12 Container, Portion, and Measure Interpretations of Pseudo-Partitive Constructions

Peter R. Sutton and Hana Filip

1. Introduction

1.1. Available Readings for Pseudo-Partitive Constructions

A number of recent studies have yielded an increasingly better understanding of the range of possible readings of the pseudo-partitive construction (henceforth PPC), such as *(two) glasses/litres of milk* (Doetjes 1997; Filip and Sutton 2017; Khrizman et al. 2015; Landman 2016; Partee and Borschev 2012; Rothstein 2011, 2016, 2017). Here we focus on PPCs formed with receptacle nouns (*basket*, *bottle*, *box*, *glass*, etc.). We begin by summarising the four readings identified by Khrizman et al. (2015) and adopt most of their terminology (however see Section 1.3 for discussion of some terminological issues). Consider the examples in (1):

(1)
a. There are two glasses of wine standing on the coffee table.
b. Mary drank two glasses of wine.
c. Amy poured two glasses of wine into the stew by eye. The second a few minutes after the first.
d. We stirred half a glass of wine into the stew.

The PPC *two glasses of wine* in (1a) has a *container classifier* (henceforth 'container') reading. It denotes pluralities of two glasses and assumes the existence of some wine in each. In (1b), there is a *contents* reading, enforced by the verb *drink*. On this reading, the PPC denotes sums of two glass-sized portions of wine, and the sentence in (1b) entails the existence of some glass that contains each portion. In (1c), there is a *free portion* reading available.

We are indebted to Susan Rothstein for her constructive criticism on earlier versions of this work. We will miss her deeply. Our thanks go to Fred Landman, Keren Khrizman, Eleni Gregoromichelaki, Kurt Erbach, and the audiences of the following workshops: 'The Count–Mass Distinction: A Linguistic Misunderstanding?' at the Ruhr University, Bochum, 2018; 'Approaches to Coercion and Polysemy (CoPo)' at the University of Oslo, 2017; and 'Ontology as Structured by the Interfaces with Semantics' (OASIS1) at Paris 8, 2018. This research is funded as part of DFG Collaborative Research Centre 991: The Structure of Representations in Language, Cognition, and Science, Project C09: A Frame-Based Analysis of Countability.

This is similar to the contents reading, but the sentence in (1c) does not entail the existence of a glass. In this paper, however, we do not provide an analysis of free portion readings (see below). In (1d), there is an *(ad hoc) measure* reading available, in which only the wine is referred to and it need not have been contained by any glass. The noun *glass* here denotes an ad hoc, or non-standard, but conventional unit of measurement relative to which the amount of wine is determined. As Partee and Borschev (2012: 459) point out, a good test for the ad hoc measure reading is whether or not fractional units can be used. For example, they point to the oddity of (2) given that *razbili* ('broke', Russian) selects for the container reading.

(2) # My razbili pol-butylki šampanskogo [Russian]
we broke half-bottle-ACC.SG champagne-GEN.SG
'(#)We broke half a bottle of champagne'

Khrizman et al. (2015) compellingly argue that the first three readings are count readings and the ad hoc measure reading is a mass reading. We adopt this position here.

1.2. Outline

In this paper, we pick up on a number of observations made in the recent literature (most notably in Khrizman et al. 2015; Partee and Borschev 2012; Rothstein 2011, 2016, 2017). We start with Partee and Borschev's (2012) observation that in many contexts the container and contents readings co-occur with the co-predication data they provide (e.g., in English, *Billie picked up and drank a glass of wine*). Such data, as they suggest, might be best analysed along the lines of Asher's (2011) dot types, but given that the required (dot-type) formalism would go beyond a simple type theory, they do not implement it.

First, as an alternative to the suggestion of Partee and Borschev (2012), we argue that we do not need to assume anything beyond mereology and a simple type theory in a dynamic semantics framework to model container+contents readings in a way that also allows us to provide an adequate account that motivates the reference to the container, the contents, and both simultaneously, while still accounting for the fact that containers and contents can be grammatically counted.

Second, we provide an analysis of the *ad hoc measure* interpretation of the PPC that is informed by Khrizman et al. (2015) and Rothstein (2011; 2016; 2017), and especially by Rothstein's (2017) work on the parameters involved in measure functions. In a slight departure from these accounts, we argue that ad hoc measure readings of PPCs formed with receptacle nouns are derived from the interpretation of the receptacle noun on its container+contents

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

reading. The main motivation for this is to follow through on one of Khrizman et al.'s (2015) observations that for container and contents readings, the standard for how much stuff there needs to be as the contents of a container is sensitive to context. For example, a glass of whiskey can be fairly empty compared to a glass of beer. We argue that, since similar contextual restrictions apply to ad hoc measure readings, the semantics of the non-standard measure concept is drawn from the semantics of container+contents concepts.

Finally, we use our analysis of ad hoc measure readings (derived from container+contents readings) to explain why measure interpretations of PPCs in which mass concepts are coerced into count concepts are hard (if at all possible) to obtain. For example, in appropriate contexts, *two white wines* can be interpreted with a container+contents reading *two glasses, each containing (a glass-sized portion of) white wine*, but not *white wine to the measure of two glassfuls*. Our explanation is based on the idea that the locus for coercion must be lexically supplied and not itself the product of a prior coerced interpretation.

1.3. A Note on a Terminological Issue

Partee and Borschev (2012) propose that PPCs have four readings, one of which they dub the *concrete portion* reading. The concrete portion reading presupposes a symmetrically branching syntactic structure, which corresponds to Rothstein's (2011) syntactic structure that correlates with the measure interpretation of the PPC. Responding to this proposal, Khrizman et al. (2015) argue that Partee and Borschev's (2012) *concrete portion* is, in fact, a count reading rather than a measure reading, which, as Khrizman et al. also argue, is mass. They then re-baptise *concrete portion* as *free portion* and provide an account of this reading that is a count and not a measure (mass) reading. Now, we completely agree that Partee and Borschev's (2012) *concrete portion* should not be modelled with symmetrically branching syntactic structure (Rothstein's (2011) measure syntactic structure), and that it should be modelled with a right-branching structure, which corresponds to Rothstein's (2011) count syntactic structure.[1] We thereby think that, in the syntactic sense, Partee and Borschev's (2012) *concrete portion* reading should, indeed, be a count reading with a count syntactic structure to match.

However, we do not think that Khrizman et al.'s (2015) *free portion* reading is a 're-baptism' of Partee and Borschev's (2012) *concrete portion* reading; rather we hold that the *free portion* reading is a new reading that Khrizman et al. (2015) uncovered, and that Partee and Borschev's (2012) *concrete*

[1] Where measure syntactic structures are: $[_{NP}\ [_{MeasP}\ [_{NUM}\ ][_{N_{meas}}\ ]]\ (\mathit{of})\ [_{N}\ ]]$ and count syntactic structures are: $[_{NumP}\ [_{NUM}\ ][_{NP}\ [_{N}\ ](\mathrm{of})[_{DP}\ ]]]$.

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

portion reading should really be re-baptised (and reformed) to be the *contents* reading. One reason to think this is that Partee and Borschev (2012) say quite categorically that the *concrete portion* reading presupposes the existence of a container. In contrast, a key characteristic of Khrizman et al.'s (2015) *free portion reading* is that it does not presuppose the existence of a container. Second, in discussing whether the concrete portion reading should be subsumed under the measure reading or the container+contents reading (which in their semantics is roughly equivalent to Khrizman et al.'s (2015) *container classifier* reading), Partee and Borschev (2012: 476) conclude that the *concrete portion* reading is 'really not a measure reading'.[2] Partee and Borschev (2012: §3.3.6) further conclude that, on the assumption of an adequate dot-type style analysis for the container+contents reading (that would explain the simultaneous reference to containers and contents) the concrete portion reading would be subsumed by the container+contents reading.

