Generalizing Individuating/Measure-Ambiguities

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Abstract

This thesis concerns a well-known kind of ambiguity usually attributed to so-called container phrases such as *glass of water*. More specifically, *four glasses of water* is known to be ambiguous between an “individuating interpretation” (four individual glasses containing water) and a “measure interpretation” (a quantity of water measuring four glassfuls). In this thesis, I show that these ambiguities are not limited to container phrases, but are witnessed in atomic predicates more generally. I propose a novel semantic analysis which captures this generalization via a type-shifting principle called “the Universal Measurer”. The result is a generalized semantics for individuating/measure-ambiguities which improves substantially on previous analyses.
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Publications


Shapiro, Stewart & Eric Snyder. 2015. Vagueness and context. *Inquiry*.


Fields of Study

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Many have observed that utterances with numerically modified “container phrases” such as *four glasses of water* are ambiguous.$^1$ (1a), for example, has an individuating interpretation (II), which is paraphrased in (1b), and a measure interpretation (MI), paraphrased in (1c).

(1) a. Mary put four glasses of water in the soup.

   b. There’s a group of four glasses $x$ such that each of $x$ is filled with water and Mary put $x$ in the soup. (II)

   c. There’s an amount of water $x$ such that $x$ measures four glasses worth and Mary put $x$ in the soup. (MI)

For the II, suppose that Mary heats water for coffee in an odd way: she places glasses full of water in boiling soup. In this situation, (1a) is true even though no water touches the soup. For the MI, suppose instead that Mary is making soup, and that the recipe calls for four glassfuls of water. Mary takes a certain glass, fills it with water, empties the water into the soup, and then repeats the process three more times. In this situation, (1a) is true even though no glass touches the soup.

The literature on individuating/measure (I/M) ambiguities has tended to focus exclusively on container phrases, perhaps suggesting that I/M ambiguities arise due to the meanings of container nouns. This primary empirical contribution of this thesis is to show that I/M ambiguities are not limited to container phrases. Rather, other countable predicates

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$^1$See e.g. Selkirk (1977); Chierchia (1998); Landman (2004); Rothstein (2009, 2010); Scontras (2014).
such as *grain of rice* and *orange* also give rise to I/M ambiguities. For example, (2a) is ambiguous between the II in (2b) and the MI in (2c).

(2)  

a. Mary put four oranges in the punch.

b. There’s a group of four oranges $x$ s.t. Mary put each of $x$ in the punch.  \hspace{1cm} \text{(II)}

c. There’s an amount of orange $x$ s.t. $x$ measures four oranges worth and Mary put $x$ in the punch. \hspace{1cm} \text{(MI)}

For the II, suppose that Mary wants to decorate already made punch. She thinks that floating fruit would look nice, so she places a few apples, some pears, and four oranges in the punch. For the MI, suppose instead that Mary’s punch recipe calls for four oranges worth of pulverized orange. Mary has no oranges handy, but she does have some prepackaged orange pulp. She pours a certain amount into the punch, estimating it to be approximately four oranges worth. (2a) is an acceptable, true answer to the question *How many oranges did Mary put in the punch?* in both scenarios.

Container nouns like *glass* belong to a larger category of nouns Scontras (2014) calls **quantizing nouns**, or nouns which help facilitate counting and other forms of measurement. These also include “measure nouns” like *ounce* and “atomizer nouns” like *grain*.

**Scontras (2014)’s Taxonomy of Quantizing Nouns**

(3)  

a. **ATOMIZER NOUNS**: ‘grain’, ‘drop’, ‘piece’, ‘quantity’

b. **CONTAINER NOUNS**: ‘glass’, ‘bottle’, ‘box’, ‘basket’

c. **MEASURE NOUNS**: ‘ounce’, ‘gallon’, ‘foot’, ‘kilowatt’

All three combine with an *of*-phrase to form what Rothstein (2009) calls a “classifier phrase”, e.g. *glass of wine*, *ounce of water*, or *grain of rice*. Nevertheless, they plausibly have different sorts of meanings, Scontras forcefully argues. Atomizer nouns are relational, partitioning a substance such as rice into countable individuals, or “atoms” in the sense of
Link (1983) or Krifka (1989). Container nouns, on the other hand, are inherently monadic, but can be used relationally in container phrases to express that some relation of containment holds between some container (e.g. a glass) and a substance (e.g. water). Finally, like atomizer nouns, measure nouns such as *ounce* are inherently relational, but unlike atomizer nouns, measure nouns do not partition substances into countable individuals. Rather, they divide substances into measured quantities.

One of the key theses here is that there is an important asymmetry between these different sorts of quantizing nouns: while container nouns and atomizer nouns give rise to I/M ambiguities, measure nouns do not. Rather, as Champollion (2010) argues, measure phrases like *four ounces of water* only have MIs.\(^2\) The primary theoretical question I want to ask is this: What explains this asymmetry?

As Rothstein (2009) explains, there are certain expressions which presuppose a domain of individuated objects, or atoms. These include distributive expressions such as ‘each’, ‘both’, and presumably ‘which’, as well as plural pronouns like ‘those’. Now consider the contrasts in (4).

Context: Mary places two oranges, two grains of rice, and two 1 oz. packets of water on a table. In addition, she places two glasses filled with wine on the table, along with two packets, each containing approximately one glassful of water. Pointing at the table, Mary says:

\[
\begin{align*}
(4) & & \text{a. Each of the \{oranges/grains of rice/glasses of wine/??glasses of water/??ounces of water\} is for John.} \\
& & \text{b. Both \{oranges/grains of rice/glasses of wine/??glasses of water/??ounces of water\} are for John.} \\
& & \text{c. Which \{orange/grain of rice/glasses of wine/??glass of water/??ounce of water\} is for John?}
\end{align*}
\]

\(^2\)Apparent exceptions to this generalization include measure nouns used as container nouns, e.g. *liter of water* or *ounce of cocaine*. See Scontras (2014) for discussion.
d. Those oranges/grains of rice/glasses of wine/??glasses of water/??ounces of water} are for John.

Similarly, Chierchia (1998) observes that certain quantizing nouns are acceptable with determiners like ‘all’ and ‘most’, unlike measure phrases.

Context: Similar to (4), only there are five of each item mentioned on the table. John asks where each item came from. Mary responds:

(5)  a. I bought all/most of the oranges from Susan.
    b. I got all/most of the grains of rice from this bag.
    c. I poured all/most of the glasses of wine from this bottle.
    d. ?? I poured all/most of the glasses of water from the tap.
    e. ?? I poured all/most of the ounces of water from the tap.

Both sets of contrasts make sense if ordinary count nouns like orange, atomizer phrases like grain of rice, and container phrases like glass of water on the II denote sets of atoms, while measure phrases like ounce of water and container phrases on the MI do not.

In fact, the relevant contrast here is between different sorts of predicates. More specifically, it corresponds to a semantic distinction Krifka (1989) makes between different kinds of quantized predicates. Formally, Quantization is the property defined in (6), where ‘⊂’ is the relation of proper parthood.

\[(6) \forall P. \text{QUA}(P) \leftrightarrow \forall x, y. P(x) \land y \subset x \rightarrow \neg P(y) \quad (\text{Quantization})\]

A quantized predicate P is such that no proper part of an object satisfying P itself satisfies P. Each of Scontras’ quantizer nouns is “quantized” in this sense. Vagueness aside, arbitrary parts of a grain of rice are not themselves grains of rice, just as arbitrary parts of an ounce of water are not themselves an ounce of water.

Krifka discusses two sorts of quantized predicates. The first – atomic predicates – have the property of Atomicity, as defined in (7b).
The notion of atomicity here is crucially a relative one: a $P$-atom is anything satisfying $P$ which has no $P$-relative proper parts. For example, the noun *glass* is atomic; it denotes the set of atomic glasses. Obviously, individual glasses have proper part – a stem, a rim, etc. Nevertheless, arbitrary proper parts of a glass are not themselves a glass. Algebraically, atoms are the bottommost elements of semilattice structures like the following, where arrows represent mereological relations and ‘⊔’ is a join-relation on individuals.\footnote{Formal definitions can be found in e.g. Link (1983), Krifka (1989), and Landman (2004).}

Thus, to claim that $a$, $b$, and $c$ are $P$-atoms is not to claim that they fail to have proper parts altogether, but rather than they fail to have proper parts in this sort of semilattice structure, one formed from the extension of a predicate $P$. An atomic predicate is one whose extension consists exclusively of $P$-atoms.

