavic languages, specifically for Russian see Ionin and Luchkina (2018) and references therein).

The apparent exceptions to this generalization, where the numeral *one* cannot simply be replaced with the indefinite article salva veritate and without any oddity, are cases where there is an independent reason that the indefinite article is precluded. For instance, in (i), *a more* is blocked by the lexical item *another*, and in (ii) an indefinite is incompatible with the definite anaphoric *that*.

(i) . . . logic is sacrificed in an effort to extract one more ounce of excitement. (ukWaC)
(ii) Even that one touch of colour visible in the red satin pincushion bore. . . (ukWaC)

(7) The FBI has a heap of information about Sam.

(8) The FBI has heaps of information about Sam.

(9) a. The FBI and NSA each have a heap of information about Sam.
b. #The US government has two heaps of information about Sam.

In other words, MMPs are generally incompatible with counting constructions.

There are two sorts of apparent exceptions to this pattern. First, there are cases where what are counted are really distinct, contextually available sources for individuation of abstract entities, rather than those entities themselves. For example, in (10) we do not count amounts of hope, but rather two different sources of hope, reasons for having hope.

(10) We still have two glimmers of hope, namely getting the visa on time or the conference being postponed because of covid.

Second, there are cases in which numerals are used not to count, but for affective emphasis:

(11) Let's give five buckets of credit and oodles of applause to the Joint Contracts Tribunal. (ukWaC)

However, arguably neither of these two cases involves counting of *quantities*, counting of entities that are denoted by the noun that is modified by the cardinal numeral.

1.4. Incomplete counting patterns, beyond English

The incomplete counting pattern that we observe with MMEs in English also shows up in other languages with comparable MMEs, where they can be combined with the indefinite article and can be pluralized, but cannot be combined with numerals. Consider these examples from three different language families: Germanic (German), Romance (Italian) and Slavic (Czech).

(12) {ein Berg | (*drei) Berge} von Sorgen (German)
'{a mountain | (*three) mountains} of worries'

(13) {un sacco | (*tre) sacchi} di odio (Italian)
'{a sack | (*three) sacks} of hatred'

(14) {kapka | (*tři) kapky} inspirace (Czech)
'{a drop | (*three) drops} of inspiration'

1.5. Modifying MMEs

Both types of MMEs, used as measure functions of concrete or abstract entities, can be 'intensified', albeit each by means of a different type of syntactic construction: X*s and* X*s* for large-quantity MMEs, and *a(n)* X *of a(n)* X for small-quantity MMEs.

(15) Carly found heaps and heaps of information about dogs.
(16) Carly couldn't find an iota of an iota of information about camels.

However, small-quantity MME intensification is not available for MMEs derived from standard measures:

(17) *Carly couldn't find an ounce of an ounce of information about camels.

We return to the role of negation in the difference between (15) and (16)–(17) in Section 4.2.

1.6. The roadmap

In the remainder of this paper, we explain the behavior of these metaphorical measure expressions and the phrases they build, and in particular address what it means for a nominal phrase to display an incomplete counting pattern. We give a formal semantics for these expressions, drawing (perhaps surprisingly) exclusively on elements used for the semantics of measurement in the concrete domain in order to build these interpretations. We lay out the theoretical tools that we take as background in Section 2, propose our analysis in Section 3, and finally in Section 4 discuss some consequences and potential objections to this analysis.

2. The Semantics of NPs

We assume that domains are structured as atomic semi-lattices closed under mereological sum minus 0. Though a common assumption for domains of types *e* and *v*, following the development of a type-general notion of sum and part (Schmitt, 2013, 2017; Haslinger and Schmitt, 2018), domains of non-basic types can also have a mereological structure thus facilitating reference to sums of entities such as propositions of type $\langle s,t\rangle$ which can form the denotations of proposition-denoting common nouns such as *information* (see Sutton and Filip, 2019b, 2020).

Two mereological properties that are central to our analysis are *quantization* (Krifka, 1986; Krifka, 1989; Bach, 1986) and *cumulativity* (Link, 1983; Krifka, 1986; Krifka, 1989).

(18) **Quantization:** No two members of a set stand in a proper part relation.
$QUA(P) \leftrightarrow \forall x \forall y[P(x) \wedge P(y) \rightarrow \neg x \sqsubset y]$
(19) **Cumulativity:** The sum of any two members of a set is also a member of the set.
$CUM(P) \leftrightarrow \forall x \forall y[P(x) \wedge P(y) \rightarrow x \sqcup y]$

Note that quantization and cumulativity are inconsistent for non-singletons, (20), and that some sets, such as $\{a,b,a \sqcup b \sqcup c\}$ are neither cumulative nor quantized, (21).

(20) $QUA(P) \vDash \neg CUM(P)$ and $CUM(P) \vDash \neg QUA(P)$, if $|P| > 1$
(21) $\neg QUA(P) \nvDash CUM(P)$ and $\neg CUM(P) \nvDash QUA(P)$.

Foreshadowing our analysis, quantization will form part of our account of the count/mass distinction. In short, count nouns specify quantized sets of entities relative to the context; mass nouns do not. Cumulativity will form part of our analysis of the selectional restrictions of, for instance, the indefinite article in English. We propose that only NPs with a non-cumulative extension can be composed with the indefinite article.

2.1. The nature of the lexicon

Contemporary approaches to the lexical representation of mass and count nouns largely agree on two key assumptions. First, virtually all those working on the semantics of the mass/count distinction agree that access to two sets is necessary to explain the different grammatical reflexes of singular and plural count nouns and mass nouns. One set is the extension of the NP, the other is some set of entities such that, at least for count NPs, each member counts as 'one' in the extension of that NP. There are two ways to formalise this common idea. Either one assumes that the lexical entry of an NP specifies (relative to a world, context, etc.) the extension, and then accesses the second set implicitly by defining a function that maps the extension to a set of entities that can be counted (e.g., Chierchia, 2010). Or one can assume that, since both sets are systematically accessed in the composition of NPs with quantifiers and numerals, both sets are explicitly recorded in the lexicon (e.g., Landman, 2011, 2016; Filip and Sutton, 2017; Sutton and Filip, 2019a, 2020; de Vries and Tsoulas, 2021a). We adopt the latter, explicit approach. A second, now almost entirely universal, assumption is that sensitivity to context is a necessary part of the semantics of count nouns, since what counts as 'one' in their extensions can shift from occasion to occasion. This idea plays a central role in Rothstein (2010), Rothstein (2017), Chierchia (2010), Landman (2016), Sutton and Filip (2016), and other studies of these authors.