Semantically, it therefore makes more sense to re-baptise Partee and Borschev's (2012) concrete portion reading as the contents reading of Khrizman et al. (2015). (This, of course, necessitates a reform of Partee and Borschev's (2012) proposed semantics, too, not least since, as Rothstein (2017) points out, Partee and Borschev's (2012) concrete portion reading wrongly attributes counting to the counting of containers, not to the counting of portions/contents.)

In summary, we do not think that Partee and Borschev (2012) actually discuss a reading that is conceptually equivalent to Khrizman et al.'s (2015) *free portion* reading, and so in this sense, identifying the free portion reading was one of Khrizman et al.'s (2015) novel contributions. We also think that the syntactic structure of the concrete portion (=contents) reading should be as Khrizman et al. and Rothstein claim. Our terminology, inherited almost exclusively from Khrizman et al., is given in Table 12.1. The one place we differ is that we combine the container and contents reading into one complex container+contents reading.

2. Data

The container+contents interpretation of the PPC. Partee and Borschev (2012) provide co-predication data as evidence that some container+contents uses of PPCs can refer simultaneously to the container and the contents. We propose to bolster this with evidence from pronominal anaphora. In (3), we see a combination of co-predication and pronominal anaphora in which the

[2] We suspect that part of the tangle in terminology arises because Partee and Borschev give their concrete portion reading a syntactic structure that Rothstein (2011) argues is a measure and therefore mass structure.

Table 12.1. *A summary of terminologies*

Partee and Borschev (2012)	Khrizman et al. (2015); Rothstein (2017)	Our terminology
container+contents	container (classifier)	container+contents
concrete portion	contents	
-	free portion	free portion
ad hoc measure	ad hoc measure	ad hoc measure
standard measure	standard measure	standard measure

cup and coffee (together) (i) and the coffee (j) can each be picked up by consequent anaphoric pronouns, which suggests that the antecedent *a cup of coffee* makes available both the container and the contents as potential discourse referents.

(3) Downstairs she made herself a cup of coffee$_{ij}$ and carried it$_j$ out onto the patio and drank it$_i$ at the table . . . [BNC]

In (4) and (5), there is no co-predication, but intuitively, the pronouns refer to the containers and contents together. For example, in (4), it is the bottles and the wine they contain which, together, have value, not the bottles or the wine individually. Likewise, in (5), the brewery exports the bottles and beer together, not primarily the bottles or primarily the beer.

(4) I Have 2 Bottles of vintage wine. Can anyone give me any information on them or how much they are worth. [ukWaC]

(5) An 18th century brewery here produces up to 60,000 bottles of beer a year, most of them for export. [ukWaC]

Lastly, we note that container+contents PPCs formed with plural receptacle nouns distribute contents to containers and then also containers to (apportioned contents), as indicated by the example in (6), in which for every glass there is a contents of vodka, and for every portion of vodka, there is a glass containing it.

(6) The waiter brought me two glasses of vodka. I held each one between my thumb and forefinger before drinking it down in one gulp.

The ad hoc measure interpretation of the PPC. Khrizman et al. (2015) and others note that in the ad hoc measure reading, there is no requirement that the measured stuff ever be contained in a relevant container. This claim is further supported by evidence from pronominal anaphora, such as (7) and (8), in which we see that, given a measure PPC antecedent, pronouns can refer to the stuff measured (the wine), but not to the container, be it a whole bottle, half full (i), or some half of a bottle (j).

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

(7) We then deglazed the pan with a little more than half a bottle$_{ij}$ of red wine$_k$, simmered for half an hour or so and reduced it$_k$ to a few tablespoons worth. [ukWaC]

(8) We then deglazed the pan with a little more than half a bottle$_{ij}$ of red wine$_k$ and stood it$_{\#i,\#j}$ next to the pan.

Partee and Borschev (2012) point out that ad hoc measure readings of PPCs are felicitous with fractions of units, whereas container+contents readings usually are not. Interestingly, in (9), we see what may, superficially, look like a case of a measure NP (*half a bottle of milk*) in which the relative pronoun picks up reference to the container. However, given that what is referred to as being thrown is not a half bottle, but rather a whole bottle, half filled with milk, this suggests that, at least in some contexts, *half a bottle of N* can mean 'a bottle half filled with N' (i.e. a container+contents interpretation, not a measure interpretation).

(9) Shortly later, there I was presenting him with half a bottle of milk from the fridge, and to my surprise he threw it back at me. [ukWaC]

Another important point regarding measure readings of PPCs is made by Khrizman et al. (2015). On the measure reading, the unit of stuff measured is fixed at every context in the sense that, for example, *two and a half glasses of milk* in (10) cannot mean 'milk to the measure of one large glass plus milk to the measure of 1.5 small glasses'.

(10) In the 50s, Swedes drank, on average, nearly two and a half glasses of milk a day.[3]

In contrast, the container+contents reading permits an alternation between the size and the volume of the receptacles that anchor the relevant container+contents reading, as demonstrated by (11).

(11) That all changed one night when Joe Carroll [...] brought 6 odd-shaped and -sized bottles of beer to my house[4]

Finally, we note that when a given PPC is used with the ad hoc measure interpretation, the unit for the ad hoc measure corresponds to the unit of measurement that apportions the volume of stuff that would be expected on the corresponding container+contents interpretation. This is something that, although seemingly obvious, will guide our semantic analysis of ad hoc measure readings of PPCs. For example, the amount of brandy that is referred to on the ad

[3] www.readersdigest.ca/food/healthy-food/is-milk-good-for-you (accessed 15 May 2019).
[4] http://scholium.securecheckout.com/product/detail/scho_beer_and_wine.html (accessed 15 May 2019).

hoc measure interpretation of the PPC in (12) and the container+contents interpretation of the PPC in (13) are the same.

(12) 'It was a splendid sauce', said Henry appreciatively. 'Consisting, I understand,' said Milsom heavily, 'of a small glass of brandy, ditto of Madeira . . .' [BNC]

(13) Children leave one or two mince pies on a plate at the foot of the chimney (along with a small glass of brandy, sherry or milk, and a carrot for the reindeer) as a thank you for filling their stockings.[5]

The mass-to-count coercion in NumPs with mass nouns. Assuming a lexicalist theory of the count–mass distinction in which common nouns are lexically specified as either mass or count,[6] when mass nouns are directly combined with numerical expressions in the NumP ($[_{\text{NumP}}\ [_{\text{Num}}\ ]\ [_{\text{NP}}\ ]]$), as in *three white wines*, they are coerced into a suitable count denotation depending on context. It is often observed that such coercion is straightforwardly available for mass nouns which denote stuff that is frequently portioned in specific ways.

However, what is less often noticed is that such (coerced) numerical phrases correspond, in their in-context interpretations, to specific readings of PPCs. Specifically, they correspond to container+contents readings (and sometimes subkind readings), while (ad hoc) measure readings are hard to get, if possible at all (see Sutton and Filip 2018b). Consider (14)–(16):

(14) Not that it takes much to get me drunk. Three or four white wines usually do the trick. [ukWaC]

(15) Good Points: The room was very clean and value for money. My only criticsm [*sic*] is that if the room is set for 2 people. Surely more than 2 little milks would be more sensible? [ukWaC]

(16) There were two intervals, so she had three Colas and two ice creams. I had one ice-cream and three waters. Although, she later told my sister that I had two gins. [ukWaC]

In (14), it is, plausibly, three of four glasses of white wine (contents reading) that do the trick. In (15), the hotel room reviewer expresses a wish for more than two of the small plastic containers containing portions of milk to be made available as part of the room's tea and coffee making facilities (container +contents reading). Given the theatre context, in (16), it is plausibly cans of

[5] http://projectbritain.com/Xmas/mincepies.htm (accessed 15 May 2019).
[6] This is in contrast to a non-lexicalist position in which, for example, the count–mass status of nouns is only fixed at the level of NPs and DPs. See, e.g., Borer (2005); Pelletier (1975).

