German measurement structures: Case-marking and non-conservativity*

Uli Sauerland
Leibniz-Center for General Linguistics (ZAS)

Robert Pasternak
Leibniz-Center for General Linguistics (ZAS)

Abstract This paper addresses the syntactic and semantic analysis of nominal measurement structures like *two cups of black coffee* in German. German measurement structures allow the case-marking on the substance noun phrase *black coffee* to vary: it can appear in genitive case, or in the same case as the measure noun *cup*. While the choice of case generally does not appear to have semantic import, we show that a semantic distinction does arise with relative measures like *percent*. Moreover, one of these interpretations serves as a *prima facie* counterexample to Keenan & Stavi's (1986) famed *conservativity hypothesis* of DP quantification, as the quantification appears to be non-conservative. We provide an overall analysis of German measurement structures and show how a syntactic-semantic account building on the proposal of Ahn & Sauerland (2017) makes the right predictions and, coincidentally, accords with the conservativity hypothesis.

Keywords: measurement, proportional, juxtaposition, nominals, conservativity, quantification, mereology, degree semantics

German measurement structures:
Case-marking and non-conservativity

1 Introduction

While the investigation of the relationship between syntax and semantics at the clausal level has made substantial progress over the last few decades, progress has been more limited when it comes to DP-internal syntax-semantics, where we use the term *DP* to refer to what Alexiadou et al. (2007) call "constituents that have been traditionally referred to as 'noun phrases'" (see also Georgi & Müller 2010). A good illustration of this limited progress is the presently unsettled status of the so-called *Conservativity Hypothesis* of DP quantification (Barwise & Cooper 1981, Keenan & Stavi 1986). To illustrate what is meant by "conservativity", consider the sentences in (1) and (2):

(1) a. Every student is happy.
     b. Every student is a happy student.

(2) a. Some students are happy.
     b. Some students are happy students.

Notice that in both (1) and (2), the (a) sentence is truth-conditionally equivalent to the (b) sentence: each is true if and only if (*iff*) the other is. More generally, if a quantificational determiner is taken to denote a relation between sets—for example, *every* in (1a) relates the set of students to the set of happy things by asserting that every member of the former is a member of the latter—then we can formally define conservativity as in (3), where for any sets A and B, $A \cap B$ is their *intersection* (the set of all objects that are elements of both A and B):

(3) For any relation Q between sets, Q is *conservative* iff for all sets A and B, $Q(A)(B)$ is equivalent to $Q(A)(A \cap B)$.

Let A be the set of all students, and B the set of all happy things. Thus, $A \cap B$ is the set of all objects that are both students and happy things, i.e., the set of all happy students. In the (a) examples above, the quantifiers *every* and *some* relate the sets A and B, and in the (b) examples they relate the sets A and $A \cap B$; the fact that each pair of examples is truth-conditionally equivalent indicates that the denotations of *every* and *some* are in fact conservative.

Put informally, the Conservativity Hypothesis states that DP quantification is conservative. Notice that this is not the same as claiming that *all* natural language quantification is conservative. To see why the latter claim is likely too strong, consider the sentences in (4):

(4)   a. Only students are happy.

       b. Only students are happy students.

If the quantification involved in this use of *only* were conservative, we would expect (4a) to be truth-conditionally equivalent to (4b). However, this is clearly not the case: the latter is near-vacuous, while the former (and only the former) is false in a scenario in which some non-students are happy. Thus, whatever quantification is going on in (4a) is by all appearances non-conservative.[1]

   While the Conservativity Hypothesis has been referred to as one of the "most celebrated semantic universals" (von Fintel & Matthewson 2008), its status is still a topic of considerable ongoing debate among semanticists (Zuber 2004, Keenan & Paperno 2012, Romoli 2015, von Fintel & Keenan 2018, Pasternak 2020 and others). However, this discussion has largely been divorced from current work on DP syntax and the syntax-semantics interface, in spite of the fact that "DP" is a clearly syntactic notion. Thus, in order for the Conservativity Hypothesis to properly relate to current syntactic theory, it must be framed along the lines of (5):

(5)   **Conservativity Hypothesis (CH):** If a quantificational relation Q between two sets A and B is expressed within a clause S and there is a DP in S such that both Q and A, but not B can be determined by the semantic content of the DP, then Q must be conservative.

   As framed in (5), the Conservativity Hypothesis makes a configurational claim about the DP-border with non-conservative quantifiers. For example, given the evidence in (4) that *only* can express non-conservative relations, the prediction made in (5) is that *only* is not part of the DP, and that the structure of (4a) must look like (6). In actuality, though, the constituency of (4a) is debated.

(6)   Only [students]$_{DP}$ are happy.

   Given the in-the-air status of DP syntax-semantics in general, and CH in particular, examples that seem to contradict CH are naturally of significant interest. In this paper we will discuss a *prima facie* counterexample to CH that arises with what we refer to as *measurement structures*. We will focus on measurement structures in German, where (non-)conservativity is connected to an intriguing aspect of the overt syntax: namely, case assignment.

   Measurement structures are a class of complex nominal phrases with two nominals, N1 and N2, such as *three feet*$_{N1}$ *of rope*$_{N2}$. Crosslinguistically, we characterize

---

1 As another example of apparent non-conservative quantification in natural language, Bhatt & Pancheva (2004) and Romoli (2015) note that the traditional denotation for the comparative morpheme *-er* is a non-conservative quantifier over degrees. However, Pasternak (2020) notes, based on proposals by Schwarzschild (2008) and Gajewski (2008), that this seemingly non-conservative quantification may arise from the semantic interaction of a conservative degree-quantifier and another head.

3

measurement structures following Krifka (1989) and Schwarzschild (2006) as consisting of a numeral or other weak quantifier followed by a *measure noun* N1, and then further material including a *substance noun* N2 and frequently a partitive marker (e.g. English *of*, hence also the term *pseudo-partitive* by Selkirk 1977) or genitive case.[2] In addition to such genitive/partitive structures, languages like German and Greek (Alexiadou et al. 2007) also allow a second kind of measurement structure in which N1 and N2 agree in case. These two types of measurement structure are illustrated for German in (7), with *Anzahl* ('number') being the measure noun (N1) and *Projekte* ('projects') the substance noun (N2):[3]

(7) Genitive and case-matching structures (Dudenredaktion 2016: p. 993):

    a. **Genitive N2:**

        Der Bericht führt eine   erstaunliche   Anzahl   neuer
        the report leads an.ACC amazing.ACC number.ACC new.**GEN**
        Projekte.
        projects.**GEN**
        'The report lists an amazing number of new projects.'

    b. **Case-Matching N2:**

        Der Bericht führt eine   erstaunliche   Anzahl   neue
        the report leads an.ACC amazing.ACC number.ACC new.**ACC**
        Projekte.
        projects.**ACC**
        'The report lists an amazing number of new projects.'

Various terms have been used for these two types of measurement structures. For example, Dudenredaktion (2016) use *partitiver Genitiv* ('partitive genitive') and *partitive Apposition* ('partitive apposition') for the two structures, while Zifonun et al. (1997) use the term *Numerativkonstruktion* ('numerative construction') for both. In order to remain maximally theory-neutral in our naming convention, we

---

2 The linear order of N1, N2, and the other elements may vary across languages. We understand *followed* to mean *preceded* in languages with the reverse word-order, but in this paper we are exclusively concerned with languages that have the word-order described in the main text.

3 German also has a third type of measurement structure with *von* ('of'), illustrated in (i):

    (i)   drei Liter von dem Bier
         three liters of   the beer
         'three liters of the beer'

We will not discuss *von* structures in this paper, primarily because they only deviate from genitive structures with respect to relatively minor morphosyntactic criteria. In terms of the semantic distinction that serves as the empirical heart of this paper, *von* structures pattern with genitive structures and not with case-matching structures.

will follow Alexiadou et al. (2007) in adopting the terms *genitive* and *juxtaposed* measurement structure.

The syntactic distinction illustrated in (7) has no apparent semantic repercussions, as (7a) and (7b) have the same truth conditions. Thus, prior to Sauerland (2014b), genitive and juxtaposed structures were not distinguished in detail: for example, Dudenredaktion (2016) treat the two as purely morphological variants. But when we turn to *proportional* measure nouns like *Drittel* ('third') and *Prozent* ('percent'), in contrast to non-proportional (hereafter *absolute*) measure nouns like *Anzahl* ('number'), substantial differences in interpretation between genitive and juxtaposed structures come to the fore. The following contrast exemplifies the dramatic semantic difference that arises with proportional measure nouns between the genitive and the juxtaposed structure:[4]

(8) Semantic distinction between genitive and juxtaposed measurement structures with proportion nouns (based on Ahn & Sauerland 2017: p. 219):

a. Dreißig Prozent der   Studierenden arbeiten.
   thirty   percent the.**GEN** students.**GEN** work

   'Thirty percent of the students work.'

b. Dreißig Prozent Studierende   arbeiten hier.
   thirty   percent students.**NOM** work   here

   'Thirty percent of the workers here are students.'