To combine these two assumptions, we assign denotations of NPs the type $\langle c, \langle s, \langle e, \langle t \times et \rangle \rangle \rangle \rangle$, functions from contexts to intensions (à la Kaplan (1989), albeit in a TY2 logic (Gallin, 1975)). The type $\langle t \times et \rangle$ is a product type (see e.g., Carpenter, 1997). An expression of this type is an ordered pair of a proposition ϕ and a set P, $\langle \phi, P \rangle$. The intension of an NP is a function from worlds to a pair of sets; in other words, the denotations of NPs have a bipartite structure. The first set in this pair we call the **extension (ext)**, the members of which are what the NP is standardly taken to describe. The second set in the pair is the **counting base (cbase)** , a subset of the extension set. The members of the counting base set are entities that are accessible to modification by numerals, determiners, distributive modifiers, etc. We assume that these entities are 'countable' if this set is quantized at world w and context c. For example, *each N* distributes down to members of the counting base set and an entity counts as *one N* if it is a member of a quantized counting base set. This sets us apart from, e.g., Landman (2016) which uses the stronger condition of disjointness, not quantization (for discussion, e.g., Sutton and Filip, 2019b).

It will be convenient to define two projection functions in terms of the standard first and second projection functions for product types. *ext* in (23a) is defined in terms of π_1 in (22a) and *cbase* in (23b) is defined in terms of π_2 in (22b).

(22) For an expression $\langle a,b\rangle$ of type $\langle \tau \times \sigma\rangle$

a. $\pi_1(\langle a,b\rangle) = a : \tau$

b. $\pi_2(\langle a,b\rangle) = b : \sigma$

(23) For a variable $\mathfrak{P}$ of type $\langle c, \langle s, \langle e, \langle t \times et\rangle\rangle\rangle\rangle$

a. $\mathrm{ext} = \lambda \mathfrak{P} \lambda c \lambda w \lambda x[\pi_1(\mathfrak{P}(c)(w)(x))]$

b. $\mathrm{cbase} = \lambda \mathfrak{P} \lambda c \lambda w \lambda x[\pi_2(\mathfrak{P}(c)(w)(x))]$

For example, for the expression in (24a), in which P and Q are constants of type $\langle c, \langle s, \langle e,t\rangle\rangle\rangle$, *ext* returns a function from contexts and worlds to the extension set as we have in (24b), and *cbase* a function from contexts and worlds to the counting base set as we have in (24c).

(24) a. $\lambda c \lambda w \lambda x \langle P_{c,w}(x), \lambda y.Q_{c,w}(y)\rangle$

b. $\mathrm{ext}(24\mathrm{a}) = \lambda c \lambda w \lambda x.P_{c,w}(x)$

c. $\mathrm{cbase}(24\mathrm{a}) = \lambda c \lambda w \lambda y.Q_{c,w}(y)$

2.2. The mass/count distinction

The combination of a bipartite lexical model and the idea that counting requires a quantized counting base set relative to a context allows us to distinguish between singular and plural count nouns and between count and mass nouns (Filip and Sutton, 2017; Sutton and Filip, 2019b). This picture as applied to number-marking languages is depicted in Figure 1. Count nouns (singular or plural) have a quantized counting base set relative to the context, mass nouns do not. Mass nouns and plural count nouns have cumulative extensions; singular count nouns do not.

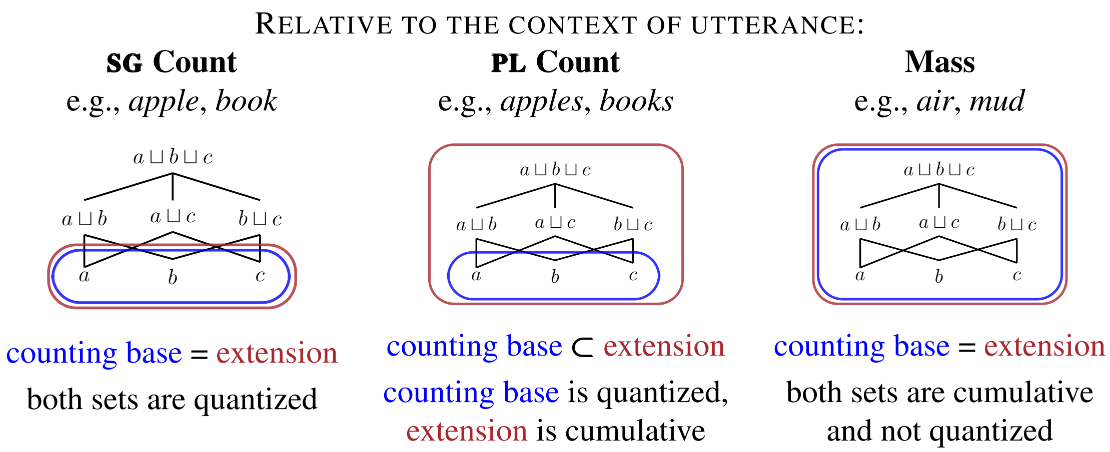


Figure 1: A bipartite approach can distinguish between singular count, plural count, and mass nouns in terms of quantization and cumulativity of the extension and counting base sets.

Furthermore, with these theoretical ingredients, we can also account for many of the grammatical reflexes of countability (see Table 1). For example, for number-marking languages with an indefinite article: (i) count nouns, but not mass nouns can be modified with numeral expressions; (ii) singular count nouns can be pluralised; (iii) singular count nouns can be combined with the indefinite article. (In all of these cases, we set aside occurrences of mass-to-count coercion.) Let us now discuss each of these in turn.