Clearly, atomicity implies quantization: if $x$ is an atomic glass, then it cannot have proper parts which are themselves glasses. Importantly, however, the converse implication does not generally hold. To see this, suppose that $a$, $b$, and $c$ from above are each quantities of water measuring half an ounce. Intuitively, then, the result of joining $a$ and $b$ together, i.e. $a ⊔ b$, is a quantity of water measuring an ounce, as are $a \sqcup c$ and $b \sqcup c$. On the other hand, $a \sqcup b \sqcup c$ is not an ounce of water, nor are $a$, $b$, or $c$ individually. It follows that *ounce of water* is quantized: no proper part of an ounce of water is itself an ounce of water. Nevertheless, it is not atomic since quantities of water measuring an ounce needn’t be atomic quantities.
of water. Rather, measure phrases like ounce of water are what Krifka calls a strictly quantized predicate.

\[(8) \quad \forall P. \text{SQU}(P) \leftrightarrow \text{QUA}(P) \land \neg \text{ATM}(P) \quad \text{(Strict Quantization)}\]

In other words, measure phrases are quantized but not atomic.

Thus, what the facts in (4) and (5) reveal is that ordinary count nouns, atomizer phrases, and container phrases on the II are atomic predicates, while measure phrases and container phrases on the MI are strictly quantized predicates. The theoretical contribution of this thesis is to account for the generalization that atomic predicates of various sorts, including orange, give rise to I/M ambiguities, but measure phrases do not. The explanation offered is that it is always possible to shift an atomic predicate to a strictly quantized predicate, but not vice versa. On this view, IIs arise due to the atomicity of the predicates in question. For example, glass of water denotes a set of atomic glasses by default, and the II of four glasses of water results from four functioning as a cardinality modifier, i.e. it counts the number of atomic glasses constituting a certain plurality.

In contrast, MIs arise thanks to a type-shifting principle dubbed “the Universal Measurer” (UM). UM applies “universally” to atomic predicates, effectively transforming them into measure expressions. For example, it shifts the meaning of glass from a predicate true of atomic glasses to a non-standard measure, or what Partee and Borschev (2012) call an ad hoc measure. As a result, four glasses of water comes to denote quantities of water measuring four glasses worth, thus resulting in an MI. Like ounce of water, glass of water on the MI is strictly quantized since quantities of water satisfying the predicate may share overlapping parts. MIs of e.g. four oranges arise thanks to a “reflexivized” version of UM, as we will see. Applying it to orange returns quantities of orange measuring a certain amount of oranges, again rendering orange strictly quantized. As a result, UM accounts for the fact that atomic predicates of various sorts are I/M ambiguous. Because UM does not have an inverse, the analysis predicts that it is not possible to shift from MIs to IIs.
And since measure phrases denote (standardized) measures by default, this also correctly predicts that they do not generally have IIs.

The rest of the thesis is organized as follows. In §2 I argue that I/M ambiguities arise for various sorts of atomic predicates, not just container phrases. To do so, I generalize Rothstein (2010)'s diagnostics for I/M-ambiguous container phrases and also develop novel diagnostics. Applying the diagnostics reveals that I/M ambiguities are more prevalent than has been previously recognized. §3 presents my analysis of I/M-ambiguities. I show that supplementing Scontras (2014)'s semantics for quantizing nouns with UM makes it possible to account for the pervasiveness of I/M ambiguities. Consequently, the resulting analysis both builds on and improves previous analyses.
Diagnosing I/M-Ambiguities

The purpose of this section is to show that I/M ambiguities are not limited to just container phrases. I present diagnostics for IIs and MIs, beginning with three diagnostics from Rothstein (2010). Though all three are applicable to container phrases, not all are applicable to atomic predicates more generally. Therefore, I develop some additional heuristics to supplement Rothstein’s. Taken together, these reveal that I/M ambiguities are more prevalent than previously recognized.

2.1 Rothstein’s Diagnostics

Rothstein (2010)’s first diagnostic for disambiguating container phrases involves distributive expressions such as each. On the II, four glasses of water denotes groups of four atomic glasses, each of which is filled with water. On the MI, it instead denotes quantities of water measuring four glassfuls. Because each presupposes a domain of atoms, it is thus compatible only with IIs:

(9) [Context: Mary has a strange way of heating up water for coffee. She fills individual glasses with water and then places those glasses in boiling soup.]
(10) [Context: Mary is making soup. Following the recipe, she fills a certain glass four times with water, pouring the contents each time into the soup.]
(11) Mary put each of the four glasses of water in the soup.
The fact that (11) is acceptable in (9) but odd in (10) shows that the former induces an II of *four glasses of water*, the latter an MI. Accordingly, I call contexts like (9) **individuating contexts** and those like (10) **measure contexts**.

Rothstein’s second diagnostic involves the possibility of *-ful* suffixation. According to it, *-ful* can be acceptably suffixed to a container noun in measure contexts but not individuating contexts. And, indeed, an utterance of (12) is acceptable in (10) but not (9).

(12) Mary put four glassfuls of water in the soup.

According to Rothstein, that’s because the function of *-ful* is to transform a container noun such as *glass* into a measure noun. It denotes quantities of a substance (e.g. water) measured in terms of an ad hoc glass-unit. Consequently, *-ful* suffixation effectively forces an MI.

Rothstein’s third diagnostic involves **degree relatives**. The diagnostic relies on Carlson’s (1977) observation that relative clauses denoting sets of individuals can be headed by either *which* or *that*, unlike relative clauses denoting measured quantities, which are necessarily headed by *that* or a null complementizer. This diagnostic is applied to measure nouns and container nouns in (13).

(13) a. I wanted to inspect the four ounces of water {∅/ ??which / that} Mary put in the soup.

b. I wanted to inspect the four glassfuls of water {∅/ ??which / that} Mary put in the soup.

c. I wanted to inspect the four glasses of water {∅/ which / that} Mary put in the soup.

(13a) shows that the measure phrase *four ounces of water* denotes only measured quantities of water. Similarly, (13b) demonstrates that *four glassfuls of water* denotes only measured quantities of water, as expected given the meaning Rothstein attributes to *-ful*. In contrast, (13c) shows that *four glasses of water* does have an II, since it is acceptable with both kinds
of relative clauses. However, because *four glasses of water* has an MI paraphrased as *four glassfuls of water*, we should expect relative clauses like the one in (13c) to be acceptably headed by *which* only in individuating contexts such as (9). This prediction is also correct.

Two of Rothstein’s diagnostics can be used to support the claim that I/M ambiguities extend beyond just container phrases. Note first that *each* is acceptable with the atomizer phrase *four drops of blood* when uttered in (14) – an individuating context – but not (15) – a measure context.

(14) [Context: John and Mary are detectives at a crime scene, where rain has recently washed away four drops of blood that were on the sidewalk. Mary says:]

I saw each of the four drops of blood before the rain started.

(15) [Context: Mary is making soup. The recipe calls for four drops of pig blood. Mary does not have a dropper, so she puts four drops worth of blood in a teaspoon and then pours it into the soup. Later, Fred asks if the soup really contains four drops of blood. John says:]

I saw (#each of) the four drops of blood while Mary was making the soup.

This is to be expected if *four drops of blood* is I/M-ambiguous, and (14) induces an II of the predicate while (15) induces an MI. Secondly, notice that while *that* in (16) is acceptable in both (14) and (15), *which* is only acceptable in (14).

(16) Earlier, John inspected the four drops of blood {which/that} Mary {saw/put in the soup.}

Again, this is to be expected if *four drops of blood* is I/M-ambiguous, and if relative clauses headed by *which* presuppose a domain of individuated objects.

Applying Rothstein’s diagnostics to the numerically modified atomic predicate *four oranges* yields similar results:
(17) [Context: John and Mary are at a party with punch that was decorated using whole, fresh fruit. Now there are only three oranges in the punch, and there is an argument about whether originally there were four. Mary says:]  
Before the party started, I saw each of the four oranges that Bill put in the punch.