Whereas the genitive structure in (8a) has roughly the same meaning as English *thirty percent of the students*, the juxtaposed structure in (8b) seems to flip the meaning: rather than asserting that thirty percent of students work, the sentence asserts that thirty percent of workers are students. For example, suppose that there are one hundred students, thirty of whom work, making up ten percent of the three hundred-person workforce. In this scenario, (8a) is true (30% of the students are workers) and (8b) is false (less than 30% of the workers are students). Conversely, if there are three hundred students, thirty of whom work at the one hundred-employee company, then (8b) is true and (8a) is false.

The "reverse" quantification seen in (8b) is fully acceptable in Standard German.[5] Most of the data in this paper are constructed examples, but it is also easy to find attested examples in corpora. The two examples in (9) from web searches both occurred in texts that are likely to be checked for grammar: (9a) is from a local newspaper, and (9b) from a government report. The context in both cases shows that the reverse interpretation is intended by the authors.

---

4 We argue below that the presence or absence of the definite determiner cannot be responsible for the difference in interpretation, but a structural difference related to the case pattern must be the cause.

5 As far as we have been able to test this up to now, the Isar valley variety of Bavarian is the only German dialect where examples like (8b) aren't acceptable. See also footnote 15.

(9) a. Gut   ein Drittel Frauen haben die LDS-Kurse   besucht ...
         good a   third   women have   the LDS-classes visited ...

         '...slightly more than a third of the people attending the LDS-classes
         are women.'

     b. Ganze 46 Prozent Frauen sind dort ... politisch   aktiv.
         whole 46 percent women are   there ... politically active

         '46% of the people politically active there...are women.'

These judgments were further corroborated by means of a questionnaire study,
which is reported in the appendix to this paper, and which illustrates the existence
of a semantic contrast between genitive and juxtaposed proportional measurement
structures for linguistically naïve native German speakers.

As discussed in detail by Ahn & Sauerland (2017), German is not alone in
allowing such reverse proportional quantification: other languages such as Korean,
French, and English have seemingly similar constructions. This is illustrated for
English in (10).[6]

(10) a. The company hired thirty percent of the students.

      b. The company hired thirty percent students.
          (≈ *Thirty percent of the hirees were students.*)

The distinction in truth conditions between examples like (8a) and (8b) is in-
triguing in part because a semantic distinction between genitive and juxtaposed
measurement structures has gone largely unnoticed in the literature (but see Ahn
& Sauerland 2015, 2017). It is also noteworthy because of its direct relevance to
the Conservativity Hypothesis: while the quantification in (8a) is conservative, the
quantification in (8b) is by all appearances non-conservative.

To see this, pretend for a moment that there are two lexical entries for *dreißig
Prozent*: one that appears in (8a) and takes a genitive complement, and one that
appears in (8b) and takes a case-matching complement. Let us refer to these as
$30\%^{con}$ ("conservative") and $30\%^{rev}$ ("reverse"), respectively. If we take these two
lexical items to be quantificational determiners on a par with English *every* and
some, then each denotes a relation between sets *A* and *B*, where *A* is determined
by the complement of the determiner (*der Studierenden/Studierende*), and *B* by the

---

6 Ahn & Sauerland note that English is more restricted than other languages with respect to reverse
proportional quantification, in that it is degraded in subject position. This is illustrated in (ii), which
can be contrasted with the fully well-formed German (8b):

(ii) ??/* Thirty percent students work here.

Since this paper focuses only on German, we will not attempt to capture this cross-linguistic variation
in acceptability.

DP's scope (*arbeiten (hier)*). In this case, the denotations for *30%^{con}* and *30%^{rev}* are roughly as in (11):

(11) a. $[\![30\%^{con}]\!](A)(B)$ is true iff 30% of *A*s are *B*s.
      b. $[\![30\%^{rev}]\!](A)(B)$ is true iff 30% of *B*s are *A*s.

Thus, $[\![30\%^{con}]\!]([\![students]\!])([\![work]\!])$ is true iff thirty percent of students work, which captures the reading of (8a), while $[\![30\%^{rev}]\!]([\![students]\!])([\![work\ here]\!])$ is true iff thirty percent of the people who work here are students, which is the correct interpretation of (8b).

Importantly, while $[\![30\%^{con}]\!]$ is conservative, $[\![30\%^{rev}]\!]$ is not. As an illustration of the former, consider the English sentences in (12):

(12) a. Thirty percent of the students work.
      b. Thirty percent of the students are students who work.

These two sentences are clearly truth-conditionally equivalent, suggesting conservativity of $[\![30\%^{con}]\!]$. However, this is not so with $[\![30\%^{rev}]\!]$. As stated above, $[\![30\%^{rev}]\!]([\![students]\!])([\![work\ here]\!])$ is true iff thirty percent of the workers are students. Using our test for conservativity—replacing *B* with $A \cap B$, i.e., replacing $[\![work\ here]\!]$ with $[\![students]\!] \cap [\![work\ here]\!]$—we want to see if the above denotation is equivalent to $[\![30\%^{rev}]\!]([\![students]\!])([\![students]\!] \cap [\![work\ here]\!])$. But by the definition of $[\![30\%^{rev}]\!]$, this is true iff thirty percent of the students who work here are students. Much like with *only* above, this is (near-)vacuous, and certainly not identical to the pre-intersection truth conditions. Thus, $[\![30\%^{rev}]\!]$ is non-conservative.

Of course, assigning *30%^{con}* and *30%^{rev}* the status of lexically stored quantificational determiners in the same syntactic class as *every* and *some* is, by all appearances, dubious at best. But even so, the non-conservative quantification in (8b) should be a cause of concern for proponents of the Conservativity Hypothesis. After all, while *30%^{con}* and *30%^{rev}* are not lexical determiners, they do seem to be DP-internal quantificational constituents, and by the formulation of CH in (5) that is what matters. Thus, either the current version of CH needs to be scrapped, or something else must be going on in (8b).

In this paper, we will argue for the latter. We will argue that genitive and juxtaposed measurement structures are configurationally distinct not just in ways that directly affect case assignment of the substance noun, but also in ways that affect semantic interpretation. Key parts of the syntactic-semantic analysis are built on work by Ahn & Sauerland (2017), especially their proposal that for juxtaposed structures—both proportional and absolute—the measure phrase (e.g., *dreißig Prozent*) covertly moves from the DP and attaches to the clausal spine, leading to illusory non-conservativity in the case of proportional juxtaposed structures. But while Ahn & Sauerland focus on cross-linguistic observations that incorporate a small range of

German data, the current paper focuses exclusively on German, taking a deeper look at what the morphosyntax and semantics of this particular language can tell us about these constructions.

The structure of the rest of the paper is as follows. In Section 2 we introduce measurement structures in greater detail, summarizing prior work and offering some novel observations; we then argue that proportional measurement structures like *dreißig Prozent* {*der Studierenden/Studierende*} are, in fact, measurement structures. In Section 3 we argue that in spite of their superficial similarities, genitive and juxtaposed measurement structures are configurationally distinct in important and semantically relevant respects. Finally, in Section 4 we show how semantics relates to syntax, so that for absolute measure nouns the two constructions generate the same truth conditions as in (7), but for proportional measure nouns distinct truth conditions arise, as in (8). Section 5 concludes.

2 Setting the table: absolute and proportional measurement structures

In this section we discuss measurement structures as a broader class, both in general and in German in particular. In Section 2.1 we briefly go over relevant aspects of prior morphosyntactic and semantic work on measurement structures. In particular we discuss in very broad terms the variation in syntactic theories of measurement structures, as well as the potential problems proportional measure nouns create for semantic analysis. In Section 2.2 we focus on German, first discussing some important empirical observations about German absolute measurement structures, and then showing that these observations largely extend to proportional measurement structures. Thus, the evidence points to a unified syntactic-semantic analysis of absolute and proportional measurement structures. In Section 2.3 we summarize the results of this section and discuss the desiderata for a theory of German measurement structures in light of the preceding observations.

2.1 A brief overview of prior work

The basic syntax of measurement structures is still under debate, much like with other binominal constructions (see, e.g., Alexiadou et al. 2007, Keizer 2007). Earlier work encodes the relationship between the measure noun N1 and the substance noun N2 in three different ways, illustrated in (13): (I) a modifier-modifee relation where N2 projects the complex noun phrase (Jackendoff 1977, Selkirk 1977); (II) a functional head-complement relation within the broad DP where N2 is selected by a functional Q head containing N1 (Löbel 1986, 1990, van Riemsdijk 1998); and (III) a complex phrase projected not by N1 or N2, but by a predicational head like English *of* (Abney 1987: p. 294, Corver 1998, Schwarzschild 2006). Alexiadou et al.

([2007](#)) collapse (I) and (II) under the label of *monoprojectional*, since exactly one nominal projects (see also [Alexiadou 2014](#), [Tănase-Dogaru 2007](#)). [Rothstein](#) ([2009](#)), meanwhile, proposes a structural ambiguity between (II) and (III) (see also [Partee & Borschev 2012](#), [Keizer 2007](#); but [Zhang 2012](#)).