(i) Modification with numerals: As outlined in Section 2.1, we propose that only count nouns have a quantized counting base set relative to the context of utterance, and so only count nouns (or NPs headed with count nouns) can be modified by numerals.

(ii) Plural marking and (iii) the indefinite article: What sets singular count nouns apart from mass nouns and plural count nouns is the extension set. Given that we adopt quantization and cumulativity as our central mereological properties, there are two options for capturing this restriction. (a) Only nouns with a quantized extension can be pluralised or combined with the indefinite article; or slightly logically weaker, (b) only nouns with a non-cumulative extension can be pluralised or combined with the indefinite article.

Interestingly, the theory also predicts there to be other categories of nouns or noun phrases, for instance, ones that have a non-quantized counting base set and a non-cumulative extension. Looking ahead to our analysis, we propose that MMEs and measure phrases formed with MMEs are cases of such.

Furthermore, the MME data regarding plural marking and use with the indefinite article also allow us to dispense with the aforementioned underspecification in our theory and so conclude that the part of the selectional restrictions of the indefinite article and plural morphology is for the extension set of the noun they compose with to be non-cumulative. These patterns are summarised in Table 1.

Table 1: The logical space for expressions with the grammatical reflexes of MME measure phrases is predicted by the theory of the count/mass distinction.

	Example	C. base set	Num Mod	Extension set	Indef	PL morph
SG count	*cat, bowl of apples*	*QUA*	Y	$\neg$*CUM*	Y	Y
PL count	*cats, bowls of apples*	*QUA*	Y	*CUM*	N	N
mass	*mud*	$\neg$*QUA*	N	*CUM*	N	N
MMP	*heap/iota of info*	$\neg$*QUA*	N	$\neg$*CUM*	Y	Y
PL MMP	*heaps/iotas of info*	$\neg$*QUA*	N	*CUM*	N	N

2.3. Lexical Entries

The final details regarding the semantics of NPs that we need before setting out our analysis of MMEs relate to the specifics of their bipartite lexical entries. We will only give a brief overview here. For more details, see Sutton and Filip (2020).

We assume that associated with every common noun is a number-neutral property of type $\langle s, \langle e,t \rangle \rangle$ as in (25a) (see also Chierchia, 2010). For example, the extension of the property *CAT* in a world where cats exist is the set of single cats and sums thereof. Since the interpretations of all common nouns are Kaplanian characters (functions from contexts to intensions), we also specify two functions that dictate how number-neutral properties can be affected by the context of utterance, namely, one which maps a number-neutral property to a property that has a quantized extension at every world at which it is defined (25b), and one which returns the property which the function applies to (25c).[3]

(25)	a.	$\lambda w.P_w$	a number-neutral property
	b.	$\lambda c \lambda w.\mathscr{Q}_c(P_w)$	a function from contexts c and worlds w to a maximally quantized subset of P_w in c; it is not always the case that for c', c'', $\mathscr{Q}_{c'}(P_w) = \mathscr{Q}_{c''}(P_w)$
	c.	$\lambda c \lambda w.\mathscr{N}_c(P_w)$	a function from contexts c and worlds w such that for all c', c'', $\mathscr{Q}_{c'}(P_w) = \mathscr{Q}_{c''}(P_w)$ (a constant function)

The context-indexed quantizing function $\mathscr{Q}_c$ is a part of the lexical entries for all count nouns. The difference between singular and plural count nouns is that the extension set of the latter is closed under sum via the application of Link's (1983) *-operator. For example, for $[\![\text{book}]\!]$ in (26), the extension set and the counting base set, $\mathscr{Q}_c(BOOK_w)$, is the set of single books, a quantized and non-cumulative set. For $[\![\text{books}]\!]$ in (27), the extension set, $^*\mathscr{Q}_c(BOOK_w)$, is the cumulative set of single books and sums thereof. The counting base set, $\mathscr{Q}_c(BOOK_w)$, is the set of single books, a quantized set, therefore, both *book* and *books* are countable, but only *book* can be pluralised and combined with the indefinite article.

(26) $[\![\text{book}]\!] = \lambda c \lambda w \lambda x. \left\langle\ \mathscr{Q}_c(BOOK_w)(x),\ \ \lambda y.\mathscr{Q}_c(BOOK_w)(y)\ \right\rangle$

(27) $[\![\text{books}]\!] = \lambda c \lambda w \lambda x. \left\langle\ ^*\mathscr{Q}_c(BOOK_w)(x),\ \ \lambda y.\mathscr{Q}_c(BOOK_w)(y)\ \right\rangle$

The constant function $\mathscr{N}_c$ is a part of the lexical entries for all mass nouns. For example, for $[\![\text{air}]\!]$ in (28), for any context, at a world w, both the extension and the counting base sets are the same as the extension of AIR_w, a cumulative and non-quantized set.

(28) $[\![\text{air}]\!] = \lambda c \lambda w \lambda x. \left\langle\ \mathscr{N}_c(AIR_w)(x),\ \ \lambda y.\mathscr{N}_c(AIR_w)(y)\ \right\rangle$

[3]We are suppressing some details here. For example, this approach assumes that Kaplanian contexts are tuples, one of which is a quantizing function: a function from sets to a quantized subset thereof. Thus, if q is such a function and $q \in c$, then $\mathscr{Q}_c$ can be defined as $\lambda P \lambda c \lambda w \lambda x[q \in c(P(c)(w))(x)]$.

Therefore, mass nouns such as *air* are not countable (as the counting base set is not quantized), nor can they be pluralised or combined with the indefinite article (barring coercion), since they have cumulative extensions.

3. Analysis of MMEs

3.1. Overview

We propose that the metaphorical sense of an MME is a discrete sense, differentiated from that of its literal interpretation. As such, MMEs that have a literal, non-metaphorical interpretation (i.e., a standard or non-standard measure reading) are polysemous between this reading and the metaphorical one (some MMEs such as *iota* have only a metaphorical interpretation, see Section 1.2). The metaphorical sense, in our view, can be thought of as a bleached version of the literal meaning insofar as the main information conveyed is that of either a contextually large or small magnitude of something. Importantly this contextually large or small magnitude part of the meanings of MMEs is part of the reason why MMEs do not encode a quantizing function and so do not output NPs with a quantized counting base, and that is, consequently, why measure phrases formed with MMEs are not felicitous in numeral constructions. Furthermore, we argue that interpretations of neither singular large- or small-quantity MMEs have cumulative extensions and can thus explain why, despite not being felicitous in numeral constructions, MMEs can be pluralised and combined with the indefinite article.