(18) [Context: John and Mary are at a party, and there is an argument about how many oranges were used to make the punch. Mary was there when Bill made the punch, and saw him measure out four oranges worth of pulp from a store-bought container. She says:]  
Before the party started, I saw (each of) the four oranges that Bill put in the soup.

(19) John wanted to inspect the four oranges {which/that} Bill put in the punch.

Four oranges is acceptable with each in the individuating context (17) but not in measure context (18). Similarly, which in (19) is acceptable only in the individuating context.

These results show that like the numerically modified atomizer phrase four drops of blood, four oranges is I/M-ambiguous. However, because neither drop nor orange denotes a container, unlike e.g. glass or box, Rothstein’s -ful suffixation heuristic is not applicable to these nouns. Nevertheless, there is a way of naturally extending Rothstein’s diagnostic to include all three categories. This is done in the next section, where I also introduce some novel diagnostics intended to supplement Rothstein’s.

2.2 Some Additional Diagnostics

I begin by generalizing Rothstein’s -ful suffixation diagnostic. Rothstein (2010) proposes that -ful transforms a container noun like glass into a measure noun, one denoting measured quantities of a substance. The proposal here is that -ful is a special case of worth in this respect. More generally, worth transforms atomic predicates into measure expressions. For example, four glassfuls of water and four glasses worth of water are synonymous: both denote quantities of water measuring four ad hoc glass-units. Similarly, four oranges worth
of orange denotes quantities of orange measuring four ad hoc orange-units, while four grains worth of rice denotes quantities of rice measuring four ad hoc grain-units. In all three cases, worth expresses a relation between substances and their measures. -ful also expresses a relation between substances and measures, only that relation is restricted to containment. Hence, glassful of water measures how much of a substance would be contained in a certain glass. On the other hand, worth is far more liberal with regard to how measures are determined, as shown in (20).

(20) [Context: John and Mary are planning a dog sledding trip. John is out buying supplies for the trip but can’t remember how many dogs they planned to bring. He calls Mary, asking her how much dog food to buy. Mary responds:]

We need four dogs #(worth) of dog food.

In (20), the function of worth is to transform dog into a measure noun, one measuring how much dog food a certain dog can eat for the duration of John and Mary’s trip.

Thus, the first diagnostic proposed here is a natural extension of Rothstein’s -ful diagnostic: I/M-ambiguous phrases are acceptable with worth in measure contexts but not individuating contexts. This is illustrated by (23), which is odd in the individuating context (21) but acceptable in the measure context (22).

(21) [Context: Mary has made some punch for the party. She wants to decorate it, and she thinks floating fruit would look nice. She places a few apples, some pears, and four oranges in the punch. John asks ‘How many oranges did Mary put in the punch?’. Fred replies:]

(22) [Context: Mary is making punch for the party. The recipe calls for four processed oranges, but Mary is out of oranges. She pours a certain amount of prepackaged orange pulp into the punch, estimating that it is roughly equal to how much orange pulp four typical oranges would produce. John asks ‘How many oranges did Mary put in the punch?’. Fred replies:]
(23) Mary put four oranges worth (of orange) in the punch.

This result makes sense if four oranges is I/M ambiguous, if worth in (23) transforms orange into a measure noun, thus resulting in an MI, and if an utterance of (23) implicates that what was put in the punch was something other than individual oranges, like e.g. orange pulp.

The second diagnostic proposed here involves the nouns number and amount. Scontras (2014) calls amount a DEGREE NOUN. It denotes a relation between kinds and degrees, specifically between instances of a kind and measures of those instances. For example, amount in (24a) denotes a relation between a certain group of apples and their collective weight, their cardinality, or some other contextually salient measure.

(24) [Context: Pointing at four 1 lb. apples in a bowl.]

a. John ate that amount of apples every day for a year.

b. John ate that number of apples every day for a year.

(24a) is ambiguous: it can mean that every day for a year John ate apples whose collective weight equals four pounds, or else that every day for a year John ate a total of four apples, regardless of their weight. On the other hand, (24b) can only mean the latter. That’s plausibly because number is a special case of amount: it too is a degree noun, but it relates pluralities to their cardinalities.

This difference between amount and number can be used to demonstrate I/M ambiguities. Notice that (25a) is true in the context given, unlike (25b).

(25) [Context: Mary places four glasses filled with water in her soup. John places eight glasses filled with water in his soup. John’s glasses are exactly half the size of Mary’s.]

a. There are four glasses of water in Mary’s soup, and there’s the same amount of water in John’s soup. (true)
b. There are four glasses of water in Mary’s soup, and there’s the same number
#(of glasses) of water in John’s soup. (false)

Again, *four glasses of water* denotes quantities of water measuring four glasses worth on the
MI. In (25), *the same amount* anaphorically refers to this abstract measure. Consequently,
(25) is true only if the amount of water Mary put in her soup is equal to the amount of water
John put in his, which is indeed the case. On the II, *four glasses of water* denotes pluralities
of four atomic glasses, each filled with water. In (25b), *the same number* anaphorically refers
to this abstract cardinality. Consequently, (25b) will be true only if the number of glasses
Mary placed in her soup is equal to the number of glasses placed in his, which is not the
case. Now consider (26).

(26) [Context: Mary places four glasses filled with water into her soup. John places four
glasses filled with water into his soup. John’s glasses are exactly half the size of
Mary’s.]

a. There are four glasses of water in Mary’s soup, and there’s the same amount of
water in John’s sou. (false)

b. There are four glasses of water in Mary’s soup, and there’s the same number of
glasses in John’s soup. (true)

These judgments make sense only if *four glasses of water* receives a MI in (26a) and an II
in (26b). That’s because there are four glassfuls of water in Mary’s soup but not in John’s,
even though there are just as many glasses filled with water in both soups.

Applying this diagnostic to atomizer phrases such as *four grains of rice* reveals that
they too are I/M-ambiguous.

(27) [Context: Mary and John are making soup. Mary adds four grains of rice to her
soup. John adds eight grains of rice to his. John’s grains are exactly half the size
of Mary’s.]
a. There are four grains of rice in Mary’s soup, and there’s the same amount of rice in John’s soup. (true)

b. There are four grains of rice in Mary’s soup, and there’s the same number of grains in John’s soup. (false)

(27a) is true only if *four grains of rice* receives an MI since there are in fact four grains worth of rice in both soups. However, (27b) is false since there are twice as many grains of rice in John’s soup. This shows that in (27b), *four grains of rice* gives rise to an II. These conclusions are confirmed by the examples in (28), where the evaluations are reversed. (28a) is false because the volume of rice in John’s soup is half of that in Mary’s, while (28b) is true because there are just as many rice grains in both soups.

(28) [Context: Mary and John are making soup. Mary adds four grains of rice to her soup, and John does the same. John’s grains are exactly half the size of Mary’s.]

a. There are four grains of rice in Mary’s soup, and there’s the same amount of rice in John’s soup. (false)

b. There are four grains of rice in Mary’s soup, and there’s the same number of grains in John’s soup. (true)

These examples show that numerically modified atomizer phrases, like numerically modified container phrases, are I/M ambiguous.

Applying the diagnostic to *four oranges* yields similar results,

(29) [Context: Mary and John are making punch. Mary adds four oranges to her punch. John adds eight oranges to his. John’s oranges are exactly half the size of Mary’s.]

a. There are four oranges in Mary’s punch, and there’s the same amount orange in John’s punch. (true)

b. There are four oranges in Mary’s punch, and there’s the same number of oranges in John’s punch. (false)
(30) [Context: Mary and John are making punch. Mary adds four oranges to her punch. John adds four oranges to his. John’s oranges are exactly half the size of Mary’s.]

a. There are four oranges in Mary’s punch, and there’s the same amount of orange in John’s punch. (false)

b. There are four oranges in Mary’s punch, and there’s the same number of oranges in John’s punch. (true)

as should be expected if four oranges is genuinely I/M-ambiguous.

The final additional heuristic proposed here involves the (un)acceptability of modifiers such as approximately and roughly, or what Lasersohn (1999) calls slack regulators. The diagnostic is illustrated in (31) using a container phrase. The individuating context in (9) and measure context in (10) are repeated for convenience.

(9) [Context: Mary has a strange way of heating up water for coffee. She fills individual glasses with water and then places those glasses in boiling soup.]