(13)

    (I) N2 projects

```
           NP
          /  \
        MP     N
       /|\     |
      3 feet of rope
```

    (II) N1 projects

```
        QP
       /  \
      3    QP
          /  \
         Q    DP
         |    / \
        feet of rope
```

    (III) *of* projects

```
          MonP
         /    \
       DP      Mon'
      / \      /  \
    3 feet   Mon   NP
             |     |
             of    rope
```

The major subclasses of measure nouns (including count measures) are shown in (14) ([Eschenbach 1995](#), [Koptjevskaja-Tamm 2001](#), [Scontras to appear](#)). However, most nouns can be coerced into a measure interpretation either via containment (e.g. *three theses of material*) or identity of measurement (*twenty football stadiums of forest*). Specific classes that have only recently become a focus of discussion are classifiers in English ([Chierchia 1998](#), [Scontras to appear](#)), swarms vs. groups ([Henderson 2017](#)), and relative/proportional measures ([Ionin et al. 2006](#), [Ahn & Sauerland 2015](#), [2017](#), [Pasternak 2019b](#), [Spathas 2019](#)). Nouns like *degree* that deal in intensive properties like heat are sometimes viewed as measure nouns (e.g. [Schwarzschild 2006](#)), but we exclude them from the present discussion.

(14)

subclasses of measures	example
counters	*two <u>dozen</u> eggs*
groups, swarms	*two <u>teams</u> of players,*
	two <u>bouquets</u> of flowers
conventional absolute measures	*two <u>kilos</u> of peaches / fruit*
relative measures	*ten <u>percent</u> of Americans*
abstract quantity nouns	*a large <u>amount</u> of peaches / fruit*
classifiers	*two <u>grains</u> of rice*
containers	*two <u>glasses</u> of beer*
(intensive properties)	**two <u>degrees</u> of water*

Measure nouns like *Liter* are not restricted to measurement structures, with three other prominent uses being *degree-denoting*, *predicative*, and *attributive*. In their degree-denoting use, measure nouns serve as the arguments of degree predicates like gradable adjectives (e.g., *three feet tall*). [Scontras](#) ([to appear](#)) suggests that degree-denoting uses are derived from measurement uses, while [Brasoveanu](#) ([2008](#))

proposes a reverse derivation. Predicative uses are illustrated by examples like *He weighs 70 kilos* and *That bag is 30 kilos*. The term *attributive* we understand to at least cover cases like German *ein Junge von drei Jahren* ('a boy of three years') and prenominal attributions like *the 2 tons of food that she gave away* (cf. Solt 2015 on Q-adjectives such as *the many items that she gave away*). The latter are closest to measurement structures, and Solt (2015) proposes to reduce them to measurement structures by reconstruction into the relative clause.

Moving on to semantics, Zifonun et al. (1997) propose a syntactic-semantic analysis of absolute measurement structures adopted from Krifka (1989) (see also Champollion & Krifka to appear). At the heart of the proposal is the idea that measure nouns denote measure functions that map entities to positive real numbers. Specifically, Krifka (1989) assumes that the measure noun forms a constituent with the numeral preceding it, subsequently combining with the substance noun. The proposal is illustrated for German (following Zifonun et al. 1997) and English (following Krifka 1989) in (15).

(15)   a. German *30 Gramm Gold*   b. English *30 grams of gold*

```
              ●                              ●
             / \                            / \
            /   \  Gold                    /   \
           /     \                        /     \
          /       \                      /\     /\
        30      Gramm                   30 grams of gold
```

For these structures, the lexical entries in (16a) for *Gramm/gram* and (16b) for *Gold/gold* are assumed, with ⟦30⟧ simply being the numeral 30:

(16)   a. ⟦Gramm/gram⟧ $= \lambda n \lambda x.$ grams$(x) = n$

                            (where grams$(x) = n$ iff x's weight is n grams)

        b. ⟦Gold⟧ $= \lambda x.\ x$ consists entirely of gold

We assume, following Heim & Kratzer (1998) and others, that in addition to functional application there is a semantic operation of *predicate modification*, which combines two predicates via conjunction.[7] Since ⟦30 Gramm/grams⟧ is a predicate true of an individual iff its weight is thirty grams, this predicate combines via predicate modification with ⟦Gold⟧, generating a predicate true of an individual x iff x weighs thirty grams and consists entirely of gold.[8] Further composition (including

---

7 Predicate modification is not assumed by Krifka (1989) and Zifonun et al. (1997) as a general compositional principle, but the results are equivalent to the ones obtained here since they build predicate modification into the lexical entry of the measure nouns.

8 Krika's proposal extends to English partitives like *thirty grams of the gold* straightforwardly by the assumption that *of* denotes the mereological part-of relation (e.g., Barker 1998).

existential closure) can then apply in a complete sentence, so that for example (17a) is interpreted as in (17b).[9]

(17) a. 30 Gramm Gold fehl-en.
          30 gram   gold be amiss-PL
          '30 grams of gold are missing.'
      b. $\exists x[\text{grams}(x) = 30 \wedge \text{gold}(x) \wedge \text{be-amiss}(x)]$

While Krifka's (1989) semantics works well for absolute measurement structures, it does not account for proportional measurement, as example (18) illustrates. The denotation of (18a) shown in (18b) is what Krifka's proposal would predict if applied, but this proposal does not capture the relational nature of *percent*: what constitutes thirty percent needs to be determined by taking into account what the whole is of which thirty percent is to be determined. The predicate modification Krifka's semantics postulates for combining the measure term and the substance noun would therefore not generate the correct denotation in the case of proportional measure nouns.

(18) a. 30 Prozent des   Golds   fehlen
          30 percent the.GEN gold.GEN be amiss-PL
          '30 percent of the gold are missing.'
      b. $\exists x[\text{percent}(x) = 30 \wedge \text{gold}(x) \wedge \text{be-amiss}(x)]$ (incorrect)

Thus, once we establish that proportional measurement structures are syntactically non-exceptional, we will be presented with three syntactic-semantic puzzles. First, given that Krifka's (1989) syntax-semantics for measurement structures fails to account for proportional measurement, what changes need to be made in order to allow for a unified semantic account of measurement structures? Second, what is it about the syntax and semantics of these constructions that leads to the observed truth-conditional distinction between genitive and juxtaposed structures with proportional measure nouns? And third, why is it that with absolute measure nouns, no such semantic distinction seems to arise, and both genitive and juxtaposed structures give rise to the same truth conditions?

2.2 Morphosyntactic unity of measurement structures

The claim that absolute and proportional measurement structures have the same morphosyntactic properties is by no means novel, but so far as we know this stance has only been tacitly assumed, rather than explicitly argued for. The literature on German measurement structures has generally shown no regard for whether the measure noun is (non-)proportional; for example, Dudenredaktion (2009: p. 984) list the

---

9 Not shown here is exhaustification that applies to the numeral *30* (Spector 2013, Sauerland 2014a).

absolute measure noun *Kilogramm* ('kilogram') and the proportional measure noun *Prozent* ('percent') together. However, the quantificational reversal phenomenon in (8b) already shows that proportional measurement structures have interesting syntactic-semantic properties that have not been noticed previously, and that do not surface in an obvious way with their absolute counterparts. This observation could be construed in one of two ways: either proportional and absolute measurement structures are in fact syntactically distinct, in spite of their surface-level similarities; or they are structurally the same, and proportional measurement structures point the way to deeper insights about measurement structures more generally. Given that we adopt the latter view, it is obviously important that we provide explicit evidence for such a unified syntactic-semantic analysis of measurement structures, a task to which we now turn. We will start by introducing some important empirical observations about German absolute measurement structures, and will follow that up by showing that these same observations (for the most part) extend to proportional measurement structures.

2.2.1 Some observations about German measurement structures

First, let us gather together some empirical observations about absolute measurement structures to give us a reference point for determining whether proportional measurement structures are in fact the same type of syntactic object. Our observations will fall into three categories: (I) grammaticality when the substance NP appears with(out) an overt determiner, (II) morphological number on the measure NP, and (III) verbal number agreement.

Overt determiner with the substance NP   Our first domain of empirical observations concerns the substance NP, and more specifically, whether measurement structures are grammatical when the substance noun appears with or without an overt determiner. Importantly, genitive and juxtaposed measurement structures differ in this regard. The picture is simplest with juxtaposed structures: in these constructions, the substance NP must be a bare NP, and the introduction of an overt determiner leads to ungrammaticality, as illustrated in (19).

(19) Sie tranken drei Liter (*das)   westfälisch -es   Bier
       they drank   three liter (*the.ACC) Westphalian -ACC beer.ACC
       'They drank three liters of Westphalian beer.'

   With genitive measurement structures, on the other hand, inclusion of an overt determiner is fully grammatical, as shown in (20):

(20) Sie tranken drei Liter des   westfälisch -en   Bier -es
       they drank   three liter the.GEN Westphalian -GEN beer -GEN

'They drank three liters of the Westphalian beer.'

However, things get somewhat more complicated when considering where overt determiners can be *excluded* with genitive structures because of a generalization due to Schachtl (1989) (see also the *Genitivregel* ('genitive rule') of Dudenredaktion 2016: p. 968). She notes that a genitive DP requires a non-nominal exponent of genitive case in the DP, as exemplified by the ungrammaticality of (21):

(21)　　*? Sie　tranken drei　Liter Bier -es
　　　　　they drank　three liter　beer -GEN

The ungrammaticality disappears when the bare noun *Bieres* is replaced with a structurally complex NP like *westfälischen Bieres*:

(22)　　Sie　tranken drei　Liter westfälisch　-en　　Bier -es
　　　　they drank　three liter　Westphalian -GEN beer -GEN

　　　　'They drank three liters of Westphalian beer.'