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

cola, small tubs of ice cream, bottles of water, and glasses of gin being referred to (container+contents reading).

In contrast, (17) and (18) are odd, precisely because the NumPs formed with mass nouns are here most naturally understood as having the measure interpretation. The difficulty in accessing the measure interpretation for coerced NumPs with mass Ns is also evident in the confusion expressed by a user in a web forum chat in (19):[7]

(17) #There are two and a half milks left in the fridge/wines left in the bottle.

(18) I'd like a cup of tea with #two and a half milks.

(19) a. The recipe I was using for soup said I needed to use '1 and a half milks'. What does that even mean? [rolling on the floor laughing emoji]
b. the 1 n half milks probably refers to a pint n half.

There are a few notable exceptions to this. For instance, NumPs formed with *beer* may be acceptable in appropriate contexts: *there are about two and a half beers left in the keg*, where *two and a half beers* can relatively naturally be used to mean 'beer to the measure of 2.5 glassfuls' (p.c. Kurt Erbach). One factor that is plausibly part of the explanation here is world knowledge, namely that beer is served in highly conventionalised portions and in certain routinised contexts, typically in countries with a beer drinking culture. Similarly, in the context of tea making, British English does permit coerced measure interpretations of NumPs with *sugars*. The measure reading of Num *sugars* is highly contextually constrained, however, and means *teaspoons/lumps of sugar* (such that a standard lump is equal in volume to a teaspoonful): *when I ask for tea with five sugars, I want tea with five sugars. Not four sugars. Not six sugars. Not four and a half sugars. Not five and a half sugars. How many did you put in?*[8]

In summary, the container+contents interpretation of the PPC licenses pronominal anaphoric reference to the container+contents together, or to the container or to the contents separately. The measure interpretation of the PPC, on the other hand, blocks reference to any container. Finally, in NumPs with inherent mass nouns that are coerced into a count interpretation, the accessibility of measure interpretations ('stuff denoted by NP to the amount of the number (Num) of implicit measurement-units') is much lower than that of the container+contents interpretation, even in appropriate contexts.

[7] www0.modthesims.info/m/printthread.php?t=463682&page=114&pp=25 (accessed 06 May 2019).
[8] From the novel *Circus of Thieves and the Comeback Caper, or, Mystery of the Spoons* by William Sutcliffe (Simons and Schuster 2016).

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

3. Analysis

3.1. Main Observations

Container+contents interpretations of PPCs are formed with nouns like *glass* or *bottle* (whose basic meaning is that of concrete physical receptacles). The main data points to be explained are:

(CC1) The container+contents interpretation distributes contents to containers (for each container, there is a contents) and containers to (apportioned) contents (for each contents, there is a container).

(CC2) It can be followed, in discourse, by anaphoric expressions that refer jointly to the container with the contents, or to solely the contents, or to solely the container.

Our compositional analysis will, approximately, follow Rothstein (2011) and Partee and Borschev (2012) in assuming a REL function that applies to the interpretation of sortal receptacle nouns and derives a relational noun concept. We also explicitly incorporate data point (CC1) into our analysis via the inclusion in the REL function of a pair of distribution conditions that crucially rely on the two aspects of our theory of the count–mass distinction: sortal nouns specify a counting base (what counts as one), and grammatical countability requires the application of a context-specific individuation schema (that identifies the objects that can be counted in that context). In relation to (CC2), we propose a mereological dynamic analysis in which container+contents PPCs denote sums of containers and apportioned contents, but also make available reference to the containers and the contents individually (such that these can be counted).

The alternative to a purely mereological analysis is one based on dot types.[9] Dot types are formed with a type constructor • that forms complex types that represent the different facets of an entity. For example, part of the representation for *book* includes the complex type **phys_object • informational_object**. Although we cannot exclude this alternative, we would like to note some complications. First, note that simple-minded application of dot types in an analysis for container+contents interpretations is a non-starter. In such an analysis, the container-type and the contents-type could be simple types (like **glass** and like **milk**), yielding the type **glass • milk** for *glass of milk*. However, due to the idempotency of • (for all a, $a \bullet a = a$; Asher, 2011: 161), such an analysis cannot work, since we can felicitously talk about *bags of bags* or *boxes of boxes*, the types for which should not be the simple type **bag** or **box**, respectively. What is needed, then, is to draw finer distinctions within a rich

[9] For an extensive discussion of dot types, see Asher (2011). A dot type based analysis for PPCs was first suggested in Partee and Borschev (2012).

type theory. For example, Sutton and Filip (2018b) use Type Theory with Records (TTR) (Cooper 2012) to give a semantics for PPCs in which types for containers and contents are highly structured, and so it is possible to account for 'box of boxes' type cases, since one can give distinct types for *box qua container* and *box qua contents*. However, in order to make this work for both singular and plural PPCs, Sutton and Filip (2018b) need not only a rich type system, but also classical mereology. Furthermore, TTR is a formalism that can implement DRT-like discourse referents, and Sutton and Filip's (2018b) analysis makes use of this. Here, we propose that once one has a dynamic formal theory enriched with classical mereology, one already has enough to model container+contents readings of PPCs even when this formal theory is simply typed. Our analysis treats the extension of *boxes of boxes*, for instance, as a set of mereological sums of boxes. What we also do, however, is place constraints on, amongst other things, the mereotopological relationships that hold between some boxes and others. In other words, we capture the PPC data within a simple type theory, and use only mereology and implicitly topological relations such as $contents\_of(a, b)$.

Ad Hoc Measure. The key observations that we seek to explain for the ad hoc measure interpretation of the PPC are:

(M1) The ad hoc measure interpretation blocks anaphoric reference to a container, or the container joint with the contents, but licenses reference to the stuff measured.

(M2) It refers to the same quantities of stuff as the container+contents interpretation of the PPC does in similar contexts.

(M3) It is such that the amount of stuff measured is fixed at every context: e.g., the measure reading of *2.5 glasses of beer* cannot mean 'two and a half volume-wise different measures of beer' (Khrizman et al. 2015).

In relation to (M1), we follow, in large part, Rothstein's (2017) model for ad hoc measures, albeit in our dynamic setting, which will derive (M1) automatically. In relation to (M2), given that, in standard contexts, the relevant unit for the measure interpretation of a *glass of whiskey*, for instance, is identical to the amount of whiskey that counts as a *glass of whiskey* on the container+contents interpretation in the same contexts, we propose that the ad hoc measure interpretation of receptacle nouns in the PPC is derived from the container +contents interpretation of receptacle nouns in the PPC. In a simplified form, and adopting Rothstein's (2011) syntactic framework, the container+contents interpretation of *glass* is of type $\langle et, et \rangle$, a function from a contents predicate (e.g. $[\![\text{milk}]\!]$) to a container+contents predicate (e.g., $[\![\text{glass of milk}]\!]$). We define a measure function, MEAS, of type (simplified) $\langle \langle et, et \rangle, \langle n, \langle et, et \rangle \rangle \rangle$ that applies to things like $[\![\text{glass}_{\text{container+contents}}]\!]$ and returns a measure function that is sensitive to the stuff measured. This contrasts with other analyses that apply the equivalent of MEAS directly to a sortal receptacle noun concept such as ⟦glass⟧. With this adjustment to previously proposed derivations for measure readings in hand, we can derive (M3) in the same way as Rothstein (2017) insofar as ad hoc measures presuppose that some particular entity is selected from the context as an ad hoc unit calibration for the measurement scale. For us, novelly, this entity is a mereologically complex container +contents entity.