(10) [Context: Mary is making soup. Following the recipe, she fills a certain glass four times with water, pouring the contents each time into the soup.]

(31) [Context: John, who was watching Mary the whole time, says:] Mary put approximately four glasses of water in the soup.

John’s utterance of (31) is acceptable in the measure context but not the individuating context. That’s plausibly thanks to an implicature carried by a use of approximately: it implicates that the speaker is unsure whether the amount indicated is the amount which actually obtains. On the MI, Mary’s utterance of (31) implicates that for all she knows, the amount of water she poured into the soup is not exactly four glassfuls. This sort of uncertainty is normal with measurement. For instance, whether a given bowl contains exactly four ounces of water is something that we can only know to a certain degree of precision. Most everyday purposes do not require a great deal of precision, and it’s only
when more precision is required that we need to use slack regulators. However, it is hard to see how a use of *approximately* could be appropriate in (31) if an II of *four glasses of water* is intended. After all, Mary just placed the four glasses in the soup, and so there would appear to be little room left for uncertainty concerning their exact cardinality. Thus, I/M-ambiguous expressions are generally acceptable with slack regulators on MIs but not IIs, at least when the cardinality is question is relatively small.¹

(32) applies this diagnostic to an example with *four oranges*. The individuating context (21) and measure context (22) are repeated for convenience.

(21) [Context: Mary has made some punch for the party. She wants to decorate it, and she thinks floating fruit would look nice. She places a few apples, some pears, and four oranges in the punch. John asks ‘How many oranges did Mary put in the punch?’ Fred replies:]

(22) [Context: Mary is making punch for the party. The recipe calls for four processed oranges, but Mary is out of oranges. She pours a certain amount of prepackaged orange pulp into the punch, estimating that it is roughly equal to how much orange pulp four typical oranges would produce. John asks ‘How many oranges did Mary put in the punch?’ Fred replies:]

(32) Mary put approximately four oranges in the punch.

Fred’s utterance of (32) is acceptable in the measure context but not the individuating context. This result is predicted if *four oranges* is I/M ambiguous, and if slack regulators are generally acceptable only with MIs in the case of small numbers.

¹Slack regulators are generally acceptable with IIs involving large cardinalities, where an exact measure is not so easily determined. It is for this reason that I use only small numbers when diagnosing I/M ambiguities.
Chapter 3

Previous Analyses

Taken together, the examples §2 show that I/M ambiguities are not limited to just container nouns. Rather, the correct generalization appears to be that atomic nouns are I/M-ambiguous. In this section, I briefly review the two prominent analyses of I/M in the literature, those due to Rothstein (2009) and Scontras (2014). It will be shown that both analyses suffer from the same problem: neither generalizes I/M ambiguities beyond container phrases. Seeing why will guide the ultimate analysis of I/M ambiguities proposed here in §4.

3.1 Rothstein (2009)

Let’s begin with Rothstein (2009)’s analysis of I/M-ambiguous container phrases. Scontras (2014) argues that glass, unlike ounce or grain, is inherently monadic. He points out that in out-of-the-blue contexts, both ounce and grain are strongly elliptical: one wants to ask ‘Ounce of what?’ or ‘Grain of what?’, but not necessarily ‘Glass of what?’.

(33) Please hand me that {glass/?ounce/?grain}.

At the same time, glass in container phrases takes on a distinctly relational character. On the II, four glasses of water is interpreted as ‘four glasses filled with water’. And on the MI, four glasses of water roughly means ‘four glassfuls of water’. Thus, the question is how an inherently monadic predicate like glass can come to function relationally when forming container phrases.
On Rothstein’s analysis, relational interpretations of glass arise thanks to a type-shifting operation she labels the Construct State Shift (CSS). This is given in (34), where the relation variable $R$ is free, signifying that its interpretation is to be provided by context.

\[(34) \quad \lambda P.\lambda Q.\lambda x.\exists y. P(x) \land Q(y) \land R(x, y) \quad \text{(CSS)}\]

What CSS does, in effect, is shift a monadic noun like glass into a relational noun, one which denotes quantities of some substance $Q$ bearing $R$ to that noun. For example, on Rothstein’s analysis, applying it to glass and then of water returns those glasses bearing $R$ to quantities of water.

\[(35) \quad \begin{align*}
\text{a.} & \quad [\text{glass}] = \lambda x. \text{glass}(x) \\
\text{b.} & \quad [\text{of water}] = \lambda x. \text{water}(x) \\
\text{c.} & \quad \text{CSS}([\text{glass}])([\text{of water}]) = \lambda x.\exists y. \text{glass}(x) \land \text{water}(y) \land R(x, y) \end{align*} \]

With container phrases, $R$ defaults to the relation of being filled with. Consequently, glass of water will denote individual glasses filled with water, or (35b).

From here, deriving IIs is fairly straightforward. Rothstein assumes an adjectival analysis of cardinality expressions like (36a), where $x$ ranges over pluralities and $\mu_\#(x)$ is a cardinality measure returning the number of singular individuals – or “atoms” in the sense of Link (1983) or Krifka (1989) – constituting a plurality.

\[(36) \quad \begin{align*}
\text{a.} & \quad [\text{four}] = \lambda P.\lambda x. \mu_\#(x) = 4 \land P(x) \\
\text{b.} & \quad [\text{four glasses of water}] = \lambda x.\exists y. \mu_\#(x) = 4 \land \text{glasses}(x) \land \text{water}(y) \land R(x, y) \\
& \quad \quad \quad \text{water}(y) \land R(x, y) \end{align*} \]

Consequently, four glasses of water will denote those pluralities consisting of four glasses, each of which is filled with water. Furthermore, (1a) will be true just in case there is at least one such plurality of glasses which Mary put in the soup.

\[(1a) \quad \text{Mary put four glasses of water in the soup.} \]
This is the II, of course.

To derive the MI, Rothstein assumes that *glass* combines either overtly or covertly with the suffix *-ful*, which Rothstein assumes has something like the meaning in (37a).

\[(37)\]
\[
a. \text{[ful]} = \lambda P. \lambda Q. \lambda n. \lambda x. Q(x) \land \mu_P(x) = n \\
b. \text{[glassful]} = \lambda Q. \lambda n. \lambda x. Q(x) \land \mu_{glass}(x) = n \\
c. \text{[four glassfuls of water]} = \lambda x. \text{water}(x) \land \mu_{glass}(x) = 4
\]

In effect, the function of *-ful* is to transform a monadic noun like *glass* into a measure noun. In (37b), ‘\(\mu_{glass}\)’ is an ad hoc measure, or a function from individuals \(x\) to numbers \(n\) such that \(x\) would fill a certain contextually determined glass \(n\)-many times. Consequently, *glassful* denotes quantities of a substance \(Q\) measuring \(n\)-many ad hoc glass-units, and so *four glassfuls of water* denotes those quantities of water measuring four glassfuls. In cases like (1a), where *glass* occurs without *-ful*,

(1a) Mary put four glasses of water in the soup.

Rothstein assumes that the latter is unpronounced but present in the syntax, thus leading to the desired MI.

Though it provides a fairly straightforward account of I/M-ambiguities, one clear problem with Rothstein’s analysis is that it fails to generalize to all I/M-ambiguous expressions. Consider again *four grains of rice*, for instance. *Grain* cannot combine overtly with *-ful*.¹ Presumably, that’s because *-ful* presupposes that the noun it combines with denotes a container of some sort, and grains are not containers. If so, then the MI of e.g. *four grains of rice* cannot result from silent *-ful* suffixation either. In other words, if *grain* denotes the wrong sort of thing to combine with *-ful* overtly, then presumably it denotes the wrong sort of thing to combine with *-ful* covertly as well. But then MIs of *four grains of rice* cannot be due to *grain* combining with unpronounced *-ful*. Likewise for MIs of *four oranges*. Thus, MIs cannot generally be due to silent *-ful* suffixation.

¹Contrast *four grains/*??grainfuls of rice.
The problem, I want to suggest, is that Rothstein’s analysis focuses too narrowly on container nouns. I argued above that -ful is a special case of worth in that the function of both is to transform monadic nouns into measure nouns. More specifically, -ful is just worth restricted to relations of containment. If so, then substituting worth for -ful in Rothstein’s analysis would lead to a fully generalizable account of I/M-ambiguities. In fact, I’m going to argue later on that something like this is ultimately correct.