We draw on two (partial) analogies to motivate our analysis. First, MMEs are a bit like measure expressions (and so, involve a measure function). However, unlike measure expressions which involve an identity, sometimes over a relatively precise value (e.g., $\mu_{kg}(x,P) = n$, for *kilo*), we suggest that MMEs involve inequalities ($\mu(x,P) > n$ or $\mu(x,P) < n$), wherein, furthermore, the numerical value is vaguely specified relative to the context.[4] Second, MMEs are a bit like expressions such as *quantity*/*amount* (*of*), and so involve an operator that partitions a predicate P relative to the context. However, unlike *quantity*/*amount* (*of*), MMEs are not constrained so as to result in quantized partitions. We address these components in Section 3.2 and Section 3.4. In Section 3.3, we motivate why we think measure phrases formed with MMEs do not have cumulative reference.

3.2. Measure functions and inequalities

We propose that if a standard or non-standard measure expression has a metaphorical interpretation, then this metaphorical interpretation will inherit any inherent largeness or smallness in quantity from the literal interpretation. For example, *tonne* encodes a measure, the granularity of which is large compared to other commonly used measure expressions for weight such as *kilo*, *gramme* or *ounce*. Therefore, the metaphorical use of *tonne* as an MME will encode some large quantity relative to the context. Similarly, since ounces are small-quantity measures in

[4]By this we mean that language users may have reasonably high degrees of uncertainty about what the threshold is in any context.

everyday contexts, the metaphorical use of *ounce* as an MME will encode some small quantity relative to the context. This also explains why intermediate quantity or extent measure expressions such as *metre* and *kilo* do not so easily get a metaphorical interpretation (see Section 1.2).

We model this large or small quantity element of the meaning of MMEs with a measure function, the value of which either must exceed some contextually specified value (large-quantity MMEs) or be less than some contextually specified amount (small-quantity MMEs). In other words, unlike standard or non-standard measure phrases such as *five kilos*, which denote entities that map to some point on a scale, MMEs denote entities that exceed (large quantity) or fall below (small quantity) some point on a scale such that there is some vagueness (i.e., metalinguistic uncertainty) with respect to where this point on the scale is.

We assume a measure function μ indexed to a scale s (μ_s) that has a polymorphic type, a function from contexts, to a function from numbers, to a modifier of sets of some type of entity: $\langle c, \langle n, \langle \alpha t, \alpha t \rangle\rangle\rangle$. The reason for this polymorphic type is that the measure function must be defined, minimally, for both sets of physical entities ($\alpha \mapsto e$) and sets of propositions ($\alpha \mapsto \langle s,t \rangle$) as indicated by the felicity of the metaphorical interpretation of both, say, *tonnes of apples* and *tonnes of information*.

Sutton and Filip (2021) argues that, for non-standardised measure readings of expressions such as *glass* (*of*), the scale for the measure function is affected by the property denoted by the downstairs NP, in addition to the context. For example, the scale for *glass of wine* is typically different to that of *glass of brandy* (see (see Khrizman et al., 2015)). For instance (suppressing the way that the scale is computed from the downstairs NP property and the context), we have:

(29) A measure function that is part of the semantics of the non-standardised measure expression, *glass*: $\lambda n.\lambda P.\lambda c.\lambda x.\mu_{\mathbf{glass},P,c}(x) = n$

(30) A measure function that is part of the semantics of the non-standardised measure phrase, *three glasses of wine*: $\lambda c.\lambda x.\mu_{\mathbf{glass},\mathbf{wine},c}(x) = 3$

We propose that the scale for the measure function in the lexical entries of MMEs is similar to those in non-standard measure functions in this respect. For example, the scale for, say, information in *heaps of information* may be different than the scale for courage in *heaps of courage*. However, the scale for the measure functions in the semantics of MMEs, we claim, is not so transparently derived from the (literal) interpretation of the upstairs NP. In other words, we do not have the equivalent of 'glass', a quantized property, to define the scale for MMEs as we do in (29) and (30). Instead, we propose that the bleached meaning of the literal interpretation of the MME (i) introduces an inequality (greater or less than) as opposed to an identity in the measure function; and (ii) encodes a context-indexed choice function over some value $n \in \mathbb{R}$ (thereby existentially closing the argument of type n).

Choice functions (Reinhart, 1997; Winter, 1997) are functions from sets to one member of that set. Where $\mathfrak{f}_c$ is a choice function determined by the context variable c, $\mathfrak{f}_c(\mathbb{R})$ is some $n \in \mathbb{R}$ selected in c.[5] For large-quantity MMEs, the quantity of P is specified to be above

[5] Rather than existentially quantifying over a variable for the choice function, yielding an indefinite interpretation, we rather assume that the context of utterance determines some value in $\mathbb{R}$ via determining a choice function.

some contextually specified threshold $\mathfrak{f}_c(\mathbb{R})$ and for small-quantity MMEs, the quantity of P is specified to be below some contextually specified $\mathfrak{f}_c(\mathbb{R})$. For example, where p is a variable of type $\langle s,t\rangle$, the measure functions in (31) and (32), in which the n argument is saturated by the choice function, are restricted to an information-based scale when applied to $[\![\text{information}]\!]$:

(31) $\lambda P.\lambda c.\lambda p.\mu_{P,c}(p) > \mathfrak{f}_c(\mathbb{R})([\![\text{information}]\!]) \;=\; \lambda c.\lambda p.\mu_{\mathbf{info},c}(p) > \mathfrak{f}_c(\mathbb{R})$

(32) $\lambda P.\lambda c.\lambda p.\mu_{P,c}(p) < \mathfrak{f}_c(\mathbb{R})([\![\text{information}]\!]) \;=\; \lambda c.\lambda p.\mu_{\mathbf{info},c}(p) < \mathfrak{f}_c(\mathbb{R})$

Importantly, these measure functions with inequalities already give us part of the grammatical reflexes of measure phrases formed with MMEs, since the sets they denote are not quantized. For example, if p and q satisfy the threshold for a large-quantity MME, then so does $p \sqcup q$. Likewise, if $p \sqcup q$ satisfies the threshold for a small-quantity MME, then so do p and q.