Mass-to-Count Coercion of Mass Nouns in the NumP. Finally, concerning the mass-to-count coercion of mass nouns in the NumP, the main observations to be accounted for are:

(MtC1) The container+contents interpretation is often available in suitable contexts.
(MtC2) The ad hoc measure interpretation is hard to get.

We derive (MtC1) and (MtC2) from our analysis of the ad hoc measure interpretation of the full PPC, and from the hypothesis that the locus of coercion can only be explicit lexical material, and not implicit material which is the output of a (preceding) separate coercion operation. This accounts for why *two white wines* can be interpreted as something equivalent to the container+contents reading of the PPC like *two glasses of white wine* (where ⟦wine⟧ is type shifted by an implicit ⟦REL⟧ (⟦glasses⟧), yielding ⟦REL⟧ (⟦glasses⟧)(⟦wine⟧)). It also explains why *two white wines* cannot be interpreted as something equivalent to the ad hoc measure reading of *two glasses of white wine*, since this would require the implicitly inferred meaning of ⟦REL⟧ (⟦glasses⟧) to be the input to the implicit MEAS function.

3.2. *Formal Framework*

Given that our analysis, among other things, includes a compositional account of pronominal anaphoric reference, we use Muskens's (1996) compositional DRT, which we enrich with standard extensional mereology (without an atomicity assumption). It is defined in terms of the part ($\sqsubseteq$) and proper part ($\sqsubset$) relations and the mereological sum operation ($\sqcup$). Similarly to Brasoveanu (2008), we introduce plural discourse referents into Muskens's (1996) system.[10] We also allow for discourse referents for properties. Specifically, we propose that (count) nouns make available a *counting base* property (see also Khrizman et al. 2015; Landman 2016; Sutton and Filip 2016a; amongst others) that can be picked up by distributive quantifier expressions. To motivate this assumption, take *Charlie saw two cats. Each had green eyes*. The strongly distributive determiner 'each' requires a singular count noun concept as its antecedent, but the noun in the first sentence is plural. A plausible

[10] Brasoveanu's (2008) analysis is more complex than the one we use here, however, since it also allows for discourse-level plurality in order to analyse particular kinds of donkey-sentences.

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

assumption is that, although *two cats* in the first sentence denotes the set of sums of cats that have a cardinality of two, the semantics of the noun *cats* also licenses the use of the ⟦cat⟧ as a property that can be accessed by distributive determiners. In terms of the formal theory, this is not an enrichment, since Kamp and Reyle (1993), for instance, assume discourse referents that stand for sets of entities in their analysis of plurals. To aid readability, unlike Kamp and Reyle (1993), we do not use capital letters X, Y, etc., as our discourse referents for sets, but instead use, for example, $cbase_{glass}$ as the discourse referent for the counting base of *glass*.

Following Filip and Sutton (2017), Rothstein (2010), and Sutton and Filip (2016a), we assume that count nouns are interpreted relative to a context i. On our approach, contexts make available individuation schemas $\mathcal{S}_i$ that are applied to the extensions and counting bases of singular count nouns and yield a quantized (*QUA*; Krifka 1989) predicate:

(20) $$QUA(P) \leftrightarrow \forall x, y[P(x) \wedge P(y) \rightarrow \neg x \sqsubset y]$$

For a context i and an individuation schema licensed by that context $\mathcal{S}_i$, $\mathcal{S}_i(P)$ is a maximal quantized subset of P i.e., ($\mathcal{S}_i(P) \subseteq_{max.QUA} P$):

(21) $$Q \subseteq_{max.QUA} P \leftrightarrow Q \subseteq P \wedge QUA(Q) \wedge \forall R[R \supseteq Q \wedge R \subseteq P \wedge QUA(R) \rightarrow R = Q]$$

For example, for a set $P = {}^{*}\{a, b, c\}$:

(22) $$\{Q | Q \subseteq_{max.QUA} P\} = \left\{ \begin{array}{lll} \{a, b, c\}, & \{a, b \sqcup c\}, & \{b, a \sqcup c\}, \\ \{c, a \sqcup b\}, & \{a \sqcup b, a \sqcup c, b \sqcup c\}, & \{a \sqcup b \sqcup c\} \end{array} \right\}$$

Maximally quantized subsets are more permissive than maximally disjoint subsets (Landman 2011) insofar as the former allow overlap at the edges. As argued by Filip and Sutton (2017) and Sutton (2019), this is preferable, since even relative to a context, count nouns have overlapping entities in their extensions, even in specific contexts. For example, fences can overlap at the corners (i.e. share a corner post).[11]

Incorporating these ingredients into compositional DRT, we get lexical entries for singular count nouns (23), plural count nouns (24), and substance mass nouns (25). $[\![glass]\!]^i$ (⟦glass⟧ interpreted at context i) is a function from entities to a DRS that is satisfied if the entity is a glass under individuation schema $\mathcal{S}_i$. It also introduces a discourse referent for the counting base (we return to the importance of this when we model counting and PPC constructions below).

[11] Sutton (2019), in fact, argues that even QUA is also too strong and proposes *weakly quantized* (relative to a context) as the condition with the right logical strength for capturing the semantics of count nouns.

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

(23) $$[\![\text{glass}]\!]^i = \lambda v \begin{array}{|c|}\hline cbase_{glass} \\ \hline \mathcal{S}_i(glass)(v) \\ cbase_{glass} = \lambda v' \boxed{\mathcal{S}_i(glass)(v')} \\ \hline \end{array}$$

$[\![glasses]\!]^i$ is the same as $[\![glass]\!]^i$, except that the predicate $\mathcal{S}_i$(glass) is closed under mereological sum. Notice that the counting base is unchanged between (23) and (24), because what counts as 'one' individuated glass is the same in the denotation of the singular count noun *glass* and its plural counterpart *glasses*.

(24) $$[\![\text{glasses}]\!]^i = \lambda v \begin{array}{|c|}\hline cbase_{glass} \\ \hline {}^{*}\mathcal{S}_i(glass)(v) \\ cbase_{glass} = \lambda v' \boxed{\mathcal{S}_i(glass)(v')} \\ \hline \end{array}$$

The mass noun *milk* differs from the count noun *glass* insofar as its interpretation is not sensitive to contexts of individuation (Filip and Sutton 2017; Rothstein 2010; Sutton and Filip 2016a; amongst others). This means that $[\![milk]\!]^i = [\![milk]\!]$. On our account, in similarity to the work of Landman (2016) and our previous work (Filip and Sutton 2017; Sutton and Filip 2016a; 2018b), mass nouns also introduce a counting base. The difference between mass noun and count noun concepts is that mass noun concepts do not specify a quantized counting base, whereas count noun concepts specify a quantized counting base predicate at every context. (However, not all the count nouns are necessarily interpreted under the same individuation schema, good examples being count nouns like *fence*.)

(25) $$[\![\text{milk}]\!]^i = [\![\text{milk}]\!] = \lambda v \begin{array}{|c|}\hline cbase_{milk} \\ \hline milk(v) \\ cbase_{milk} = \lambda v' \boxed{milk(v')} \\ \hline \end{array}$$

We also want to allow for mass noun concepts to be portioned out, i.e., to be shifted into count interpretations when this shift is sanctioned by the grammar. We propose that such 'apportioning' is at play when mass nouns are used in the PPC in order to get the 'contents' part of the container+contents interpretation. This can be done by applying a maximally quantizing individuation schema to a mass noun concept. We define this via the operation **S** in (26), the output of which is a count concept, namely, some apportioning of milk into a quantized set of portions relative to the context.