3.2 Scontras (2014)

Scontras (2014)’s analysis of I/M-ambiguities is differs from Rothstein’s in certain important respects. The first point of disagreement concerns how relational interpretations of container nouns arise within container phrases. Whereas Rothstein derives relational interpretations via type-shifting, namely via CSS, Scontras instead attributes relational interpretations to the meaning of the preposition of, which he assumes has the meaning in (38a).

\begin{align*}
&\text{(38) a. } \text{[of]} = \lambda k. \lambda x. \exists y. \cup(k(y) \land \text{filled-with}(x,y)) \\
&\text{b. } \text{[of water]} = \lambda x. \exists y. \cup\text{WATER}(y) \land \text{filled-with}(x,y)
\end{align*}

Here, $k$ is variable ranging over KINDS in the sense of Carlson (1977) or Chierchia (1984, 1998), and $\cup$ is Chierchia’s “down”-operator taking a kind as argument and returning the instances of the kind in the world of evaluation. Consequently, of water will denote the set of things filled with quantities of water. This can then combine with the inherently monadic noun glass via intersective modification, which I formalize here using Landman (2004)’s type-shifting principle “ADJUNCT” in (39a).

\begin{align*}
&\text{(39) a. } \lambda P. \lambda Q. \lambda x. P(x) \land Q(x) \tag{ADJUNCT} \\
&\text{b. } \text{ADJUNCT([glass])} = \lambda Q. \lambda x. \text{glass}(x) \land Q(x) \\
&\text{c. } \text{[glass of water]} = \lambda x. \exists y. \text{glass}(x) \land \cup\text{WATER}(y) \land \text{filled-with}(x,y)
\end{align*}
Combining ADJUNCT with *glass* coerces the latter into an intersective modifier. Consequently, it can combine with the denotation of *of water* from above, ultimately resulting in (39c). As a result, *glass of water* will denote individuals glasses *x* which are filled with at least one quantity of water *y*.

From here, securing IIs for container phrases is straightforward. Like Rothstein, Scontras assumes an adjectival semantics for cardinality modifiers, repeated here in (40a).

\[(40) \text{a. } \lambda P. \lambda x. \mu_\#(x) = 4 \land P(x) \]
\[\text{b. } \lambda x. \exists y. \mu_\#(x) = 4 \land \text{glasses}(x) \land \text{WATER}(y) \land \text{filled-with}(x, y) \]

Thus, combining *four* with the denotation for *glass of water* from above resulting in (40b): *four glasses of water* will denote those pluralities consisting of four glasses, each of which is filled with water. Consequently, (1a) will be true just in case Mary set at least one such plurality of glasses in the soup,

\[(1a) \text{ Mary put four glasses of water in the soup.} \]

thus leading to the intended II.

Unlike with Rothstein, MIs are derived via type-shifting on Scontras’ analysis. More specifically, Scontras posits the type-shifter in (41a), which he dubs “\(\text{SHIFT}_C^M\)”.

\[(41) \text{a. } \lambda P. \lambda k. \lambda n. \lambda x. \text{WATER}(x) \land \mu_\#(x) = n \quad (\text{SHIFT}_C^M) \]
\[\text{b. } \text{SHIFT}_C^M([\text{glass}]) = \lambda k. \lambda n. \lambda x. \text{WATER}(x) \land \mu_\text{glass}(x) = n \]
\[\text{c. } \text{SHIFT}_C^M([\text{glass}])([\text{of water}]) = \lambda n. \text{WATER}(x) \land \mu_\text{glass}(x) = n \]

In essence, \(\text{SHIFT}_C^M\) shifts a monadic noun such as *glass* into a measure noun such as *ounce*. In (41b), “\(\mu_\text{glass}\)” is an ad hoc measure in the sense of Partee and Borschev (2012): it measures a substance *x* in terms of how much *x* would fill a certain contextually-determined
glass, e.g. the glass Mary used to pour water into the soup or a typical glass. Thus, the function of $\text{SHIFT}_{C-M}$ is to shift a container noun into an ad hoc measure. This can then combine with $\text{of water}$ in the way suggested in (41c), where $\text{of}$ is semantically vacuous.\footnote{Scontras presupposes Chierchia (1998)'s analysis of bare nouns, whereby bare $\text{water}$ denotes the kind $\text{WATER}$. Since this is what is contributed by the phrase $\text{of water}$ on the MI of $\text{glass of water}$, $\text{of}$ contributes no semantic content.}

Finally, we combine the result with a numeral such as $\text{four}$ to return a predicate true of quantities of water measuring four glasses worth, or (42).

\begin{equation}
\lambda x. \uparrow \text{WATER}(x) \land \mu_{\text{glass}}(x) = 4
\end{equation}

Consequently, (1a) will be true just in case Mary put a quantity of water in the soup measuring four glassfuls,

(1a) Mary put four glasses of water in the soup.

or the intended MI.

As with Rothstein’s analysis, though it provides a fairly straightforward account of I/M-ambiguities, the problem with Scontras’ semantics is that it fails to generalize to all I/M-ambiguous expressions. Consider first MIs for $\text{four grains of rice}$. On Scontras’ analysis, these should presumably be derivable in a manner similar to MIs for $\text{four glasses of water}$, i.e. via $\text{SHIFT}_{C-M}$. However, the first problem is that ‘grain’ is inherently relational on Scontras’ semantics, and so has the wrong semantic type to combine with $\text{SHIFT}_{C-M}$.

\begin{equation}
\begin{align*}
\text{a. } \llbracket \text{grain} \rrbracket &= \lambda k. \lambda x. x \in \pi_{\text{grain}}(k) \\
\text{b. } \llbracket \text{grain of rice} \rrbracket &= \lambda x. x \in \pi_{\text{grain}}(\text{RICE})
\end{align*}
\end{equation}

Here, $\pi$ is a partitioning function; it partitions a substance such as rice into countable units, or atoms. Thus, $\text{grain}$ denotes a relation between a substance and atomic grains of that substance. Consequently, it has the wrong semantic type to combine with $\text{SHIFT}_{C-M}$, and thus to function as an ad hoc measure.
However, it might be reasonably thought that this problem can be avoided by applying another independently motivated type-shifter, Barker (1998)’s “detransitivizer” given in (44a).³

(44)  a. $\lambda R. \lambda x. \exists y. R(x, y)$  
   b. $\text{DETRAN}([\text{grain}]) = \lambda x. \exists k. x \in \pi_{\text{grain}}(k)$

Applying it to the inherently relational grain returns a monadic predicate true of grains of some substance. Consequently, (44b) has the right type to combine with Scontras’ $\text{SHIFT}_{C-M}$. Doing so gives us (45a), where “$\mu_{dg}$” is an ad hoc measure employing detransitivized grain as a unit.

(45)  a. $\text{SHIFT}_{C-M}($DETRAN([grain])) = $\lambda k. \lambda n. \lambda x. \uplus_k(x) \land \mu_{dg}(x) = n$
   b. $[^{\text{four grains of rice}}] = \lambda x. \uplus_\text{RICE}(x) \land \mu_{dg}(x) = 4$

Ultimately, this leads to the denotation in (45b): four grains of rice will be true of those quantities of rice measuring four ad hoc detransitivized grain-units.

Unfortunately, however, (45b) makes some undesirable predictions, owing to the detransitivized nature of the ad hoc measure employed. According to (44b), detransitivized grain is true of atomic grains of a particular substance, e.g. rice, sand, salt, or wheat. Not all of these are the same size, of course. Grains of rice tend to be quite large compared to grains of salt, for instance. Suppose for argument’s sake that four grains of salt is roughly equivalent in volume to one quarter of one grain of rice. Then (45b) wrongly allows for the following possibility: Mary put four grains of rice in the soup is true on the MI if Mary put an amount of rice in the soup equal to one quarter’s worth, i.e. the equivalent of four grains of salt. The problem is that there is no guarantee that the substance being measured (in this case rice) is the same substance being partitioned and subsequently measured by grain, thanks to its detransitivization.