3.3. Motivating the non-cumulative extensions of MMEs

If a measure function such as the one in (32) is part of the semantics for small-quantity MMEs, then measure phrases formed with small-quantity MMEs are neither quantized nor do they have cumulative reference in almost all contexts. This is because if the contextually specified measure value is not the uppermost value on the scale, there will be propositions/entities the sums of which are not in the extension of the MME (non-cumulative reference). When it comes to large-quantity MMEs however, non-cumulative reference cannot be derived from the inverse inequality $>$, since the set of any amount of, say, information, that exceeds some threshold will be a cumulative set. Put another way, in Table 1, we claim that neither large-quantity nor small-quantity MMPs, when singular, have a cumulative extension, and this may be prima facie puzzling, given the inequality in (31).

Let us take a moment, then, to motivate our claim. The examples in (33)–(35) are evidence of context shifts in the extension of the large-quantity MMP *heaps of data*. In (33), we can describe the data collected by Alex and Billie individually as *a heap of data*, or together as *heaps of data*. However, we can also shift our perspective as in (34) and conceive of the data taken together as *a heap of data*. Now, if *heap of data* were genuinely cumulative, we should expect (35) to be straightforwardly felicitous, but it is not.

(33) After experiments 1 and 2, Alex and Billie each had a heap of data / Alex and Billie together had heaps of data.

(34) After experiments 1 and 2, Alex and Billie together had a heap of data.

(35) $^{?}$After experiments 1 and 2, Alex and Billie each had a heap of data and, together they had a heap of data.

Contrast this with a genuinely cumulative singular NP such as *(a lot of) information*. The equivalent of (35) for this expression is straightforwardly felicitous, as seen in (36).

(36) After experiments 1 and 2, Alex and Billie each had collected (a lot of) information and, together, they had collected (a lot of) information.

To get a handle on what is going on here, let us consider the different kinds of context shifts pertaining to individuation for the concrete domain. First, there are cases where physical entities undergo some kind of mereotopological change which changes their cardinality with respect to some count nouns, accordingly. For example, for the literal interpretation of *heap of sand*, two discrete piles of sand count as *two heaps of sand*, but if these piles get pushed together into one mound, then the resulting entity no longer counts as *two heaps of sand*, but as *one heap of sand*. Secondly, and more interestingly, there are also what we might call *conceptual context shifts*. These are the kinds of context shifts discussed extensively by Rothstein (2010, 2017) (see also Krifka, 1989: 86-88; Zucchi and White, 1996, 2001; Chierchia, 2010). These kinds of context shifts require no change at all in the entity/entities in question, but, depending on our counting perspective, we can truthfully describe the entity/entities as having different cardinalities. For example, suppose that sand is piled in such a way as there are not two discrete piles, but rather sand with two peaks (forming roughly an M-shape). For many such configurations, we can describe the sand as *one heap of sand* under one counting perspective/in one context, but also as *two piles of sand* in others.

Turning back to the abstract domain, and to large-quantity MMPs, not only is it the case that there is no equivalent of a physical context shift in this domain (entailing that all abstract-domain context shifts are conceptual), but shifting our individuation perspective on, say, *heap(s) of data* is highly fluid. It seems that all we need to do is conceive of the data-collected-by-Alex as distinct from the data-collected-by-Billie to conceive of it as *heaps of data*, or as lumped together to think of it as *a heap of data*. Nonetheless, as shown by (35), duck-rabbit like, we seemingly cannot entertain both of these means of conceptualising the data simultaneously. It is this fluidity of contextual shifts when it comes to individuating entities in the abstract domain that explains why large-quantity MMPs have a cumulative 'flavour' even if they are not genuinely cumulative. They are what could be termed *pseudo-cumulative*.

3.4. Context-indexed covers

Turning now to the second ingredient in our analysis of MMEs, namely, a partitioning operator, let us start with the intuitive idea that MMEs encode information that they denote either a large or small quantity/amount of something, and so may share some properties with the literal readings of expressions such as *quantity* and *amount* (*of*). Chierchia (2010), for instance, proposes that *quantity* and *amount* (*of*) encode a contextual partition operator Π_c, such that for all P, $\Pi_c(P)$ is a disjoint (and so quantized) subset of P:

(37) $[\![\text{amount}]\!] = \lambda c \lambda P \lambda x.\Pi_c(P)(x)$

For example, the extension of *amount of apples* at each context is a subset of $[\![\text{apples}]\!]$ such that no two members of the set overlap. Earlier proposals articulate the related idea that these expressions are quantized only relative to a context of use (see Krifka, 1998; Zucchi and White, 1996, 2001).

One way to think of this is that expressions such as *amount*/*quantity* need a relatively restrictive operator such as Π_c in order to ensure that the resulting set is quantized/disjoint and so countable. However, there are many alternative, logically weaker operations that could be applied to a property that result in non-disjoint or non-quantized partitions. We propose that, to the extent that we can draw an analogy between MMEs and the meaning of expressions such as *amount*, the former are not constrained as strictly in how the set of entities they modify are partitioned: part of the semantics of MMEs is a partitioning operation that does not necessarily result in quantized sets. However, if we are forming some kind of partition, it follows that measure phrases formed with either large or small-quantity MMEs do not have cumulative reference. For example, if part of the meaning of *tonne of information* is, relative to a context, some subset of sums of propositions in the denotation of *information*, there will be many contexts in which this subset is not cumulative.