(26) $$(\mathbf{S}[\![\text{milk}]\!]^i) = \lambda v \begin{array}{|c|}\hline cbase_{milk} \\ \hline {}^*\mathcal{S}_i(milk)(v) \\ cbase_{milk} = \lambda v' \boxed{\mathcal{S}_i(milk)(v')} \\ \hline \end{array}$$

3.3. Counting Constructions

We assume that numerical expressions in English are polysemous between a singular term of type n and a predicate modifier. Without assuming that one meaning is more basic, for simplicity, we define the function that maps the singular term to the modifier in (27). The entry for *two* is given in (28).

(27) $$[\![\text{NMOD}]\!] = \lambda n \lambda P_{:[cbase_x]} \lambda v \begin{array}{|c|}\hline \\ \hline \mu_{\#}(cbase_x, v) = n \\ \hline \end{array} ; P(v)$$

(28) $$[\![\text{two}]\!] = \begin{cases} 2 \\ [\![\text{NMOD}]\!]\,(2) \end{cases}$$

The NMOD function introduces a cardinality function $\mu_{\#}$ of type $\langle\langle et\rangle, \langle n, \langle et\rangle\rangle\rangle$ that is relative to a counting base property of type et, since the same entity/entities may have different cardinalities depending on the predicate with respect to which we are counting; for example, several volumes can be extensionally equivalent to one dictionary (Link 1983). Similarly to Landman (2011, 2016), we assume that this function is not defined for mass counting base sets (i.e., non-quantized sets for us, non-disjoint sets for Landman). The formalisation of $\mu_{\#}$ is given in set theoretic terms in (29). In words, d counts as n Ps iff the cardinality of the set of P parts of d is n.

(29) For all $d \in \mathcal{D}_e$, for all $P \in \mathcal{D}_t^{\mathcal{D}_e}$, and for all $n \in \mathbb{N}$, if $QUA(P)$, then:
$\mu\,(P, d) = n$ iff $|\,\{x : x \in P, x \sqsubseteq d\}\,| = n$
$\mu_{\#}(P, d)$ is undefined otherwise

The semantics for *two glasses* is given in (30). The extension of (30) is the set of sum entities that are glasses and have a cardinality of two with respect to the counting base for *glass(es)* relative to the individuation schema $\mathcal{S}_i$. In this case, since only one counting base set is available, counting is done with the counting base for *glass*. (The case of multiple counting base sets will be discussed momentarily.)

(30) $$[\![\text{two glasses}]\!]^i = \big([\![\text{NMOD}]\!]\,([\![\text{two}]\!]\,)\big)([\![\text{glasses}]\!]^i)$$

$$= \lambda v \begin{array}{|c|}\hline cbase_{glass} \\ \hline {}^*\mathcal{S}_i(glass)(v) \\ cbase_{glass} = \lambda v' \boxed{\mathcal{S}_i(glass)(v')} \\ \mu_{\#}(cbase_x, v) = 2 \\ cbase_x = cbase_{glass} \\ \hline \end{array}$$

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

In (30), *two glasses* is an NP. However, NumPs and bare plural NPs in English can get the reading of an indefinite DP equivalent to that of *some two glasses* or *some glasses*, respectively. For this, we assume a null determiner DET, which has the semantics of a regular indefinite determiner (see Muskens 1996: 165 for the latter), i.e. a function from an NP denotation to an existential GQ (we abstract away from any differences in selectional restriction here).

(31) $$[\![\text{DET}]\!] = \lambda P \lambda P' \left(\begin{array}{|c|}\hline u_n \\ \hline \\ \hline \end{array} ; P'(u_n), P(u_n) \right)$$

In (31), the λ-bound variable is saturated with a discourse referent that is introduced at the level at which it is processed (as with other indefinites; Kamp and Reyle 1993: 336). Applied to a predicate P, it returns a function from predicates, Q, to a DRS with the conditions that the discourse referent introduced is a P and a Q.

3.4. *The Container+Contents Interpretation of the PPC*

The relation REL in (32) maps a sortal receptacle noun concept (e.g., one for *glass*, *bowl*, etc.) to a relational one (a relation between things that are those receptacles and their contents).

In (32), we assume that the P λ-term (the one for the receptacle) is restricted to be a property for a common noun, namely one involving a DRS that introduces a counting base as a discourse referent. The Q λ-term is a variable for the contents predicate and is assumed to be likewise restricted. An innovation of our approach is to allow the entity that saturates the v argument to be a mereologically complex sum of container(s) and contents. The mereological conditions in the main DRS ensure that if something is a sum entity constituting bottles and milk, for instance, both the bottles and the milk are a part of the v argument, and that the sum of the bottles and the milk make up the totality of the v argument (otherwise v could be a sum of bottles and milk and something else).[12] The first conditional sub-DRS (the first duplex condition) in (32) expresses that for every part of the receptacle(s) that counts as one receptacle, there is some Q as its contents. (We use a convention that if u_1 is a discourse referent for a sum entity, then u_{11}, u_{12}, etc. are discourse referents for parts of u_1.) The $Contains_i$ relation is indexed to the context i, given that, as Khrizman et al. (2015) point out, the standards of how full a receptacle needs to be with its contents varies with context and the nature of the container and the contents. (In actuality, therefore, the full version of this should be $Contains_{i,P,Q}$, but we simplify it here.)

[12] The **not** $\boxed{u_1 \circ u_2}$ is included to deal with cases such as *boxes (full) of boxes*, in which case, none of the container boxes should also be boxes that are contained by other boxes in the relevant set.

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

The second conditional sub-DRSs in (32) express that, for every part of the contents (apportioned via the **S** operation; see example 26), there is some receptacle of which it is the contents. REL also introduces a constraint on Q, namely that it is not a quantized predicate (Krifka 1989), thus excluding expressions such as *basket of book* as felicitous (since $[\![\text{book}]\!]^i$ is a quantized predicate).

(32)
$$[\![\text{REL}]\!]^i = \lambda P \lambda Q \lambda v \begin{array}{|c|}\hline u_1\, u_2 \\ \hline u_1 \sqsubseteq v, u_2 \sqsubseteq v \\ \textbf{not}\,\boxed{u_1 \circ u_2}, u_1 \sqcup u_2 = v \\ \begin{array}{|c|}\hline u_{11} \\ \hline u_{11} \sqsubseteq u_1 \\ cbase_P(u_{11}) \\ \hline \end{array} \Rightarrow \begin{array}{|c|}\hline u_{21} \\ \hline u_{21} \sqsubseteq u_2 \\ Q(u_{21}) \\ Contains_i(u_{11}, u_{21}) \\ \hline \end{array} \\ \begin{array}{|c|}\hline u_{21} \\ \hline u_{21} \sqsubseteq u_2 \\ cbase_Q(u_{21}) \\ \hline \end{array} \Rightarrow \begin{array}{|c|}\hline u_{11} \\ \hline u_{11} \sqsubseteq u_1 \\ cbase_P(u_{11}) \\ Contains_i(u_{11}, u_{21}) \\ \hline \end{array} \\ \textbf{not}\,\boxed{\text{QUA(Q)}} \\ \hline \end{array} ; P(u_1); \mathbf{S}(Q)(u_2)$$

For brevity, in the following, we abbreviate the conditional DRSs as the following two relations $Contains\_each_i(u_1, u_2)$ and $Each\_contained\_by_i(u_2, u_1)$, which yields an abbreviated version of (32), given below in (33):

(33)
$$[\![\text{REL}]\!]^i = \lambda P \lambda Q \lambda v \begin{array}{|c|}\hline u_1\ u_2 \\ \hline u_1 \sqsubseteq v, u_2 \sqsubseteq v \\ \textbf{not}\,\boxed{u_1 \circ u_2}, u_1 \sqcup u_2 = v \\ Contains\_each_i(u_1, u_2) \\ Each\_contained\_by_i(u_2, u_1) \\ \textbf{not}\,\boxed{\text{QUA(Q)}} \\ \hline \end{array} ; P(u_1); \mathbf{S}(Q)(u_2)$$