³According to Barker, this is needed to explain purportedly intransitive uses of relational nouns like relative, as with e.g. A relative came to visit yesterday.
A similar point can be made regarding MIs of *four oranges*. This can be paraphrased as ‘four oranges worth of orange’, recall. Thus, it appears that we are measuring quantities of orange in terms of an ad hoc orange-unit, i.e. something like how much orange is contained in some contextually-determined orange. Now, Scontras’ $\text{SHIFT}_{C-M}$ takes two nominal arguments: the head of a pseudopartitive (e.g. *glass*), and the complement (e.g. *water*). The head provides the ad hoc measure, while the complement provides the substance measured. But since *orange* isn’t a pseudopartitive, it cannot provide both nominal arguments. Thus, $\text{SHIFT}_{C-M}$ cannot be used to generate the intended MI. What’s needed is some principled way of guaranteeing that the substance being measured (in this case orange) is the same as that doing the measuring (in this case an orange).

A final, unrelated problem for Scontras’ analysis is that it makes mistaken predictions concerning container phrases involving plural noun complements, e.g. *box of tires*. Consider the following scenario.

Context: John and Mary work in a recycling plant specializing in recycling two items: aluminum cans and tires. Once the items are ground, they are sifted and the recycled material is packaged into boxes. John and Mary find some unmarked boxes, and there is some uncertainty as to what they contain. After dumping the contents of the boxes into two sorted piles, Mary points at one of the piles and says:

(46) That’s four boxes of {tires/tire}.

Obviously, a MI is intended here: Mary is talking about four boxes’ *worth of* tires, not four boxes *containing* tires. Moreover, (46) plausibly receives a grinding interpretation, in the sense of Pelletier (1975). For one thing, Mary is pointing at ground up bits of tire, and so she could have just as well used the massivized noun ‘tire’ in the scenario described. Moreover, (46) isn’t false just because Mary failed to point at piles of whole tires.

However, $\text{SHIFT}_{C-M}$ wrongly predicts that (46) is false in this scenario.

(47) a. $\text{SHIFT}_{C-M}([\text{box}]) = \lambda k.\lambda n.\lambda x. \bigcup \text{TIRE}(x) \land \mu_{\text{box}}(x) = n$
b. \([\text{four boxes of tires}] = \lambda x. TIRE(x) \land \mu_{box}(x) = n\)

Here’s the problem. On the background semantics assumed by Scontras, namely Chierchia (1998), bare nouns are kind-denoting, including bare plural nouns such as tires. On Chierchia’s semantics, the kind TIRE is a function from worlds \(w\) to the maximal plurality of tires in \(w\). Thus, ‘\(\lambda x. TIRE(x)\)’ denotes the set of all pluralities of tires (in the world of evaluation). And pluralities of tires consist of atomic tires, of course. Furthermore, taking the closure of all the atomic tires plus the pluralities of tires forms the denotation of massivized tire on Chierchia’s semantics. In other words, ‘\(\cup \cap \lambda x. \text{tire}(x)\)’ effectively massivizes the count noun tire.\(^4\) And ‘\(\lambda y. [\lambda x. \text{tire}(x)](y)\)’ is equivalent to ‘\(\lambda x. TIRE(x)\)’ in (47a). Thus, while the denotation resulting from an application of \(\text{SHIFT}_{C-M}\) correctly predicts that the plural noun tires in (46) can receive a massivized interpretation (thanks to Chierchia’s analysis of mass nouns), it incorrectly predicts that (46) should be true only if Mary is pointing at a pile of whole tires, i.e. sums of atomic tires, contrary to fact. What’s needed is a semantics according to which (46) can be true in genuine grinding scenarios, i.e. where we are talking about four boxes worth of tire parts.

Chapter 4

Generalizing I/M-Ambiguities

To summarize, there are two analyses of I/M-ambiguities available in the literature, those due to Rothstein (2009) and Scontras (2014), and both analyses suffer from the same problem: they fail to generalize. More specifically, because MIs arise from silent -ful suffixation on Rothstein’s analysis, and since -ful suffixation is restricted to just container nouns, Rothstein’s analysis wrongly predicts that MIs should be unavailable for e.g. *four grains of rice* or *four oranges*. On the other hand, Scontras’ type-shifting analysis fails to generalize to atomizer phrases and ordinary count nouns thanks to type-theoretic considerations. What’s more, it wrongly predicts that *four boxes of tires* is exclusively true of groups of whole tires.

The purpose of this section is to develop a semantics which avoids the problems just mentioned. It represents a synthesis of previous analyses. It borrows Rothstein’s type-shifting analysis of IIs, and thus avoids the need to postulate multiple meanings for *of*, e.g. a relational meaning posited specifically for container phrases like *glass of water*, and a null meaning for measure phrases like *ounce of wine* and atomizer phrases like *grain of rice*. Rather, on the semantics developed here, *of* has a uniform meaning in all three sorts of quantizing phrases; it expresses a mereological relation, following Ladusaw (1982). The semantics here also borrows Scontras’ type-shifting analysis of MIs, and thus avoids the need to posit the analog of silent -ful suffixation. Following e.g. Partee (1986) and Chierchia (1998), I assume that type-shifting principles are part of the grammar, just like general semantic principles like Function Application or familiar syntactic principles. As such, they needn’t be triggered by the presence of an underlying morpheme in the syntax. Furthermore, following Barker (1998), I assume that the application of a type-shifting operation is not
obligatorily triggered by mismatch of some sort. Rather, some type-shifting operations are triggered pragmatically, i.e. as a function of extralinguistic context, or what Barker calls “free optional application”.¹

Let’s start with I/M-ambiguous container phrases like four glasses of water. As Scontras suggests, we may reasonably assume that glass is lexically a monadic predicate, one true of individual glasses, or (35a).

\[(35a) \quad \text{[glass]} = \lambda x. \text{glass}(x)\]

Following Rothstein, I assume that glass receives its relational interpretation in container phrases via the Construct State Shift, as suggested in (48), where the free relation variable R is interpreted in context as ‘is filled with’.

\[(48) \quad \text{CSS([glass])} = \lambda Q. \lambda x. \exists y. \text{glass}(x) \land Q(y) \land R(x, y)\]

As mentioned, I assume that of denotes the parthood relation in (49a), following Ladusaw (1982).

\[(49) \quad \text{a. [of]} = \lambda x. \lambda y. y \sqsubseteq x.\]
\[\text{b. [of water]} = \lambda y. y \sqsubseteq \forall \text{WATER}\]

Furthermore, following Carlson (1977) and Chierchia (1984, 1998), I assume that bare nouns are kind-denoting. Thus, I assume that water in glass of water denotes the kind WATER, or a function from worlds w to the maximal quantity of water in w. Consequently, according to the denotation assumed for of in (49a), of water creates a type-mismatch; water is type \(\langle s, e \rangle\), not \(\langle e \rangle\). To remedy the mismatch, I assume that Montague (1974)’s extensionalizing \(\forall\)-operator is available. Applying it to the kind WATER returns the maximal quantity of water in the world of evaluation. As a result, of water will denote all parts of the actual, maximal quantity of water, or all actual quantities of water. Combining this with the denotation for the relational meaning for glass from above results in (50),

¹See (Barker, 1998, p. 8).
(50) \[ \text{glass of water} = \lambda x. \exists y. \text{glass}(x) \land y \subseteq \uparrow \text{WATER} \land R(x, y) \]

or a predicate true of glasses filled with water.

From here, deriving the II of \textit{four glasses of water} is fairly straightforward. For example, one could assume with Scontras that IIs arise from the numeral \textit{four} combining with a silent morpheme \textit{CARD} having the meaning in (51a).

(51) a. \[ [\text{CARD}] = \lambda n. \lambda P. \lambda x. \mu_\#(x) = n \land P(x) \]
   b. \[ [\text{four CARD}] = \lambda P. \lambda x. \mu_\#(x) = 4 \land P(x) \]
   c. \[ [\text{four CARD glasses of water}] = \lambda x. \exists y. \mu_\#(x) = 4 \land \text{glasses}(x) \land y \subseteq \uparrow \text{WATER} \land R(x, y) \]

Alternatively, one could follow Landman (2004) in assuming that when the numeral \textit{four} occurs within a measure phrase occurring without an overt measure noun such as \textit{ounce}, the measure phrase is by default interpreted as an intersective cardinality predicate, one which can be type-lifted into an intersective modifier having the meaning as (51b). In either case, \textit{four glasses of water} will denote a predicate true of pluralities consisting of four individual glasses, each of which is filled with water, or (51c), thus leading to the intended II.