In order to model this pseudo-cumulativity of large-quantity MMPs and also to account for the context sensitivity of both large and small-quantity MMPs, we introduce the notion of a *context-indexed cover*, which we assume to be part of the lexical entries of MMEs in place of the context-indexed partition operator that is part of Chierchia's analysis of *quantity of* in (37). We assume a mereological rendering of the notion of a cover of a predicate P in the sense of Gillon (1987), and define a context-indexed operator Δ_c of type $\langle et, et\rangle$ such that for any context c and predicate P, $\Delta_c(P)$ is a cover of P (importantly, not necessarily a minimal cover):

(38) $\forall c \forall P \exists X\, [\Delta_c(P) = X \wedge X \subseteq {}^*P \wedge \sqcup X = \sqcup P]$

Relative to a context, (38) defines a subset of ${}^*P$, the supremum of which is the same as the supremum of P. In words, this gives us a set which covers, in some combination of sums and atoms, all single Ps. For example, for $\Delta_c(\{a, b, a \sqcup b\})$, there are five possible context-indexed covers of $\{a, b, a \sqcup b\}$: $\{a, b\}$, $\{a \sqcup b\}$, $\{a, a \sqcup b\}$, $\{b, a \sqcup b\}$, $\{a, b, a \sqcup b\}$. Importantly, these covers are neither necessarily quantized nor necessarily cumulative.

3.5. Final analysis

We now have all of the ingredients we need to provide our analysis of the semantics of MMEs: a context-sensitive measure function that ensures that the denotation of a measure phrase formed with an MME (an MMP) either exceeds or falls below some contextually specified threshold; and a context-indexed cover operator that selects some subset of the (upwards closure of the) denotation of the downstairs NP in the MMP. Combined with our bipartite lexical entries, this gives us lexical entries for large-quantity MMEs such as *heap* (39), small-quantity MMEs such as *iota* (40) and for large-quantity MMPs such as *heaps of information* (41) and small-quantity MMPs such as *iota of information* (42). ($\mathfrak{x}$ is a variable of polymorphic type (either e, v or $\langle s, t\rangle$), p, q are variables of type $\langle s, t\rangle$).

(39) $$[\![\text{heap}_{MME}]\!] = \lambda \mathscr{P} \lambda c \lambda w \lambda \mathfrak{x}. \left\langle \begin{array}{l} \Delta_c(\mathbf{ext}(\mathscr{P})(c)(w)(\mathfrak{x})) \wedge \mu_{\mathscr{P},c}(\mathfrak{x}) > \mathfrak{f}_c(\mathbb{R}), \\ \Delta_c(\mathbf{cbase}(\mathscr{P})(c)(w)(\mathfrak{x})) \wedge \mu_{\mathscr{P},c}(\mathfrak{x}) > \mathfrak{f}_c(\mathbb{R}) \end{array} \right\rangle$$

(40) $$[\![\text{iota}_{MME}]\!] = \lambda \mathscr{P} \lambda c \lambda w \lambda \mathfrak{x}. \left\langle \begin{array}{l} \Delta_c(\mathbf{ext}(\mathscr{P})(c)(w)(\mathfrak{x})) \wedge \mu_{\mathscr{P},c}(\mathfrak{x}) < \mathfrak{f}_c(\mathbb{R}), \\ \Delta_c(\mathbf{cbase}(\mathscr{P})(c)(w)(\mathfrak{x})) \wedge \mu_{\mathscr{P},c}(\mathfrak{x}) < \mathfrak{f}_c(\mathbb{R}) \end{array} \right\rangle$$

(41) $[\![\text{heaps}_{\text{MME}} \text{ of info}]\!] = \lambda c \lambda w \lambda p. \left\langle \begin{array}{l} {}^{*}\Delta_c(\mathscr{N}_c(INFO_w)(p)) \wedge \mu_{[\![\text{info}]\!],c}(p) > \mathfrak{f}_c(\mathbb{R}), \\ \lambda q.\Delta_c(\mathscr{N}_c(INFO_w)(q)) \wedge \mu_{[\![\text{info}]\!],c}(q) > \mathfrak{f}_c(\mathbb{R}) \end{array} \right\rangle$

(42) $[\![\text{iota}_{\text{MME}} \text{ of info}]\!] = \lambda c \lambda w \lambda p. \left\langle \begin{array}{l} \Delta_c(\mathscr{N}_c(INFO_w)(p)) \wedge \mu_{[\![\text{info}]\!],c}(p) < \mathfrak{f}_c(\mathbb{R}), \\ \lambda q.\Delta_c(\mathscr{N}_c(INFO_w)(q)) \wedge \mu_{[\![\text{info}]\!],c}(q) < \mathfrak{f}_c(\mathbb{R}) \end{array} \right\rangle$

It is worth stressing, however, that for all MMEs that have a literal interpretation, we assume that they are polysemous between the kind of metaphorical interpretations we see in (39) and (40), and a measure/classifier interpretation.

Importantly, all MMPs, on this analysis, have the following properties. In most contexts, they have non-quantized counting base sets, non-cumulative extensions when the MME is singular, and cumulative extensions when the MME is plural. See Figure 2 for an example of a large-quantity MMP, *heap of information*, and Figure 3 further below for a small-quantity MMP, *iota of information*. For large-quantity and small-quantity MMPs, the counting base set is not quantized, because the inequality in the measure function ensures that, for any covers of $INFO_w$ that do not only include the atoms of $INFO_w$, there are proper part relations between entities in its denotation. Furthermore, the extension set is not cumulative for any cover of $INFO_w$ that does not include $\sqcup INFO_w$, and so even large-quantity singular MMPs do not have cumulative extensions.

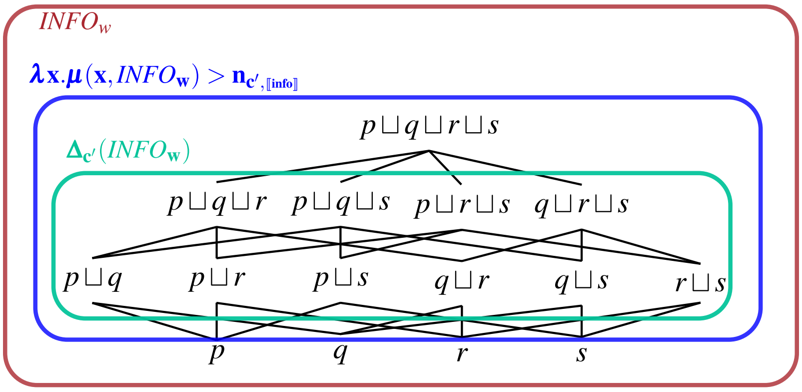


Figure 2: If $INFO_w = {}^{*}\{p,q,r,s\}$, there is a context c', such that the counting base set and the extension set of *heap of information* are equivalent to $\Delta_{c'}(INFO_w)$. The counting base set is not quantized and the extension set is not cumulative.