The container+contents reading for an NP such as *glasses of milk*, on our account refers to both the glasses and their milk contents (i.e. a mereological sum of glass_1, glass_2, milk_1, and milk_2). This sets our account apart from others in which only the container is referred to, or in which the contents reading is completely separated from (and in fact derived from) the container reading. However, Partee and Borschev (2012: 476) raise a concern over this kind of strategy, since, in their view, if the PPC applies to mereological sums of containers and contents, ‘counting would make no sense’. Yet, given our definitions for $\mu_{\#}$ and REL and our dynamic framework, we can maintain a simply typed mereological approach in which counting does make sense. Our analysis of *two glasses of milk* is in (34). This gives us the set of sums of glasses and milk portions such that each glass contains a milk portion and each milk portion is contained in a glass. Crucially, as it stands, the representation is underspecified with respect to what is counted. The $cbase_x$ that restricts the cardinality function $\mu_{\#}$ can be bound to $cbase_{glass}$ or to $cbase_{milk}$. Given the definition of $\mu_{\#}$, binding to $cbase_{glass}$ restricts the set to sets of two glasses (each containing a portion of milk). Binding to $cbase_{milk}$ restricts the set to sets of two portions of milk (each the contents of a glass).

(34) $[\![\text{two glasses of milk}]\!] = [\![\text{NMOD}]\!]\,(2)\big([\![\text{REL}]\!]^{i}\big([\![\text{glasses}]\!]^{i}\big)([\![\text{milk}]\!])\big)$

$$= \lambda v \begin{array}{|c|}\hline u_1 \quad u_2 \quad cbase_{glass} \quad cbase_{milk} \\ \hline {}^{*}\boldsymbol{\mathcal{S}}_i(glass)(u_1), \;\; u_1 \sqsubseteq v \\ {}^{*}\boldsymbol{\mathcal{S}}_i(milk)(u_2), \;\; u_2 \sqsubseteq v \\ \textbf{not}\boxed{u_1 \circ u_2}, u_1 \sqcup u_2 = v \\ cbase_{glass} = \lambda v' \boxed{\boldsymbol{\mathcal{S}}_i(glass)(v')} \\ cbase_{milk} = \lambda v'' \boxed{\boldsymbol{\mathcal{S}}_i(milk)(v'')} \\ Contains\_each_i(u_1, u_2) \\ Each\_contained\_by_i(u_2, u_1) \\ \textbf{not}(QUA([\![\text{milk}]\!])) \\ \mu_{\#}(cbase_x, v) = 2 \\ \hline \end{array}$$

Because we analyse the container+contents NumP as introducing discourse referents for both the containers and the contents, we can explain co-predication data and anaphoric reference to containers and contents. For example, by applying DET in (31) to the formula in (34) we would get a discourse reference added to the DRS (call this u_0). This discourse referent can then be picked up as a reference to all of the mereological sums that are glasses containing milk. However, the discourse referents u_1 and u_2 can be used to refer exclusively to the glasses and exclusively to the milk, respectively. For example, if the discourse proceeds with VPs which select for rigid physical objects or potable liquids such as *smashed them* or *drank them*, we get access only to the glasses in the first case, and only to the milk portions in the second. For co-predication constructions, the availability of these three discourse referents (the container+contents sum, the container, and the contents) are all

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

available as arguments to transitive verbs. For example, in *picked up and tasted, but then smashed the glass of milk*, *picked up* is free to apply to the container+contents, *tasted* to the contents, and *smashed* to the container.

We therefore have covered data points (CC1) and (CC2) from above: our compositional analysis which derives the container+contents reading of the PPC from the interpretation of a sortal receptacle noun and a noun denoting the contents is such that the plural PPC distributes contents to containers and containers to contents, and the semantics for the PPC, on this reading, makes available reference to the container+contents, the container, and the contents. Furthermore, we have proposed a way that this can be done using conservative assumptions with respect to the complexity of the formal theory.

3.5. The Ad Hoc Measure Interpretation of the PPC

Our starting point for modelling the ad hoc measure interpretation of the PPC is a point of broad consensus: extensive measure functions are additive functions from entities to the set of real numbers (Krifka 1989). We also assume Rothstein's (2017) analysis of measure functions, which makes them relative to a dimension (such as volume), and a property that specifies the unit for the measurement scale (such as GLASS).

While our analysis is inspired by the analysis of measure functions in the PPC on its ad hoc measure interpretation which is proposed by Rothstein (2017) and Khrizman et al. (2015), it crucially differs from them in one key respect. On our analysis, the ad hoc measure interpretation is derived from the container+contents interpretation, and not from the sortal meanings of the relevant nouns that form a given PPC (such as ⟦glass⟧ and ⟦milk⟧ in the PPC – *a glass of milk* on its ad hoc measure interpretation). This allows us to capture all of points (M1)–(M3) from Section 3.1. We can explain why the amounts of stuff that count as units for ad hoc measures and the amounts of stuff in container+contents readings align in similar contexts (M2). At the same time, we ensure that such containers or contents are not accessible by anaphoric pronouns (M1), and that relative to a single context, the unit for an ad hoc measure is stable (M3).

Rothstein (2011, 2017) argues that the syntax of the ad hoc measure interpretation for a PPC like *two glasses of milk* is symmetrically branching, as in (35), and we adopt this structure as well.

(35) $[_{NP}\ [_{MeasP}\ [_{NUM}$ three$][_{N_{meas}}$ glasses$]]$ (*of*) $[_{N}$ milk$]]$

Implicit in Rothstein's analysis is that the semantics for the N_{meas} *glasses* is derived from the sortal concept ⟦glass⟧ (plural morphology is semantically null for measure readings on her account). Rothstein's analysis of the measure reading of *glass* (=*glassful*) is given in (36).

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

(36) $[\![\text{glass}_{\text{measure head}}]\!] = \lambda n \lambda x.\text{MEASURE}_{\text{VOLUME, GLASS}}(x) = n$
(Rothstein, 2017, p. 58)

In (36), measuring involves 'assigning to a sum an overall value on a dimensional scale calibrated in dimension-appropriate units' (Rothstein 2017: 134). In this scale, VOLUME is a dimension, and GLASS 'is the unit of measurement in the relevant dimension, in terms of which the scale is calibrated' (Rothstein 2017: 135).

Khrizman et al. (2015) propose that the measure head is also related to the predicate that specifies the actual stuff being measured. This is schematised in (37) (Khrizman et al. 2015: 199).[13]

(37) a. $[_{\text{measure}}\text{glass}] \rightarrow \lambda N \lambda P \lambda x.\left(\mu_{[\text{VOLUME,GLASS},P,c],w,t} \circ N\right)(x) \wedge P(x)$

b. $[_{\text{NP}}\text{three glasses of wine}] \rightarrow \lambda N \lambda P \lambda x.\mu_{[\text{VOLUME,GLASS,WINE},c],w,t}(x) = 3 \wedge \text{WINE}_{w,t}(x)$

Given that this kind of measure is an ad hoc measure (not an exact, standardised measure), Rothstein (2017: 225) incorporates suggestions from Schvarcz (2014) that, in context, some member of the unit property can be selected such that the ad hoc measure function approximates an exact measure function based on this unit.

In general, we are highly sympathetic to this kind of approach. However, given data point (M2) (repeated below), an implicit assumption is required regarding the way that the unit is selected for the measure function. We propose that, if we make this assumption explicit, it reveals something interesting about how we arrive at the ad hoc measure interpretation of the PPC.

(M2) The ad hoc measure interpretation of the PPC refers to the same quantities of stuff as the container+contents interpretation of the PPC does in similar contexts.