Deriving the MI is far less straightforward. In effect, my proposal is that MIs result from a generalized version of Scontras’ type-shifting operation \textit{SHIFT}\textit{C}–\textit{M}. More specifically, I propose that MIs result from the following type-shifting operation, which I dub the \textbf{Universal Measurer (UM)}\textsuperscript{2}.

(52) a. \[ \lambda P. \lambda Q. \lambda n. \lambda x. \gamma(Q(x)) \land \mu_P(x) = n \]  \hspace{1cm} \text{(UM)}
   b. \[ \gamma(P) = \{x | \exists y. P(y) \land x \subseteq y\} \]

\text{UM} differs from Scontras’ \textit{SHIFT}\textit{C}–\textit{M} in two important respects. First, the second argument of \textit{UM} is a predicate rather than a kind. The significance this will be clarified shortly.

\textsuperscript{2}This formulation of “the Universal Measurer” is slightly different from the one formulated by Snyder and Barlew (2016), which goes under the same name.
Secondly, UM is formulated using the grinding-operation $\gamma$ defined in (52b). In essence, $\gamma$ returns all parts of all members of the extension of a predicate. Similar sorts of grinding-operations can be found in Link (1983), Rothstein (2010), and Landman (2011). Plausibly, UM encodes the meaning of \textit{worth} suitably restricted in various ways.\footnote{3}{See Snyder and Barlew (2016) for discussion.}

At least with regard to container phrases, UM generates MIs in a manner very similar to Scontras’ \textit{SHIFT}_{C-M}. As before, applying UM to a container noun like \textit{glass} effectively coerces it into a measure noun.

\begin{align*}
\text{(53) a. } & \text{ UM(} [\text{-glass}] \text{) = } \lambda Q. \lambda n. \lambda x. \gamma(Q(x)) \land \mu_{\text{glass}}(x) = n \\
\text{b. } & \text{ UM(} [\text{-glass}]([\text{of water}]) \text{) = } \lambda n. \lambda x. \gamma(\text{of-water}(x)) \land \mu_{\text{glass}}(x) = n \\
\text{c. } & [\text{four glasses of water}] = \lambda x. \gamma(\text{of-water}(x)) \land \mu_{\text{glass}}(x) = 4
\end{align*}

Assuming the same denotation for \textit{of water} from above, \textit{glass of water} will thus denote all parts of all quantities of water measuring $n$ glasses worth, or (53b). Since all parts of all quantities of water are just all extant quantities of water,\footnote{4}{As guaranteed by the cumulativity of \textit{water}; if $x$ and $y$ are both quantities of water, then so is the sum of $x$ and $y.$} ultimately \textit{four glasses of water} will denote those quantities of water measuring four glasses worth, or (53c), thus leading to MIs.

To see the purchase of the grinding-operation $\gamma$, consider again (46).

Context: John and Mary work in a recycling plant specializing in recycling two items: aluminum cans and tires. Once the items are ground, they are sifted and the recycled material is packaged into boxes. John and Mary find some unmarked boxes, and there is some uncertainty as to what they contain. After dumping the contents of the boxes into two sorted piles, Mary points at one of the piles and says:

\begin{align*}
\text{(46) That’s four boxes of } \{\text{tires/tire}\}. \\
\end{align*}
As with *four glasses of water*, the MI for *four boxes of tires* proceeds by first combining *box* with UM, and then combining the result with *of tires* and the numeral.

\[(54)\]

a. \(\text{UM}(\text{box}) = \lambda Q. \lambda n. \lambda x. \gamma(Q(x)) \land \mu_{\text{box}}(x) = n\)

b. \(\text{UM}(\text{box})(\text{of tires}) = \lambda n. \lambda x. \gamma(\text{of-tires}(x)) \land \mu_{\text{box}}(x) = n\)

c. \([^\text{four boxes of tires} = \lambda x. \gamma(\text{of-tires}(x)) \land \mu_{\text{box}}(x) = 4\]

If we assume with Chierchia (1998) that bare plural nouns are kind-denoting, then *tires* in (46) ought to denote a function from worlds \(w\) to the maximal plurality of tires in \(w\). Combining this with the meaning for *of* assumed above and repairing the resulting type-mismatch, *of tires* in (46) ought to denote the actual, maximal plurality of tires. Hence, applying \(\gamma\) to the resulting predicate returns the set of all parts of all pluralities of tires, including e.g. all of the atomic tires plus all the bits of rubber and metal constituting them. Consequently, (46) is predicted to be true in the scenario described: Mary is pointing at a quantity of tire parts measuring four boxes worth. Hence, the first advantage of UM is that it captures MIs of container phrases involving plural nouns which receive genuine grinding-interpretations.

Capturing MIs for atomizer phrases and ordinary count nouns is significantly less straightforward, however. As with \(\text{SHIFT}_{C-M}\), the basic problem is that *grain* and *orange* both have the wrong semantic type to combine with UM. More specifically, *grain* is inherently relational and so has the wrong type to serve as the first argument of UM, while *orange* is not a pseudopartitive, and so can provide UM with only one argument. The solution to both problems, I submit, is to reflexivize UM. Recall that with the MI of *four oranges*, paraphrasable as ‘four oranges worth of orange’, the substance measured (orange) is of the same kind as the ad hoc measure employed (an orange). Intuitively, what’s needed then is a way of guaranteeing that the first two arguments of UM are identical.

We see something similar with relational verbs like ‘bathe’ when occurring without overt objects. Witness (55b), for instance.
Unlike (55a), (55b) can only be understood reflexively, i.e. as claiming that John bathed himself. According to Reinhart and Siloni (2005), the reflexivization of ‘bathe’ can be seen as the consequence of applying a certain type-shifting function – call it “VREF” – to the basic relational denotation of ‘bathe’ in (56a).

\[(56) \begin{align*}
\text{a. } & [\text{bathe}] = \lambda x. \lambda y. \text{bathe}(x, y) \\
\text{b. } & \lambda R. \lambda x. R(x)(x) \\
\text{c. } & \text{VREF}([\text{bathe}]) = \lambda x. \text{bathe}(x, x)
\end{align*}\]

In effect, VREF resets the arguments of ‘bathe’ to be identical, thus reflexivizing the verb.

Now, let’s suppose with Reinhart and Siloni that VREF is one instance of a more general reflexivization principle, one which takes relations of various types and reflexivizes them. Then another possible instance of this generalized reflexivization principle would be “REFL” in (57a), where ‘Ω’ is an expression having the same type as UM.

\[(57) \begin{align*}
\text{a. } & \lambda \Omega. \lambda P. \lambda n. \lambda x. \Omega(P)(P)(n)(x) \\
\text{b. } & \text{REFL(UM)} = \lambda P. \lambda n. \lambda x. \gamma(P(x)) \land \mu P(x) = n
\end{align*}\]

Similar to (56c), applying REFL to UM effectively resets its first two arguments to be identical, thus resulting in (57b), or what I call the Reflexivized Universal Measurer (RUM). RUM effectively guarantees that the substance being measured, i.e. “\(\gamma(P)\)”, is of the same kind as the ad hoc measure being employed, i.e. “\(\mu P\)”. This is why changing the second argument \(\text{SHIFT}_{C-M}\) from a kind to a predicate is significant, especially if reflexivization is generally the result of resetting two arguments of the same type to being identical.
With RUM in place, deriving MIs for atomizer phrases and ordinary count nouns is relatively simple. Let’s being with *four oranges*. First we apply RUM to *orange*, and then combine the result with a numeral.

\[(58) \quad \text{a. } \text{RUM}([\text{orange}]) = \lambda n. \lambda x. \gamma(\text{orange}(x)) \land \mu_{\text{orange}}(x) = n \]

\[\text{b. } [\text{four oranges}] = \lambda x. \gamma(\text{orange}(x)) \land \mu_{\text{orange}}(x) = 4 \]

As a result, *four oranges* will denote quantities of orange measuring four oranges worth. Consequently, *Mary put four oranges in the punch* will be true just in case put that amount of orange in the punch, i.e. the MI.