To get around the effects of Schachtl's (1989) generalization, we generally use German examples with either an inflected adjective or a noun such as *Beamte* ('state employee') that inflects like an adjective.

Morphological number on the measure NP　　In terms of morphological expression of number, there appear to be three classes of measure noun: (I) those that *never* inflect for number in measurement structures (even if they can do so outside of measurement structures), such as *Kilo* ('kilo(gram)'); (II) those that *always* inflect for number, such as *Flasche* ('bottle'); and (III) those with *optional* number inflection, such as *Glas* ('glass'). But regardless of whether the measure noun inflects for number, any adjective modifying the measure noun—such as *gut* ('good') in (23a) and (23b)—must bear the semantically correct number agreement. While (23) illustrates this for juxtaposed measurement structures, the same facts hold for genitive structures.[10]

(23)　　a. Sie　aßen drei　gut-e/*-es　　　Kilo / *Kilo-s　Fleisch
　　　　　　they ate　three good-PL/*-SG kilo　/ *kilo-PL meat

　　　　　　'They ate three good kilos of meat.'

---

10 The German adjectival agreement paradigm has many syncretisms. Example (iii) corroborates the analysis of (23a) as involving a plural adjective form, since the adjectival ending *-er* with the neuter noun *Glas* ('glass') must be the Genitive plural of the so-called 'strong' inflection.

(iii)　　Sie　erfreuten sich drei　gut-er　　　　Glas / Gläs-er　　　westfälischen Bier-es
　　　　　they enjoyed　self three good-GEN.PL glass / glass-GEN.PL Westphalian　beer-GEN

　　　　　'They enjoyed three generous glasses of Westphalian beer.'

   b. Sie tranken drei gut-e   Glas / Gläs-er Bier
      they drank   three good-PL glass / glass-PL beer
      'They drank three generous glasses of beer.'

   c. Sie   tranken drei   *Flasche / Flasch-en Bier
      they drank   three *bottle   / bottle-PL beer
      'They drank three bottles of beer.'

With container nouns such as *Glas* ('glass') in (23b), Zifonun et al. (1997) and Grestenberger (2015) show that the presence or absence of number marking on the noun has a semantic effect. For example, only the singular form *Glas* allows a pure amount interpretation, as seen in (24a); the plural only allows the pragmatically odd interpretation involving actual glasses filled with wine and inside of a caraffe. However, this semantic effect is restricted to container nouns that exhibit optional number marking: with non-container nouns and nouns with non-optional number-marking, these effects are not observed. Thus, the optionally number-marked pure measure noun *Liter* ('liter') in (24b) does not show any number-dependent semantic effects, while the obligatorily number-marked container noun *Flasche* ('bottle') can have a pure amount interpretation in (24c) in spite of its plural number.

(24)   a. Sie kamen mit drei Glas / #Gläs-ern   Wein in einer Karaffe.
       the arrived with three glass / #glass-DAT.PL wine in a   pitcher
       'They arrived with the amount of three glasses of wine in a pitcher.'
       #'They arrived with three actual glasses of wine inside of a pitcher.'

    b. (After Dudenredaktion 2009: p. 984:)
       Sie kamen mit drei Liter / Liter-n   Wasser.
       they arrived with three liter / liter-DAT.PL water
       'They arrived with three liters of water.'

    c. Sie   kamen mit drei *Flasche / Flasche-n Wein in einer Karaffe.
       They arrived with three *bottle   / bottle-PL wine in a   pitcher
       'They arrived with three bottles of wine in a pitcher.'

Verbal agreement   Genitive and juxtaposed measurement structures in subject position also show variability in verbal agreement patterns. Dudenredaktion (2009) note that with a plural measure noun and singular substance noun in a juxtaposed measurement structure, both singular and plural verbal agreement are possible, though they describe singular agreement as colloquial in examples like (25a). However, with an adjective modifying the substance noun, exemplified in (25b), both singular and plural verbal agreement seem fully acceptable. In contrast, with genitive measurement structures there is a significant preference for agreement with the plural measure noun, even with an adjective present, as in (25c).

(25) a. (Dudenredaktion 2009: p. 984:)

Drei Liter Wasser reich { $^?$-t / -en }
three liter water suffice { $^?$-SG / -PL }
'Three liters of water suffice.'

b. Drei Liter sauber-es Wasser   reich { -t / -en }
three liter clean-NOM water.NOM suffice { -SG / -PL }
'Three liters of clean water suffice.'

c. Drei Liter sauber-en Wassers   reich { $^{?*}$-t / -en }
three liter clean-GEN water-GEN suffice { $^{?*}$-SG / -PL }
'Three liters of clean water suffice.'

The paradigm in (26) illustrates that just like with adjectival agreement, what is relevant for verbal agreement is semantic number, rather than the morphological number of the measure noun. All of the examples in (26) use the measure noun *Kilo*, which has a plural form (*Kilos*), but is among the class of measure nouns that cannot be pluralized in measurement structures. The generalization from these examples, all of which involve juxtaposed structures in subject position, seems to be as follows: when the semantic number of the measure noun and the substance noun is the same, the verb must show the same number ((26b) and (26c)), but if the two nouns differ in semantic number then agreement with the measure noun is preferred, and agreement with the substance noun is permissible but slightly dispreferred ((26a) and (26d)):

(26) a. Ein gut -es Kilo grüne Bohne -n reich { -t / $^?$-en }
one good -SG kilo green bean -PL suffice { -SG / $^?$-PL }
'One generous kilogram of green beans is sufficient.'

b. Drei gut -e Kilo grüne Bohne -n reich { *-t / -en }
three good -PL kilo green bean -PL suffice { *-SG / -PL }
'Three generous kilograms of green beans are sufficient.'

c. Ein gut -es Kilo Butter -∅ reich { -t / *-en }
one good -SG kilo butter -SG suffice { -SG / *-PL }
'One generous kilogram of butter is sufficient.'

d. Drei gut -e Kilo Butter -∅ reich { $^?$-t / -en }
three good -PL kilo butter -SG suffice { $^?$-SG / -PL }
'Three generous kilograms of butter are sufficient.'

Summary As a very brief summary of our results thus far, here is what we have found. First, genitive and juxtaposed structures differ in whether the substance noun can (or must) appear with an overt determiner: for juxtaposed structures, the determiner is disallowed, and for genitive structures the determiner is always allowed,

15

and sometimes obligatory. Second, measure nouns differ in their morphological expression of number when they are semantically plural: some never inflect, some always inflect, and for some inflection is optional, occasionally leading to semantic distinctions. And third, genitive and juxtaposed structures behave differently with respect to verbal agreement: with genitive structures as subjects, verbs strongly prefer to agree with the measure noun, but with juxtaposed structures agreement with the measure noun or the substance noun is possible, with a modest preference for the former.

Clearly this is not a complete empirical picture of German measurement structures, and much more data—some of which will similarly point toward a unified analysis of absolute and proportional measurement structures—will be discussed later. However, the data discussed above will provide a convenient lens through which to observe this morphosyntactic unity, so we will stick to these for now.

2.2.2 Extension to proportional measurement

We will now show that proportional measurement structures generally behave like their absolute counterparts in terms of the presence or absence of an overt determiner with the substance NP, and likewise with respect to verbal agreement. As regards measure NP number inflection, we will show that proportional measure nouns display the same sort of variation seen previously: some cannot inflect, some must inflect, and some show optionality.

Overt determiner with the substance NP   We start with the presence/absence of an overt determiner with the substance NP. Juxtaposed structures again present the clearest picture: just like with absolute measure nouns, the substance NP must be a bare NP:

(27)   Sie   tranken dreißig Prozent (*das)   westfälisch -es   Bier
        they drank   thirty   percent (*the.ACC) Westphalian -ACC beer.ACC
        'Thirty percent of what they drank was Westphalian beer.'

As discussed in the introduction, the interpretation that arises here is the "reverse" interpretation (thirty percent of the drunk liquid was beer) and not the conservative interpretation (thirty percent of the beer was drunk). This holds across the board: juxtaposed structures with proportional measure nouns not only *can*, but *must* give rise to reverse interpretations.

With genitive measurement structures, examples with proportional measure nouns look similar, but not quite identical, to their absolute counterparts. In the similarity column is the fact that just like with absolute measure nouns, proportional

16

genitive measurement structures are fully well-formed when the substance noun comes with an overt determiner, as illustrated in (28):

(28) Sie tranken dreißig Prozent des   Bieres
      they drank   thirty   percent the.GEN beer.GEN
      'They drank thirty percent of the beer.'

Notice again that in the case of genitive measurement structures, the interpretation is necessarily conservative, and a reverse interpretation is unavailable.