The implicit assumption is that by specifying the context, the dimension (e.g. VOLUME), the unit predicate (e.g. GLASS), and the predicate for the stuff measured (e.g. WHISKEY), the selected unit determines that what is 1 on the measure scale is the same volume as what counts as one on the container +contents reading. In the present example, that would mean that, in most contexts, the ad hoc measure reading of *glass of whiskey* would relate to a volume of whiskey that is small in relation to the interior volume of the glass, just as is the case with the contents part of any container+contents reading in the same contexts. Now, if that is the case, then it makes sense for the same function that determines the relevant size of the glass-sized unit in question and what counts as one portion relative to this glass-unit in the container

[13] We make explicit the implicit dimension specifier.

+contents interpretation to also determine what is one portion relative to the same glass-sized unit on the ad hoc measure interpretation.

On our account, this is the pair of distributive relations $Contains\_each_{i,[\![\mathrm{glass}]\!],[\![\mathrm{whiskey}]\!]}(x,y)$ and $Each\_contained\_by_{i,[\![\mathrm{glass}]\!],[\![\mathrm{whiskey}]\!]}(y,x)$, the argument structure for which is introduced by REL. On the account of Khrizman et al. (2015), for example, this would be a similar pair of relations introduced by their container and contents readings, respectively (their **contents** and **contents**$^{-1}$). If this is right, then, given that the calibration of an ad hoc measure turns on, in part, the information provided by the relevant container+contents reading, it make sense to derive the former from the latter. It is this strategy that we propose to implement.

Given that we wish to retain the distinction between measure syntax and counting syntax, in a measure NP such as *1.5 glasses of wine*, the semantic structure should be as in (38):

(38) $([\![_{\mathrm{Nmeas}}\ \mathrm{glasses\ (of)}]\!]\ ([\![1.5]\!]))([\![\mathrm{milk}]\!])$

This, in turn, suggests that any function MEAS should be a function from concepts such as $[\![_{\mathrm{container+contents}}$ glasses (of)$]\!]$ to concepts such as $[\![_{\mathrm{Nmeas}}$ glasses (of)$]\!]$. The entry in (39) gives the container+contents reading of *glass (of)* which can provide such an input to the MEAS measure shifting operation. (This is so whether the measure phrase is singular or plural, since we adopt Rothstein's assumption that plural morphology in measure readings of PPCs is semantically vacuous.) In (39), $[\![_{\mathrm{c+c}}$ glass of$]\!]$ is shorthand for $[\![_{\mathrm{container+contents}}$ glass of$]\!]$.

(39) $[\![_{\mathrm{c+c}}\ \mathrm{glass\ of}]\!] = [\![\mathrm{REL}]\!]([\![\mathrm{glass}]\!]^{i})$

$$= \lambda Q \lambda v \begin{array}{|c|} \hline u_1\ u_2\ \ cbase_{glass} \\ \hline \mathcal{S}_i(glass)(u_1), \quad u_1 \sqsubseteq v, \quad u_2 \sqsubseteq v \\ \textbf{not}\ \boxed{u_1 \circ u_2},\ u_1 \sqcup u_2 = v \\ cbase_{glass} = \lambda v'\ \boxed{\mathcal{S}_i(\mathrm{glass})(v')} \\ Contains\_each_i(u_1, u_2) \\ Each\_contained\_by_i(u_2, u_1) \\ \textbf{not}\ \boxed{\mathrm{QUA(Q)}} \\ \hline \end{array} ; Q(u_2)$$

Where the variable $\mathfrak{R}$ stands for a relational concept such as the one represented in (39), the semantics for our MEAS function is as in (40). One important part of the entry in (40) pertains to the unit of the scale, $\mathfrak{f}_i(\mathfrak{R}(Q))$ in $\mu_{[VOLUME, \mathfrak{f}_i(\mathfrak{R}(Q))]}(v) = n$, which takes a little bit of unpacking to make clear. In this formula, $\mathfrak{R}(Q)$ is the container+contents reading of a PPC

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

where $\mathfrak{R}$ is a variable for something like $\llbracket_{\text{container+contents}}$ glass (of)$\rrbracket$ and Q is a variable for something like $\llbracket$milk$\rrbracket$. $\mathfrak{f}_i$ is a choice function (determined by the context variable *i*). Choice functions (Winter 1997) are functions from sets to one member of that set. If the choice function is selected by context, then in $\mathfrak{f}_i(\mathfrak{R}(Q))$, this amounts to a formalisation of Schvarcz's (2014) proposal for the selection of a member of the set denoted by the unit predicate as a calibration for the ad hoc measure. This means that $\mathfrak{f}_i(\mathfrak{R}(Q))$ is an entity, namely some salient container+contents sum in the context (e.g., some specific glass of milk). This yields a final interpretation for the unit specification. Given that, for example, (40) is applied to $\llbracket$glass of$\rrbracket$ and $\llbracket$milk$\rrbracket$, the unit is specified in terms of a single container+contents sum of a glass of milk selected from the context.

(40) $$\llbracket \text{MEAS} \rrbracket^i = \lambda\mathfrak{R}\lambda n\lambda Q\lambda v \begin{array}{|c|}\hline Q(v) \\ \mu_{[VOLUME,\mathfrak{f}_i(\mathfrak{R}(Q))]}(v) = n \\ \hline\end{array}$$

The representation for *1.5 glasses of milk* is in (41). Since the counting base $cbase_{milk}$ is not accessible to the main DRS, potentially countable entities are not accessible either. (This is not relevant for *1.5 glasses of milk* but would be more so for the ad hoc measure reading of, e.g., *two boxes of apples* after which, for example, *each* should not be able to refer to the individual boxes or apples.) The set denoted is a set of milk that measures 1.5 with respect to a volume scale calibrated to a unit based upon a contextually salient container +contents *a glass of milk.*

(41) $$\llbracket \text{1.5 glasses of milk} \rrbracket = \big(\llbracket \text{MEAS} \rrbracket^i\big(\llbracket \text{REL} \rrbracket^i\big(\llbracket \text{glass} \rrbracket^i\big)\big)\big)(1.5)\big(\llbracket \text{milk} \rrbracket^i\big)$$

$$= \lambda v \begin{array}{|c|}\hline \\ \hline \begin{array}{|c|}\hline cbase_{milk} \\ \hline \text{milk}(v) \\ cbase_{milk} = \lambda v' \begin{array}{|c|}\hline \text{milk}(v') \\ \hline\end{array} \\ \hline\end{array} \\ \mu_{[VOLUME,\mathfrak{f}_i(\llbracket REL \rrbracket^i(\llbracket glass \rrbracket^i)(\llbracket milk \rrbracket^i))]}(v) = 1.5 \\ \hline\end{array}$$

Importantly, when shifted to a DP (via the application of DET in (31)), the representation in (41) only makes available a discourse referent for the milk (of the relevant measure), and not to the container or contents that is used to define the unit of the measure scale.

Evidence from diminutives. We conclude this section by briefly considering a possible source of further evidence for the view that ad hoc measure readings of PPCs are derived from container+contents readings, namely, those languages that have morphology that encodes a mass-to-count container

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

+contents shift. (See Hnout, Laks, and Rothstein, this volume, Chapter 6, for a discussion of other mass-to-count shifts in Palestinian Arabic.) Among such languages, two that we will briefly consider here are Dutch and Czech, in which certain uses of the diminutive occur with mass nouns and yield a count noun that has a container+contents interpretation (albeit one where the container is sensitive to conventions, the context, and possibly other socio-cultural world knowledge). The reason such data are relevant is that, if ad hoc measure readings are derived from container+contents readings, then measure readings for numerical expression constructions containing these nouns should be readily available, and, indeed, this is what we find.

In Dutch, *biertje* (beer.DIM) means 'glass/can of beer' and *wijntje* (wine. DIM) means 'glass of wine'. Our theory would predict that *biertje* can be combined directly with numerical expressions and get a measure reading, which is what our preliminary investigation into the evidence suggests, as shown by (42) and (43).