Based on our proposal for the count/mass distinction, including the selectional restrictions of the indefinite article and plural morphology, this correctly captures the data: MMEs are not straightforwardly compatible with numeral expressions, but, when singular, MMEs can be pluralised and MMPs can be in the scope of the indefinite article (assuming the following structure: $[_{\text{DP}}\ [_{\text{D}}$ an $]\ [_{\text{NP}}$ iota of courage $]]$, see Section 4.1). In other words, we can account for the sense in which MMEs have an *incomplete counting pattern* (see Section 1.3): their grammatical reflexes are a mixture of some of those typical of count nouns AND some of those typical of mass nouns.

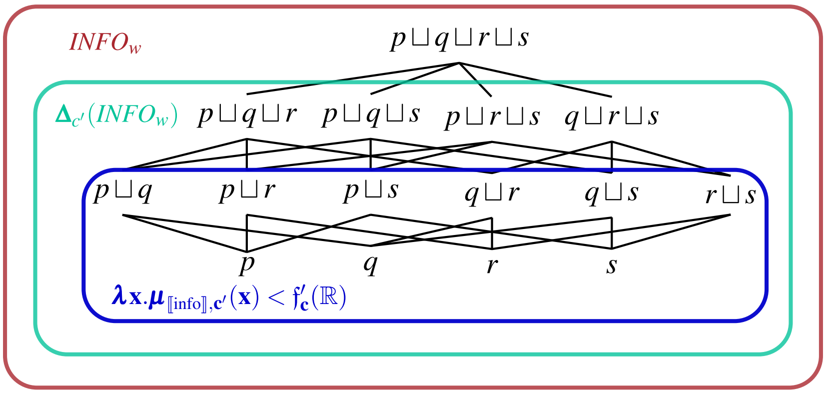


Figure 3: If $INFO_w = {}^*\{p,q,r,s\}$, there is a context c', such that the counting base set and the extension set of *iota of information* are equivalent to $\lambda x.\mu_{[\![\text{info}]\!],c'}(x) < \mathfrak{f}'_c(\mathbb{R})$. The counting base set is not quantized and the extension set is not cumulative.

4. Discussion

Having now given our analysis of MMEs, to conclude this paper, we will briefly discuss some potential objections to our proposal based on some comments in the literature on MMEs and from one of our reviewers as well as discussing the connection between MMEs, NPIs, and PPIs.

4.1. Objections to a polysemy-based account (de Vries and Tsoulas, 2021b)

A pragmatic account of some of the large-quantity MME data that we have discussed here is provided by de Vries and Tsoulas (2021b), which applies this account to other phenomena such as the pluralisation of mass nouns in Greek. We will not discuss the details of this proposal here, since space limitations would not allow us to do it justice, however, we will address what could be taken as a series of objections to our claim that MMEs that have a literal standard or non-standard measure reading are polysemous between this sense and a metaphorical interpretation.

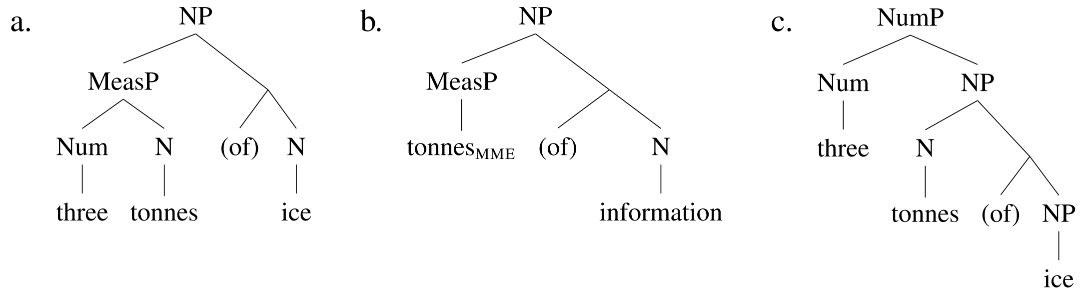
Three reasons are given by de Vries and Tsoulas (2021b) for why the metaphorical interpretation of large-quantity MMEs should not be identified with a “figurative or vague use of the classifier interpretation of ‘large quantity of’” (de Vries and Tsoulas, 2021b: 9–10):

i. The literal interpretation of ‘large quantity of’ can be used with numerals, unlike the metaphorical interpretation: *You should drink three large quantities of water every day.*
ii. Numeral constructions such as *two reams of paper* should, contrary to fact, display a metaphorical-literal reading ambiguity.
iii. Large-quantity MMEs can take singular agreement (e.g., *heaps of information was uploaded*), but a figurative interpretation of ‘large quantity of’ does not predict this.

Regarding (i.) and (ii.), we have claimed that, although MMEs do have a reading akin to a figurative or vague use of an expression such as ‘large quantity of’, this figurative interpretation is not identical to the literal interpretation of ‘large quantity of’, but rather a bleached form of vague measure that does not ensure a quantized counting base, hence the differences in the grammatical reflexes of literal uses of ‘large quantity of’ and the metaphorical uses of large-quantity MMEs do not constitute counterevidence to our proposal.

Regarding (iii.), as observed by Rothstein (2016, 2017), measure readings of measure NPs can govern either singular or plural agreement.[6] The measure structure for measure NPs in Rothstein (2016) is given in (43a), whereas that for a numeral construction is given in (43c).