However, with respect to when the determiner can be dropped in genitive structures, proportional measure nouns don't play quite so nicely. Recall that with absolute measure nouns, when the substance NP is a bare noun, genitive structures are ill-formed without an overt determiner, but when the substance noun is modified by an adjective determiner-less examples are fully grammatical. Meanwhile, proportional genitive measurement structures are similarly ill-formed with bare substance nouns, but are also quite marked with adjective-modified determiner-less NPs, as seen in (29):

(29) a. * Sie tranken dreißig Prozent Bieres
            they drank   thirty   percent beer.GEN

      b. ?? Sie tranken dreißig Prozent westfälisch -en   Bier -es
            they drank   thirty   percent Westphalian -GEN beer -GEN.SG
            'They drank 30% of (the) Westphalian beer.'

We do not have a full account at hand for why (29b) should be odd, in contrast to its absolute counterpart. That being said, we suspect that the oddity is semantic rather than structural in nature. By all appearances, the substance NP in genitive measurement structures occurs in the syntactic context of a full DP, hence the frequent presence of an overt determiner. If this is true, then in cases where there is no overt determiner there must be a silent one, i.e., a bare mass/plural DP. But cross-linguistically such DPs are known to exhibit a variety of semantic peculiarities and give rise to seemingly diverse readings depending on their environment, as illustrated for English in (30) with the bare plural DP *coyotes*:

(30) a. Coyotes barked at me.   *(existential)*
      b. Coyotes have four legs.   *(generic)*
      c. Coyotes are extinct.   *(kind-denoting)*

There are well-known attempts at a unified semantic account of bare plural DPs—perhaps most famously, Carlson 1977—as well as the seemingly similar bare mass DPs like *(westfälischen) Bieres* in (29). But regardless of whether such a unified account is possible, in our opinion the oddness of (29b) is more likely to be due

to some aspect of the semantics of bare plural/mass DPs than it is to stem from a syntactic distinction between absolute and proportional measurement structures.

As further evidence in favor of such an account, the oddness of proportional genitive measurement structures with bare substance DPs is not universal. A well-formed example can be seen in (31), retrieved from the Internet:[11]

(31) . . . weil   sie die gleichen Probleme habe   wie **75 Prozent**
     . . . because she the same   problems have.SUBJ as   **75 percent**

   deutscher   Frauen . . .
   German.GEN women . . .

   '. . . because she has the same problems as 75 percent of German women. . .'

The well-formedness of (31) favors an account of (29b) in which the oddness is semantic rather than structural in origin.

Morphological number on the measure NP Recall that when it comes to the morphological expression of number, we noted three broad categories of measure noun: those that cannot inflect for number (e.g., *Kilo*), those that must inflect for number (*Flasche*), and those that show optional number inflection (*Glas*), and that for the latter there were sometimes semantic repercussions for choosing plural inflection on the measure noun. We will now show that proportional measure nouns can be divvied into the same three categories.

In the first category, the proportional measures *Prozent* ('percent') and *Promille* ('permille', i.e., per 1,000) can generally not be marked plural (Dudenredaktion 2016: p. 175–176), as illustrated for both genitive and juxtaposed structures in (32).[12]

(32) a. Dreißig Prozent { -∅ / *-e } der   Studierenden arbeiten hier.
       thirty   percent { -SG / *-PL } the.GEN students.GEN work   here

     'Thirty percent of the students work here.'

    b. Dreißig Prozent { -∅ / *-e } Studierende   arbeiten hier.
       thirty   percent { -SG / *-PL } students.NOM work   here

     'Thirty percent of the workers here are students.'

Plural marking on *Prozent* ('percent') improves slightly when the preceding numeral quantifier also carries over plural morphology. Again, there is no discernible difference between genitive and juxtaposed structures in this regard.

---

11 https://www.abendblatt.de/hamburg/article107201016/Ich-ruehr-in-vielen-Toepfen.html
Last accessed October 17th, 2019.
12 Dudenredaktion (2016) note that plural marking can occur on proportional measures when the substance noun is elided; e.g. *einige Prozente sparen* ('some percent-s save').

(33) a. Viel -e Prozent { -Ø / $^{*?}$-e } der   Arbeiter sind erkrankt.
           many -PL percent { -SG / $^{*?}$-PL } the.GEN worker   are   sick
           'Several percent of the workers are sick.'

      b. Viel -e Prozent { -Ø / $^{*?}$-e } Arbeiter sind erkrankt.
           many -PL percent { -SG / $^{*?}$-PL } worker   are   sick
           'Several percent of the sick are workers.'

To see examples of the other two categories of measure noun—that is, obligatorily and optionally number-marked nouns—we next turn to fractions. Fractions other than *half* in German all end with the suffix *-tel* and have the same morphological properties, so it suffices to consider the fractions *Hälfte* ('half') and *Drittel* ('third'). With the former, plural number marking is obligatory when it is construed with quantity expressions other than one.[13]

(34) a. Anderthalb Hälfte { *-Ø / -n } der   Frauen haben ein iPhone
           one-and-half half   { *-SG / -PL } the.GEN women have   an iPhone
           gekauft
           bought
           '75% of the women have bought an iPhone.'

      b. Anderthalb Hälfte { *-Ø / -n } Frauen haben ein iPhone gekauft.
           one-and-half half   { *-SG / -PL } women have   an iPhone bought
           '75% of the iPhone buyers were women.'

Thus, whereas *Prozent* falls in the same category as *Kilo* in its universal absence of number-marking, *Hälfte* patterns with *Flasche* in always inflecting for number.

With *Drittel* ('third'), number marking is null in nominative and accusative case, so we must get creative in order to test whether number inflection is disallowed, obligatory, or optional. With this in mind, consider (35), where *Drittel* is part of the dative case-marked experiencer argument of the psych-verb *gefallen* ('please'). Here there is a difference between the genitive and juxtaposed structures: while plural marking is fully optional in the genitive example (35a), it is slighly degraded in the juxtaposed example (35b):

(35) a. Zwei Drittel { -Ø   / -n   } der   Frauen gefiel
           two third { -DAT.SG / -DAT.PL } the.GEN women please
           Conchita.
           Conchita.NOM

---

13 Combining *half* with a quantity other than one but between zero and two is slightly odd because it could always be expressed more easily with another fraction. The examples become most acceptable in a context where comparison on the basis of halves is salient. Concretely, (34a) might be preceded by *One half of the men bought an iPhone* and (34b) by *One half of the iPad buyers were women*.

'Two thirds of the women liked Conchita.'

b. Zwei Drittel { -∅ / ^{??}-n } Frauen gefiel Conchita.
two third { -DAT.SG / ^{??}-DAT.PL } women please Conchita.NOM

'Two thirds of those who liked Conchita were women.'

At first glance, the oddness of the plural in the juxtaposed example is somewhat puzzling. Based on the full optionality of plural marking in (35a), in conjunction with the fact that in general we have not seen any difference between genitive and juxtaposed structures with respect to morphological number on the measure noun, one would expect plural marking in (35b) to be equally optional, contrary to fact.

However, the markedness of plural-marked fractions in cases like (35b) might be related to the fact that some fractions have non-proportional uses as measure nouns for fractions of liters, specifically when used with drinks. (36) shows that plural marking is slightly preferred with these non-proportional uses of fractions:

(36) Sie hat ihn zu zwei [?]Viertel   / Viertel-n   Wein eingeladen.
       she has him to two   [?]quarter.SG / quarter-PL wine invited

'She treated him to two quarter-liter portions of wine.'

This non-proportional use of fractions is closer to a container use than a pure amount use. For instance, suppose I twice ordered one eighth of a liter of wine (*ein Achtel Wein*). It would then be inaccurate for me to follow this up by saying that I drank one quarter (*ein Viertel Wein*); I would instead have to describe my consumption as two eighths (*zwei Achtel*). This does not hold for the proportional uses of fractions: if Joe and Mary each drank one eighth of the wine, then it is also the case that Joe and Mary cumulatively drank one quarter of the wine.

Importantly, this non-proportional use of fractions only arises in juxtaposed structures like (36), and not in genitive structures like (37):

(37) Sie hat ihn zu zwei Viertel-n   des   Weins   eingeladen.
       she has him to two   quarter-PL the.GEN wine.GEN invited

'She treated him to two fourths of the wine.'

Suppose that there is a two-liter jug of wine. On a pure amount reading, (37) would be true iff Mary gave Joe one liter—one half, or two fourths—of the wine. On a non-proportional interpretation, meanwhile, (37) should be true iff Mary gave Joe two quarter-liter portions of wine, a smaller amount. But in fact (37) is only true in the former context, meaning that a non-proportional, container-like reading is unavailable for genitive structures.

We would thus like to suggest that non-half fractions like *Drittel* fall into the category of measure nouns with optional number inflection, but that examples like (35b) with plural morphology are odd due to competition between proportional and

container-like interpretations of fractions. Since non-proportional interpretations only arise in juxtaposed structures and preferably include number inflection, the prediction is that this competition should be fiercest precisely in the corner of the paradigm in (35) at which oddity arises: namely, (35b) with plural morphology on *Drittel*. Notice that for our purposes it does not matter whether this competition is at the level of the grammar or the parser, so long as we accept that this type of competition can lead to (perceived) oddity. Either way, the result is consistent with a view in which *Drittel* and other non-half fractions are full-fledged optionally-inflecting measure nouns.

In summary, we have seen that just like with absolute measure nouns, proportional measure nouns fall into three categories: non-inflecting (*Prozent*), obligatorily inflecting (*Hälfte*), and—at least if the above account is correct—optionally inflecting (*Drittel*).