(42) Er zit nog voor twee biertjes in het vat. [Dutch]
there sit.3SG still for two beer.DIM in the barrel
'There are still around two glassfuls of beer in the barrel.'

(43) Er zit nog voor twee wijntjes in de fles. [Dutch]
there sit.3SG still for two wine.DIM in the bottle
'There are still around two glassfuls of wine in the bottle.'

In Czech, we get the same pattern for *pivečka* ('beer.DIM'), as shown in (44).

(44) V soudku jsou ještě nejméně dvě pivečka. [Czech]
in barrel.DIM are.3PL still at.least two beer.DIM
'There are still around 2 glassfuls of beer in the barrel.'

One issue that we will leave for future consideration is exactly what syntactic and semantic analysis measure readings of such constructions should have. It is tempting to consider them as NumPs, just like other kinds of counting constructions. However, if that is right, then they would differ syntactically and semantically from measure readings of PPCs insofar as they would not have Rothstein's 'measure' syntactic structure. Similar considerations apply on the semantic side with respect to whether we consider the numerical expression to denote a numeral, as in measure readings of PPCs, or to be a numerical modifier, as in NumPs.

3.6. *Restrictions on Mass-to-Count Coercion*

As observed above (see (MtC1) and (MtC2) in Section 3.1), the main puzzle raised by the counting construction with mass nouns (e.g., *two white wines*) is that the requisite mass-to-count coercion is relatively easy to get under the container+contents reinterpretation, but the ad hoc measure reinterpretation is hard (if not impossible) to get.

What is at stake here is type coercion, which is commonly understood (see, e.g., de Swart 1998) as a process triggered by a type mismatch between a functor and its argument in the composition of a string or utterance, which may trigger a reinterpretation of that string or utterance (by the hearer adding some contextually understood content) to satisfy the input requirement of the functor, and thus restore compositionality. If such a reinterpretation is not possible, that string or utterance will be uninterpretable or even ungrammatical.

In our case, exemplified with *two white wines*, the type mismatch is between a numerical expression in an adjectival use that requires a count NP as an argument, and a mass NP filling its argument slot.[14] This type mismatch triggers the insertion of a hidden coercion operator mapping a mass noun denotation to a count one, or, put differently, the coercion operator reinterprets the mass predicate as a count one. Coercion operators generally allow for a range of possible interpretations, which are constrained by lexical and contextual information. For instance, for *two white wines*, the coercion operator leads to the following enriched interpretations: (a) a set of subkinds of white wines; (b) a set of container+contents entities with white wine as the contents and some contextually specified type of container (e.g. a glass); and, in principle at least, (c) an ad hoc measure function that takes a numerical expression as an argument. In what follows, let us take a closer look at cases (b) and (c), setting aside the subkind coercion (a).

Coerced container+contents interpretations. Consider contexts in which *two white wines* is used in such a way that it can be interpreted as *two* GLASSES OF *white wine*. The coercion process is triggered by a type clash between ⟦two⟧ and ⟦white wine⟧^{i}. To repair the type clash, a contextually salient relational concept is needed. For wine, this may often be something like ⟦REL⟧^{i}(⟦glasses⟧^{i}). Applying ⟦REL⟧^{i}(⟦glasses⟧^{i}) to ⟦white wine⟧^{i} yields something equivalent to a count NP, and compositionality with the numerical is restored.

Coerced ad hoc measure interpretations. Now consider contexts in which it was possible to use *two and a half white wines* in such a way that it could be interpreted as *two and a half* GLASSFULS OF *white wine*. The coercion process would be triggered by a type mismatch between ⟦two and a half⟧ and ⟦white wine⟧^{i}. In this case, the fact that there is a fractional numerical

[14] Such clashes could be characterised syntactically or semantically, with the later being dependent on one's semantic theory of countability. For us, this would be between the interpretation of numerical expressions which presuppose an argument that specifies a quantized counting base, and a mass noun concept provided as an argument that does not specify a quantized counting base.

https://doi.org/10.1017/9781108937979.013 Published online by Cambridge University Press

expression militates against a container+contents interpretation. To repair the type mismatch, therefore, a contextually salient measure is needed.

Based on our proposal that the measure interpretation is derived from the container+contents interpretation, the coercion process would have to look as follows. The ad hoc measure interpretation of *two white wines* would have to be derived by retrieving from the context, and then applying the (implicit) $[\![\text{MEAS}]\!]^i$ function to an implicitly inferred container+contents receptacle concept (such as $[\![\text{REL}]\!]^i([\![\text{glasses}]\!]^i)$). But this would mean that the implicitly inferred $[\![\text{MEAS}]\!]^i$ would have to modify what is an implicitly inferred contextually determined meaning (e.g., $[\![\text{REL}]\!]^i([\![\text{glasses}]\!]^i)$), which is the result of reinterpretation triggered by a type mismatch. This type of modification, we propose, is not available via coercion.

There are at least two reasons for ruling this out as coercion, one cognitive, the other theoretical. In relation to cognition, we speculate that it is too cognitively burdensome to perform combinatorial operations on two implicit (non-lexically realised) concepts (namely, applying an implicit MEAS to an implicit $[\![\text{REL}]\!]^i([\![\text{glasses}]\!]^i)$). On the theoretical side, we think there is a case to be made that coerced ad hoc measure interpretations, should they be possible at all, are not really what we should solely think of as coercion, but rather as general pragmatic reasoning operating on the output of (i.e. 'on top of') coercion. Whereas coercion has been argued to arise all over the place in natural language communication, processes that tightly combine applying general pragmatic reasoning on top of coercion outputs do not, as far as we are aware, have any precedents in other areas of semantics and pragmatics. Hence, the coerced interpretation of *two and a half white wines* as *two and a half* GLASSFULS OF *white wine* is not possible, since this interpretation requires more than coercion to get it (and so is not, properly speaking, coercion at all).

In summary, we have proposed a reason why ad hoc measure interpretations are not available, via coercion, for many combinations of numerical expressions and mass nouns even though container+contents interpretations often are in rich enough contexts (points (MtC1) and (MtC2) in Section 3.1).

4. Summary

The main novel claims in this paper are threefold. First, we have argued that it is possible to give an adequate analysis of container+contents readings of PPCs in a simply-typed, dynamic, mereological framework. The crucial aspect of this analysis is that PPCs, when used in sentences, make available discourse referents for the container, for the contents, and for the container and contents together. We also accounted for the way in which PPCs make available two counting base sets that can be used as parameters in cardinality functions, one for the containers (each of which has a contents), and one for the contents (each of which is in a container). In this way, we have assuaged the worry of Partee and Borschev (2012) that, on a purely mereological analysis of PPCs, counting would not make sense.

Second, we argued that ad hoc measure readings of PPCs are derived from the container+contents reading insofar as MEAS applies to the container +contents shifted interpretation of *glass*. Our motivating evidence for this was that ad hoc measure readings typically specify the same volumes of stuff relative to container size as container+contents readings (see Sutton and Filip 2018b for other evidence for this based on, inter alia, co-predication data).

Third, we argued that this analysis of ad hoc measure interpretations of PPCs gives us a window on mass-to-count coercion. In NumPs formed with mass nouns, we observed that, in all but a few rarified cases (discussed in Section 2), coerced ad hoc measure interpretations are not available, whereas coerced container+contents interpretations are, modulo a suitable context. We proposed that this restriction is explained by the fact that coerced ad hoc measure interpretations would have to be derived via the application of an implicit (non-lexically provided) MEAS function applying to an implicit (non-lexically provided) container+contents interpretation of a suitable receptacle concept, and that this does not fit the standard pattern of coercion, but would be a combination of general pragmatic reasoning applied on top of coercion, something that may be blocked, we hypothesised, on cognitive and theoretical grounds.