(43)



Given that we analyse the metaphorical use of MMEs such as *tonnes of information* in terms of a measure function with the type *n* saturated by a choice function, i.e., with the structure given in (43b), and not as an NP that can be modified by an adjectival use of a numeral expression as in (43c), our account actually predicts that we should find not only the singular agreement attested in de Vries and Tsoulas (2021b), but also plural agreement as we see in (44).

(44) Tons and tons of water were ejected an immense distance into the air. (enTenTen)

4.2. NPIs and PPIs

The unacceptability of (17) (in contrast to (16)) and the improvement of (5) by exhaustive expressions lead to the question of whether MMEs exhibit polarity effects.[7] Specifically, as small-quantity modifiers, we might expect small-quantity MMEs to behave as NPIs. And in fact, there is quite a bit of overlap in the distribution of small-quantity MMEs with NPIs. Like NPIs, small-quantity MMEs often occur in downward-entailing environments, appearing alongside established NPIs like *yet* as well as scalar operators like *even* and *only*.[8]

(45) a. We don’t (even) have a glimmer of hope (yet).
b. We only have a glimmer of hope.

However, we would argue that this behavior is due to their semantics as measures of small quantities, rather than to grammatical polarity sensitivity. It is clear that unlike genuine NPIs, small-quantity MMEs are perfectly felicitous in non-downward-entailing environments.

(46) We (still) have a glimmer of hope.

As shown above, small-quantity MMEs can occur in ordinary positive contexts, and can even co-occur with weak PPIs like *still*. We can see this in both the metaphorical uses and the literal

[6]However, unlike Rothstein (2016, 2017), we do not claim that measure NPs are mass NPs.
[7]Thanks to Berit Gehrke for raising this in the Q&A for our talk.
[8]As discussed in footnote 2, MMEs can co-occur with the numeral *one*, which often also involves an overt scalar operator. And it seems that when there is no overt scalar operator, *one* still includes some kind of covert ‘even’ or ‘just’. This is unsurprising, given the robust morphosemantic relationship between the numeral *one* and scalar operators (e.g., *single, simple, only, alone*, etc.).

uses of small-quantity expressions, as shown in the following examples.

(47) a. John smelled a whiff of eggs in the air.
b. John had a whiff of insecurity about him.

On the flipside, large-quantity MMEs have actually been claimed to be PPIs in the literature. Krifka (1994) provides (48b) as an example of ungrammaticality for negated *tons*, and argues that this constitutes evidence that *tons* is a PPI.

(48) a. John has TONS of money.
b. *John doesn't have tons of money.
[o.k. as a denial of (a) or with contrastive focus on *tons*] (Krifka, 1994: (45))

He explains that "*tons of money* applies to maximal amounts of money" and therefore this is a bad assertion because "the proposition that John doesn't own a maximal amount of money is weaker than the proposition that John doesn't own some other amount" (Krifka, 1994: 212). This claim has since propagated, usually citing the same data points originally noted in Krifka (1994) (Krifka, 1995; van Rooy, 2001; Israel, 1996, 2001; Iatridou and Zeijlstra, 2013; Penka forthcoming). Israel (2001) calls both *tons of* and *heaps* PPIs, claiming that they are "emphatic PPIs". He discusses that seeming counterexamples are still *polar* in that they are *scalar*, and have an implicit *even* in their interpretations.

However, we would argue that the claim that large-quantity MMEs cannot occur in the scope of negation is empirically incorrect. We have found numerous instances of negated large-quantity MMEs in various corpora, as well as consulted native speaker judgments, and have found that negated large-quantity MMEs do not require any additional rhetorical effects or special prosody in order to be felicitous. A few examples are provided below.

(49) The piece doesn't provide tons of information, but it's a decent little archival slice. (enTenTen)

(50) We don't have loads of experience between us. (enTenTen)

Returning to Krifka's original example, we argue that the most natural intonation for the string *John doesn't have tons of money* is a neutral prosodic contour, with no special contrastive focus on *tons*.[9] In this case, the utterance would simply mean that John has a non-large amount of money, and is perfectly compatible with John having very little money.

An interesting additional note on the discussion of MMEs and polarity effects is the fact that while we argue that ordinary MMEs should not be analyzed as polarity items, it is quite possible that the emphasized MMEs *are* polarity items. Specifically, while *glimmer* seems perfectly fine in non-negative contexts, the emphatic partitive construction *glimmer of a glimmer* is somewhat marked. Likewise for large-quantity MMEs, *tons* and *heaps* are acceptable under negation, but *tons and tons* is less acceptable.

(51) We have a glimmer of ($^{?}$a glimmer of) hope.

[9]Though, of course, contrastive focus on *tons* is also perfectly felicitous. It simply has a different interpretation.

(52) John doesn't have tons ($^{?}$and tons) of money.

Given these kinds of data, it is possible that Krifka's original analysis of *tons* is actually the correct analysis for *tons and tons*. This seems quite reasonable, as *tons and tons* is the emphatic form, which may genuinely refer to the extreme end of a scale in a way that the bare MME *tons* does not. We leave this question to future research.

4.3. Pluralisation of small-quantity MMEs

One reviewer commented that they "don't find plurals with the small-quantity MMEs to be so great", but noted, correctly, that "the theory predicts that they should be fine". And indeed that prediction is borne out by corpus data (enTenTen), as in (53)–(56).

(53) . . . who are the Young Avengers anyway? (. . .) We get only *slivers* of information.

(54) Calling on his last *shreds* of courage, Temp smiled down at him and parted his legs.

(55) . . . the little *glimmers* of beauty, joy and love that make life sweet. . .

(56) In an entirely futile attempt to preserve the few remaining *iotas* of Danny's good character. . .

Generally speaking, we acknowledge that there is a tension of sorts between plural marking – which often conveys greater numerosity relative to an unmarked form – and our small-quantity MMEs – whose function is to convey a relatively small amount –, which might help to explain any markedness of examples with both plural marking and small-quantity MMEs, such as the reviewer's (57) (with the reviewer's judgment stigmata).

(57) $^{??}$I only found a few iotas of information.

Nevertheless, there are many contexts where this tension is surmountable, and where small-quantity MMEs are pluralized with no markedness, as demonstrated by (53)–(56).

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