Verbal agreement   Finally, consider verbal agreement with measurement structures in subject position. Examples (25) and (26) in the previous section showed that absolute juxtaposed measurement structures allow number agreement with either the measure noun or the substance noun when the two have different semantic number, though agreement with the measure noun is preferred (and also prescriptively mandated). Proportional juxtaposed measurement structures conform to the same generalization, as illustrated in (38).

(38) a. Ein Prozent Japaner   wohn { -t   / ?-en   } in Berlin.
          one percent Japanese.PL live   { -3SG / ?-3PL } in Berlin
          'One percent of Berlin residents is/are Japanese.'

      b. Sechzig Prozent Butter komm { ?-t   / -en   } in   diesen Teig.
          sixty   percent butter come   { ?-3SG / -3PL } into this   dough
          '60% of what goes into this dough is butter.'

Proportional genitive measurement structures, however, differ from their absolute counterparts with respect to agreement. Both exhibit a strong preference for agreement with the measure noun, but while the *semantic* number of the measure noun is what is relevant for non-proportional units, for proportional units *morphological* number seems more relevant. The paradigm in (39) illustrates the contrast between the absolute measure *Dutzend* ('dozen') and the proportional measure *Drittel* ('third') in (39b). At this point, we have no explanation for this pattern. Note, though, that even with the morphologically plural measure noun *Hälften* in (39c), plural agreement is not strongly preferred over singular, so alternatively it may be that proportional genitive structures don't exhibit any agreement, with the singular verb form serving as a kind of default.

(39) a. Zwei Dutzend deutscher Frauen ^{?*}hat / haben ein iPhone
two dozen.**SG** German.**GEN** women ^{?*}have.**SG** / have.**PL** an iPhone
gekauft
bought
'Two dozen German women bought an iPhone.'

b. Zwei Drittel deutscher Frauen hat / ^{?*}haben ein iPhone
two third.**SG** German.**GEN** women have.**SG** / ^{?*}have.**PL** an iPhone
gekauft
bought
'Two thirds of German women bought an iPhone.'

c. Anderthalb Hälften deutscher Frauen ^{??}hat / [?]haben ein
one and a half half.**PL** German.**GEN** women ^{??}have.**SG** / [?]have.**PL** an
iPhone gekauft
iPhone bought
'75% of German women bought an iPhone.'

Summary   In sum, the data from agreement and case largely confirm the proposal that there is a morphosyntactic unity of measurement structures encompassing both proportional and non-proportional cases. Those instances where morphosyntactic unity do not hold appear to be attributable to independent factors, with perhaps the sole exception being the verbal agreement data with genitive structures as seen in (39). But since these are marginal to begin with and will not be central for the following, we put them aside for the rest of the paper. In the next section, we address the syntactic analysis of measurement structures.

3 Two structures for measurement structures

The previous section showed that absolute and proportional measurement structures behave in a morphosyntactically parallel fashion in German. Specifically, both allow two main variants: genitive and juxtaposed. We also saw in the previous section that the difference in interpretation between the proportional genitive structure (8a) and juxtaposed structure (8b), repeated below, is not predicted by a straightforward Krifka-style account of measurement structures, as such theories cannot implement proportional measurement in the first place, let alone resolve the central problem of quantificational reversal.

(8) Semantic distinction between genitive and juxtaposed measurement structures with proportion nouns (based on Ahn & Sauerland 2017: p. 219):

a. Dreißig Prozent der   Studierenden arbeiten.
   thirty   percent the.**GEN** students.**GEN** work

   'Thirty percent of the students work.'

b. Dreißig Prozent Studierende   arbeiten hier.
   thirty   percent students.**NOM** work   here

   'Thirty percent of the workers here are students.'

In this section, we will argue that genitive and juxtaposed measurement constructions have different syntactic structures, and in the next section we will show how these syntactic distinctions lead to the observed semantic distinctions in (8). While our proposal is primarily motivated by and framed in terms of proportional measurement structures, given the morphosyntactic parallels it is also intended to apply to absolute measurement structures as well. As a result, we claim that the quantificational reversal phenomenon in (8) applies equally well to absolute as to proportional measurement structures. However, due to features of the lexical semantics of absolute measure nouns like *Kilo*, the pre- and post-reversal truth conditions will turn out to be equivalent when the measure noun is absolute.

The two structures we propose for genitive and juxtaposed measurement structures are shown schematically in (40).

(40)   a. genitive structure   b. juxtaposed structure
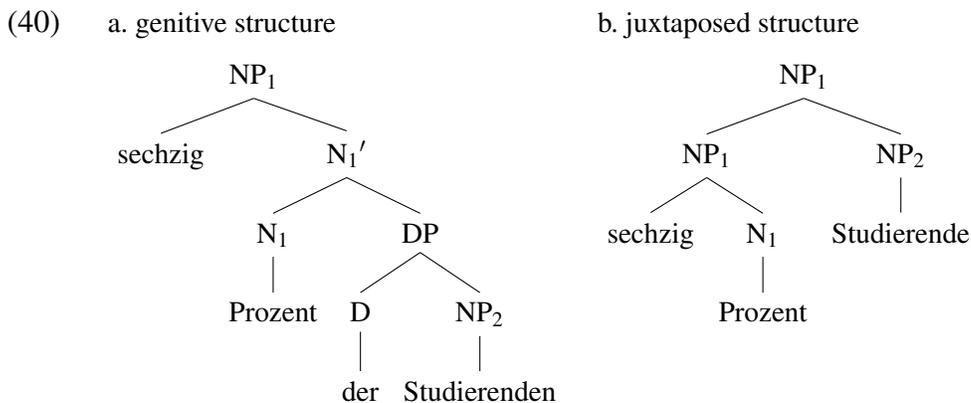
In both cases, we propose that the measure noun N_1 projects an NP, which presumably serves as the complement of a silent indefinite determiner; note that an overt definite determiner is also possible, as seen in (41):

(41)   Sie ist von   dem einen Liter Bier, den sie getrunken hat, benommen.
        she is from the one   liter beer the she drunk   has affected

        'She is affected by the one liter of beer that she drank.'

In both structures the case of N_1 is licensed externally, determined by the position the containing DP occupies in the clause. (For the illustration in (40), we assume the external case is nominative.) In the genitive structure, only N_1 bears the external

case, and the substance DP is assigned genitive case, as commonly occurs with DP complements of nouns. In the juxtaposed structure, meanwhile, the substance NP (NP$_2$) is adjoined to NP$_1$, and the two NPs share the external case assigned to DP (nominative in (40b)). Note also the DP/NP distinction for the substance phrase in the two structures: genitive structures include a full substance DP, while for juxtaposed structures it is only an NP, hence the unavailability of an overt determiner.

In terms of generating the semantic distinctions between the two constructions, the most important difference between (40a) and (40b) is whether the measure noun and the associated number form a constituent excluding the substance noun as in (40b), or not as in (40a). As we previously discussed, both of these possibilities have been proposed in the literature on measurement structures cross-linguistically, as well as for German in particular: Grestenberger (2015) assumes a structure like (40a) for all measurement structures, while Krifka (1989), Zifonun et al. (1997), and Dudenredaktion (2009) assume a structure similar to (40b) for all measurement structures. But it has not been previously proposed that both structures are available and that they are associated with the genitive/juxtaposed distinction.

Our arguments for the structures in (40) fall into two classes. First, we will present a set of arguments in support of the claim that both genitive and juxtaposed structures form NP constituents headed by the measure noun. While we share this assumption with all previous work on German measurement structures, this is nonetheless an important step because proportional juxtaposed measurement structures look superficially similar to structures with quantity adverbials—especially with the preposition *zu* ('at') as in *zu sechzig Prozent* ('at 60%')—in which the measure noun is clearly *not* the head of the structure to which it is adjoined. We will show that quantity adverbials can be adjoined to DPs, but that nevertheless the NP analysis is correct for measurement structures. After discussing what genitive and juxtaposed structures share in common—namely, measure noun headedness—we will then turn to those traits that distinguish between the two structures, thereby justifying the syntactic distinction displayed in (40).

3.1 Measurement structures as NPs: Contrast with DP adverbials

Both genitive and juxtaposed measurement structures have been regarded as NP constituents in prior work, which has focused on non-proportional measurement. In the previous section we saw evidence that proportional measurement structures are (for the most part) morphosyntactically unexceptional, and thus that syntactic and semantic facts about proportional measurement structures ought to inform any analysis of measurement structures more generally. But given the difficulties traditional analyses face in accounting for proportional measurement, can and should an NP analysis for both genitive and juxtaposed measurement structures still be

maintained, or do the facts about proportional measurement force us to adopt a different approach altogether?

The relevance of this question is highlighted by another construction with proportional measure phrases that bears a compelling resemblance to juxtaposed structures: namely, sentences with quantity adverbials like *zu sechzig Prozent* (lit. 'at sixty percent') as in (42), which give rise to similar "reverse" interpretations:

(42) Zu sechzig Prozent Frau-en   haben ein iPhone gekauft
     at sixty   percent woman-PL have   an iPhone bought
     'Sixty percent of iPhone buyers were women.'