A similar derivation can be given for *four grains of rice*. Let’s assume Scontras’ semantics for atomizer nouns, repeated here in (59a).

\[(59) \quad \text{a. } [\text{grain}] = \lambda k. \lambda x. x \in \pi_{\text{grain}}(k) \]

\[\text{b. } [\text{of rice}] = \lambda y. y \sqsubseteq \forall \text{RICE} \]

\[\text{c. } [\text{grain of rice}] = \lambda x. x \in \pi_{\text{grain}}(\cap \lambda y. y \sqsubseteq \forall \text{RICE}) \]

Unlike with Scontras’ semantics, however, we continue to assume that *of* semantically contributes a mereological relation, as suggested in (59b). Since *grain* takes a kind as argument, by hypothesis combining it with *of rice* creates a type-mismatch. This is readily fixed by an application of (Chierchia (1998))’s $\cap$-operator, which when applied to the predicate in (59b), returns the kind RICE. Ultimately, then, *grain of rice* has the same meaning given originally by Scontras: it is a predicate true of those quantities of rice partitioned into atomic grains. Combining this with RUM results in (60a), where ‘g-o-r’ abbreviates the predicate in (59c).

\[(60) \quad \text{a. } \text{RUM}([\text{grain of rice}]) = \lambda x. \gamma(\text{g-o-r}(x)) \land \mu_{\text{g-o-r}}(x) = n \]

\[\text{b. } [\text{four grains of rice}] = \lambda x. \gamma(\text{g-o-r}(x)) \land \mu_{\text{g-o-r}}(x) = 4 \]
Parts of grains of rice are quantities of rice. Ultimately, then, *four grains of rice* will denote those quantities of rice equal in amount to four grains of rice, thus leading to the desired MI.

Summing up, postulating UM leads to a fully generalizable analysis of I/M-ambiguities, one which avoids the problems noted for the analyses of Rothstein and Scontras. First, because UM is a universally available, but optionally applicable, type-shifting principle, MIs do not generally rely on something like silent *-ful* suffixation. The Universal Measurer is “universally available” in the sense that it applies to all atomic predicates, similar to Pelletier (1975)’s famous Universal Grinder. And it is “optionally applicable” because its application is not triggered by a mismatch in type or sort. Rather, its application is triggered by extralinguistic context, specifically by measure contexts. Thus, as with Barker (1998)’s analysis of possessive and relational nouns, the analysis of I/M-ambiguities given here provides further evidence for a pragmatic treatment of at least some type-shifting operations.

Furthermore, unlike SHIFT_{C-M}, UM naturally generalizes to all sorts of atomic predicates because (i) it employs a grinding-operation $\gamma$ and (ii) its first two arguments have the same type. The first feature allows for derivations of MIs of container phrases with plural noun complements like *box of tires*. The second feature allows for a natural reflexivization of UM, thus leading to MIs for atomizer phrases and ordinary count nouns. As a bonus, I’ve shown how I/M-ambiguities can be derived for both sorts of quantizing phrases without needing to assume that *of* is lexically ambiguous, i.e. that it expresses the relation of containment in container phrases but is semantically vacuous in atomizer and measure phrases. Overall, then, UM represents a significant improvement on Scontras’ original analysis.
Chapter 5

Conclusions and Future Prospects

In this thesis, I have proposed an account of the novel empirical generalization that atomic predicates generally, including atomizers and container nouns, give rise to I/M ambiguities, unlike measure nouns. I argued that these ambiguities arise due to a universally available type-shifting operation, the Universal Measurer. It shifts the meaning of an atomic predicate to that of a strictly quantized predicate. Crucially, this shift in meaning is unidirectional. Since UM does not have an inverse, and since MIs only arise thanks to an application of UM, it is in general impossible to recover IIIs from MIs. Similarly, because measure nouns denote standardized measures of substances by default, they generally fail to give rise to IIIs.

Though the discussion here has focused only on the nominal domain, I expect the analysis to apply to atomic predicates across all domains, just as certain influential analyses of the mass/count distinction apply across multiple domains Bach (1986); Krifka (1989); Link (1998). For instance, consider the verbal predicate flew for four days in (61a), which is also plausibly ambiguous between the II suggested in (61b) and the MI in (61c).

(61)  a. Mary flew for four days.
  b. There’s a group of four days x s.t. Mary flew on each of x. (II)
  c. There’s an interval of time x s.t. x measures 96 hours and Mary flew for x. (MI)

For the II, imagine that Mary has a private plane. On some days, she flies to work, and on other days, she drives. The flight is only 30 minutes one way, so each day she flies she gets about an hour of flying time. In this scenario, John can truly utter (61a) to describe

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Mary’s behavior over a given four day period. This is the II of flew for four days. For the MI, suppose instead that Mary has had numerous business flights over the past month, each lasting different intervals of time. After calculating the total amount of time Mary has spent flying over the past month, John, who is in charge of reimbursing Mary for her travel costs, truly utters (61a), meaning that Mary flew 96 hours in total over the past month. How the analysis of I/M-ambiguities sketched in §4 can be extended to examples like (61) is something I will leave to future research.

Here’s another important question I will leave for the future: How exactly are ad hoc measures determined? Up to this point, all prior research on I/M-ambiguities has focused exclusively on container phrases, and it is relatively easy to see how glass could be coerced into a measure noun: intuitively, four glasses worth of water denotes quantities of water measuring four times the amount that would be contained in a certain glass. Similarly, four boxes worth of tires intuitively denotes quantities of tires measuring four times the amount that would be contained in a certain box. In both cases, it is clearly the relation of containment which is relevant to determining the appropriate ad hoc measure.

However, it seems that containment is not always relevant to determining ad hoc measures. Contrast (62) with (63), for instance.

Context: Mary is making punch. The recipe calls for four oranges worth of orange pulp. Accordingly, Mary pours a certain amount of orange pulp directly from a prepackaged container into the punchbowl, estimating it to be approximately how much four typical oranges would produce.

(62) Mary put four oranges worth of orange in the punch.

Context: Mary has made punch for the party. She wants to decorate it, and she thinks that adding some fresh fruit to the punchbowl would look nice. Consequently, she washes four unpeeled oranges and drops them into the punch, along with several other pieces of fruit.

(63) Mary put four oranges into the punch.
(63) Mary used four oranges worth of water to wash the oranges.

While both examples employ the same ad hoc measure, namely an orange, they plausibly do so in different ways. What’s relevant to determining the truth of (62) is plausibly something like containment, i.e. how much orange is contained within a certain orange. Not so with (63), however, where how much pulp each of the oranges contains is not obviously relevant to how much water is needed to wash them. (64) makes a similar point.

Context: John and Mary are planning a week-long trip. They want to take their dogs, and so need to determine how much dog food to take. They have four dogs, but one of them does not do well in the car. Thus, Mary asks John how much dog food they should take on the trip. John responds:

(64) Let’s take four dogs worth of dog food.

Here, *four dogs worth of dog food* clearly cannot mean ‘how much dog food would be contained in four dogs’. Rather, it is naturally interpreted as ‘how much dog food our four dogs can collectively eat over a week’.

What these examples suggest is that while the general semantic function of *worth* in \( N_1 + \text{worth of } + N_2 \) is to transform the noun \( N_1 \) into an ad hoc measure, one which measures quantities of the substance named by \( N_2 \), the measure determined varies widely and is strongly context-dependent. However, on the analysis developed here, MIs of the various quantizing phrases result from an application of (R)UM. And it is at least prima facie plausible that the relation relevant to determining ad hoc measures in all of these cases is that of containment.\(^1\) For example, MIs of *four glasses of water* are naturally paraphrased as *four glassfuls of water*, or how much water would be contained in a certain glass. Similarly, in scenario such as (62), *four oranges* is naturally interpreted as ‘four oranges worth of orange’, or something like ‘how much orange is contained in a typical

\(^1\)And containment is plausibly one of the “natural relations” discussed by Vikner and Jensen (2002).
orange'. Likewise, *four grains of rice* in a measure context like the one described in §2.2 is naturally interpreted as ‘four (rice) grains worth of rice’, or something like ‘how much rice is contained in a typical (rice) grain’. But whether this seemingly plausible generalization holds in fully generality is something I will once again leave to future investigation.
References