One property of the relevant class of adverbials illustrated by (42) is that they can occur in verb-second clauses together with a nominal phrase as the preverbal constituent. Other adverbials that belong to this class are *größtenteils* ('for the most part'), *ausschließlich* ('exclusively'), and *nur* ('only'). Following Bayer (1996) and Meyer & Sauerland (2009), we assume that these adverbials can adjoin to DP and that this underlies their ability to occur preverbally with a DP as in (42) (cf. the proposed English syntax for *only students* in (6)). We will therefore refer to this class of adverbials as *DP-adjoinable adverbials* in the following. Note that other classes of adverbials cannot occur preverbally together with only a nominal in German, as (43) illustrates for the temporal adverb *meistens* ('most of the time').

(43) *Meistens   Frau-en   haben ein iPhone gekauft
     most of the time woman-PL have   a   iPhone bought

Given the obvious parallels between adverbial *zu sechzig Prozent Frauen* and juxtaposed *sechzig Prozent Frauen*, unifying these two constructions is quite tempting. One could thus say the following: genitive structures are indeed NPs, perhaps as in (40a), or perhaps with some different internal structure. But what we have been calling "juxtaposed" structures—both absolute and proportional, given the morphosyntactic unity of the two—are really adverbial constructions of the sort exemplified in (42), rather than measure-noun-headed NPs like in (40b). We now take on the task of arguing against this analysis and in favor of an NP analysis for both genitive and juxtaposed measurement structures, based on (I) the constituency implications of the case and agreement data discussed in the previous section, (II) adjacency requirements and left dislocation, and (III) co-occurrence with the definite determiner.

3.1.1 Case, agreement, and constituency

While DP-adjoined adverbials share some of the constituency properties of measurement structures, their agreement and case properties differ substantially. Consider

first agreement. While (38) showed that both the measure noun and the substance noun could determine verbal agreement in juxtaposed measurement structures, agreement with DP-adverbials is impossible and as (44) shows agreement must be with the nominal following the adverbial.[14]

(44)   a. Zu einem Prozent Japaner   *wohn-t / wohn-en in Berlin.
          at one   percent Japanese.PL *live-SG / live-PL in Berlin
          'One percent of Berlin residents is/are Japanese.'

       b. Zu sechzig Prozent Butter ?komm-t   / *komm-en in   diesen Teig.
          at sixty   percent butter ?come-SG / *come-PL into this   dough
          'Sixty percent of what goes into this dough is butter.'

As for case marking, we have seen that measure nouns in measurement structures must always bear the case assigned to the argument position the DP occupies, while the substance NP/DP can occur either with genitive or matching case, depending on the type of measurement structure. With DP-adverbials the case pattern is different, as (45) shows. First, the noun phrase hosting the DP-adverbial cannot be marked genitive—hence the ill-formedness of (45a)—but must have the case assigned by the verb, as in (45b). This is consistent with the hypothesis that only juxtaposed structures involve DP adverbials, but more problematic is the fact that the equivalent of the measure noun in *zu* adverbials must always bear dative case, as assigned by the preposition *zu* ('at'). Thus, (45c), in which dative case is replaced with structural accusative case, is ill-formed.

(45)   a. *Sie tranken zu ein-em   Prozent bayrisch-en   Bier-es
          they drank   at one-DAT percent Bavarian-GEN beer-GEN

       b. Sie tranken zu ein-em   Prozent bayrisch-es   Bier
          they drank   at one-DAT percent Bavarian-ACC beer.ACC
          'One percent of the drink they consumed was Bavarian beer.'

       c. *Sie tranken zu ein   Prozent bayrisch-es   Bier
          they drank   at one.ACC percent Bavarian-ACC beer.ACC

The agreement properties of measurement structures provide an argument that the measure noun is a head noun of the argument of the verb, at least when the verb

---

14 The slight degradation of (44b) is related to the size of the preverbal constituent. The sentence become fully acceptable if the preverbal constituent is broken up, and still only singular agreement is possible on the verb as shown in (iv). (44b) is provided for better comparability with the corresponding measurement structure in (38).

(iv)   Zu sechzig Prozent komm-t   / *komm-en Butter in   diesen Teig.
       at 60   percent come-SG / *come-PL butter into this   dough
       '60% of what goes into this dough is butter.'

agrees with the measure noun and not with the substance noun. Of the different case patterns, examples with the measure noun bearing argument case and the substance noun in genitive case seem to also force an analysis where the measure noun heads the measurement noun phrase. But case agreement in German also can generally be taken as evidence for constituency. This is shown in the literature on quantifier float such as in (46a), and on split topicalization like (46b) (Ott 2012).

(46) a. Diese-n   Student-en habe ich gestern   all-en   geschmeichelt.
        these-DAT student-PL have I   yesterday all.DAT flattered
        'I flattered all these students.' (Merchant 1996: p. 182)

    b. Einen Wagen hat er sich noch keinen   leisten können.
       a.ACC car   has he self yet   none.ACC afford could
       'As for cars, he hasn't been able to afford one yet.'
       (van Riemsdijk 1989: p. 4)

Therefore case agreement in juxtaposed structures also corroborates an analysis of measurement structures as a single nominal constituent, especially given that the measurement structures can be the initial constituent of a verb-second clause.

3.1.2 Adjacency requirements and left dislocation

Adjacency requirements constitute a second argument for the constituency of measurement structures. Neither genitive nor juxtaposed structures allow the measure noun (phrase) alone to occupy the topic position of the German clause, as shown by (47a) and (47b). In contrast, *zu*-adverbials allow this separation of unit and substance noun as in (47c). Once again, this contrast illustrates that neither measurement structure should be equated with adverbials.

(47) a. * Sechzig Prozent haben hier heute der   Kinder   übernachtet
         sixty   percent have   here today the.GEN children overnighted
         INTENDED: 'Today sixty percent of the children stayed here overnight.'

    b. * Sechzig Prozent haben hier heute Kinder   übernachtet
         sixty   percent have   here today children overnighted
         INTENDED: 'Today children were sixty percent of the people who stayed here overnight.'

    c. Zu sechzig Prozent haben hier heute Kinder   übernachtet.
       at sixty   percent have   here today children overnighted
       'Today children were sixty percent of the people who stayed here overnight.'

The reverse order—topicalization of the substance NP/DP to the exclusion of the measure NP—exhibits a different pattern, illustrated in (48). In this case, only the

genitive structure disallows substance NP/DP topicalization, while both juxtaposed and adverbial structures allow such separation.[15]

(48) a. * Der   Kinder   haben hier heute sechzig Prozent übernachtet
             the.GEN children have here today sixty   percent overnighted

      b.   Kinder   haben hier heute sechzig Prozent übernachtet
            children have here today sixty   percent overnighted
            'Today children were sixty percent of the people who stayed here overnight.'

      c.   Kinder   haben hier heute zu sechzig Prozent übernachtet.
            children have here today at sixty   percent overnighted
            'Today children were sixty percent of the people who stayed here overnight.'

But the difference between (48a) and (48b) is a general feature of split topicalization, as previously discussed by van Riemsdijk (1989). For example, we find the same difference with numerals in (49):

(49) a. * Der   Kinder   haben hier heute drei übernachtet.
             the.GEN children have here today three overnighted

      b.   Kinder   haben hier heute drei übernachtet.
            children have here today three overnighted
            'Today three children stayed here overnight.'

Left dislocation further confirms that the derivation of (48b), but not (48c), involves split topicalization. Split topicalization is generally incompatible with left dislo-cation, and (50) shows that juxtaposed measurement structures and *zu*-adverbials diverge vis-à-vis the combination of substance-only fronting and left dislocation.[16]

(50) a. * Kinder, die haben hier heute sechzig Prozent übernachtet.
             children they have here today sixty   percent overnighted

15 The few speakers mentioned in fn. 5 who don't fully accept data like (8b) still accept data like (48b). In other words, for these speakers split topicalization is obligatory with juxtaposed measurement structures.

16 Example (v) below ought to be a test of left dislocation from genitive measurement structures. The example does not have the conservative interpretation expected for a genitive structure, but is surprisingly quite acceptable, albeit old-fashioned-sounding. But (v) only permits the reverse interpretation, so it cannot be a genitive measurement structure, but must have some other structure. Because of the stilted character of (v), we put it aside for now.

(v)   ? Die Kinder, derer   haben hier heute sechzig Prozent übernachtet
          the children they-GEN have here today sixty   percent overnighted
          'Today children were sixty percent of the people who stayed here overnight.'

    b.   Kinder, die haben hier heute zu sechzig Prozent übernachtet
           children they have here today at sixty percent overnighted

           'Today children were sixty percent of the people who stayed here overnight.'

Thus, while (48b) is apparently a case of split topicalization (hence why (50a) is ungrammatical), the acceptability of (50b) suggests that whatever separates *Kinder* from *zu sechzig Prozent* in (48c) must be some other process altogether.

3.1.3 Co-occurrence with the definite determiner

Finally, the definite construal of measurement structures strongly supports the constituency of both types of measurement structure. In (41) we already saw an example of an absolute juxtaposed measurement structure with a definite determiner. In fact, both genitive and juxtaposed proportional measurement structures can be part of definite descriptions, as shown in (51a) and (51b), respectively. However, the interpretations of the two are quite distinct.[17]

(51)   a.   Die sechzig Prozent der Kinder, die hier heute übernachtet
            the sixty percent the.GEN children the here today overnight
            haben, waren zufrieden.
            have were satisfied

            'The sixty percent of the children who stayed here tonight were satisfied.'

---

17 In both examples, omission of the relative clause renders the example degraded in an out of the blue context. In (51b), this follows because some additional restriction must be provided to select a unique sixty-percent share from all the children. This can also be done by a superlative as in *die schnellsten sechzig Prozent der Kinder* ('the fastest sixty percent of the children') or a prepositional phrase as in *die sechzig Prozent der Kinder aus Deutschland* ('the sixty percent of the children from Germany'), though not as smoothly by just an adjective as in *die deutschen sechzig Prozent der Kinder* ('the German sixty percent of the children'). In (51b), the relative clause seems to play a more important role. Specifically, it might provide a site for reconstruction in a way similar to the analysis of *the few men who came* by Solt (2015). This correctly predicts that a superlative cannot fill in for the relative clause easily in (vi). However, the prepositional phrase case in (vii) is yet more complicated. We leave resolution of these issues for future work.

(vi)   *? Die schnellsten sechzig Prozent Kinder waren zufrieden.
          the fastest sixty percent children were satisfied

(vii)   Die sechzig Prozent Kinder aus Deutschland waren zufrieden.
         the sixty percent children from Germany were satisfied

         'Sixty percent of the children come from German and the German children were satisfied.'
         'Sixty percent of the Germans were children and the German children were satisfied.'

b. Die sechzig Prozent Kinder, die hier heute übernachtet haben,
the sixty   percent children who here today overnight   have

waren zufrieden.
were   satisfied

'Tonight sixty percent of the people who stayed here were children and these children were satisfied'

DP-adjoined *zu*-adverbials (and other DP-adjoined adverbials) contrast clearly with measurement structures here: as (52a) shows, *zu*-adverbials cannot be part of a definite description, though they can adjoin to a definite DP as in (52b).

(52) a. * Die zu 20 Prozent Kinder, die hier heute übernachtet haben, waren
the to 20 percent children the here today overnight   have   were

zufrieden.
satisfied

b. Zu 20 Prozent die Kinder, die hier heute übernachtet haben, waren
to 20 percent the children the here today overnight   have   were

zufrieden.
satisfied

'20% of the people who were satisfied were the children that stayed here today overnight.'

In summary, facts pertaining to case assignment, verbal agreement, movement, and co-occurrence with the definite determiner show uniformly that genitive and juxtaposed measurement structures form NP constituents, in contrast to *zu*-adverbials.[18]

3.2   Internal constituency of proportional measurement structures

In (40), we proposed two differences in internal constituency between genitive and juxtaposed measurement structures. One was that the substance noun can project a DP in genitives, but only an NP in juxtaposed structures. The other was that the substance DP is a complement of the measure noun in genitives, but the substance NP is an adjunct to the full measure NP in juxtaposed structures.

We already saw clear evidence in favor of the first conclusion in the previous section: in genitive structures and only genitive structures, the substance NP can appear with an overt determiner. The availability of an overt determiner in genitive structures obviously points to the presence of a determiner, and while the unavailability of an overt determiner in juxtaposed structures doesn't necessarily entail the

---

18 Data from scope reconstruction discussed by Sauerland (2014b) further point toward this conclusion.

absence of a determiner altogether, at least as a first hypothesis a bare NP seems more plausible than a DP with obligatorily silent determiner.[19]

The second difference between the two types of measurement structures is more difficult to establish based on morphosyntactic evidence alone, with the best available evidence coming from the split topicalization data in (48) above. If split topicalization involves movement, as argued by van Riemsdijk (1989) and Ott (2012, 2015), then (48) shows that the substance NP of juxtaposed structures is available for this kind of movement, but not the substance DP of genitive structures. The analysis of measurement structures in (40) lends itself to a convenient explanation of these facts when combined with Ott's (2012, 2015) theory of split topicalization. Ott argues that split-topicalization involves movement of a predicative NP from a constituent consisting of a DP and an NP. For example, in the case of (53a), Ott's proposed derivation is as in (53b).

(53)   a. Reptilien hatten sie   nur eine Schlange
          reptiles had   they only a   snake
          'As for reptiles, they only had a snake.' (Ott 2015: ex. (38))

       b. [Reptilien]$_{NP}$ hatten sie [[nur eine Schlange]$_{DP}$ t]

Split-topicalization from juxtaposed measurement structures can receive an analogous derivation if the analysis in (40) is correct. For (48b), repeated below, this derivation is illustrated in (54).

(48b)   Kinder   haben hier heute sechzig Prozent übernachtet
        children have   here today sixty   percent overnighted
        'Today children were sixty percent of the people who stayed here overnight.'

(54)   [Kinder]$_{NP}$ haben hier heute [$_{DP}$ D [$_{NP}$ [sechzig Prozent]$_{NP}$ t]] übernachtet

Juxtaposed structures and split-topic constructions share a number of important properties. First, in both constructions the two nominals must agree in case. In

_____

[19] While the substance noun in genitive structures clearly occurs within the environment of a DP, other principles such as as the partitive constraint (Ladusaw 1982) and the Genitive rule (Dudenredaktion 2016: 968) further constrain what DPs can occur in this position:

(viii) $^?$ Sechzig Prozent einiger   Studenten sind angenommen worden
            sixty   percent some.GEN students   were accepted   PASS
            'Sixty percent of some students passed.'

(ix) $^{*?}$ Sechzig Prozent ihrer   sind angenommen worden
            sixty   percent them.GEN were accepted   PASS
            'Sixty percent of them passed.'

addition, Ott (2015: fn. 10) points out three important distinctions between split-topic constructions and descriptive appositions such as *Merkel, die Kanzlerin, …* ('Merkel, the chanceleress, …'): only the former (I) allow number mismatches, such as (53a)'s plural *Reptilien* ('reptiles') and singular *Schlange* ('snake'); (II) can be split by topicalization; and (III) disallow the definite determiner in the second (topicalized) NP/DP. Juxtaposed measurement structures share all three traits, as was shown above: they allow number mismatches as in (38), they allow topicalization of the second NP as in (48b), and the second part cannot be definite (illustrated in (19) and (27)).

But there is also an important difference between cases of split-topicalization like (53b) and juxtaposed structures like (54): topicalization is *obligatory* in the former, but only *optional* in the latter, at least for Standard German. Hence, while we've seen many examples of juxtaposed structures without substance NP topicalization in this paper, (53a) is ungrammatical without topicalization of *Reptilien* ('reptiles'), as seen in (55):

(55)　　* Sie　hatten nur　eine Schlange Reptilien
　　　　　 they had　only a　　snake　　reptiles

We believe that this is a matter of parametric syntax, for two reasons. First, as discussed in footnotes 5 and 15 there appears to be at least one dialect of German in which topicalization of the substance NP is in fact obligatory with juxtaposed measurement structures. And second, we will argue in the next section that the measure noun phrase (e.g., *sechzig Prozent*) in a juxtaposed structure must always be extracted to a position with clausal scope at logical form, due to a semantic type mismatch at its initial merge position. Thus it may be that for both split-topic and juxtaposed measurement structures, there is some condition, holding across dialects, that requires that one of the NPs be extracted and attached to the clausal spine.[20] But for reasons that have yet to be determined, dialects differ in what sorts of movement satisfy this condition. In those dialects that require substance NP topicalization in juxtaposed structures, the movement requirement can only be satisfied by overt topicalization; the covert extraction of the measure NP does not suffice, and so there is always overt topicalization of the second NP in both constructions. In Standard German, meanwhile, covert movement suffices, so that LF-extraction of the measure NP satisfies the movement requirement and renders substance NP topicalization optional rather than obligatory. Split-topic constructions presumably lack an analog to covert measure NP extraction, and so overt topicalization is the only option

---

20 For example, Ott (2015) attributes this movement requirement for split-topic structures to the labeling algorithm: if everything were to stay in place, the labeling algorithm would crash. Ott frames his proposal in terms of PF—hence, movement must be overt in split-topicalization structures—but one might be able to expand it to LF as well.

available in all dialects. However, we can only offer this as a sketch of an account, and must leave a fuller account for future work.

Next we turn to genitive measurement structures. At this point, we mostly adopt the structure in (40) for concreteness. Since genitives do not allow split-topicalization and differ in several other ways from juxtaposed structures, the structure of the former must differ from that of the latter. The structure in (40) is adopted from work by Grestenberger (2015) and Scontras (2014). However, one argument in favor of such an account is the genitive case assigned to the substance DP. If this substance DP is the complement to the measure noun, as in our analysis, the fact that it appears in the genitive case is immediately predicted, since genitive is the case typically assigned to the complements of nouns:

(56) die   Zerstörung der   Stadt
      the.NOM destruction the.GEN city
      'the destruction of the city'

That being said, we do not see any overwhelming evidence in favor of precisely the structure in (40a), and other similar analyses might be feasible. However, a crucial observation that must be accounted for in any theory, and is predicted by our analysis, is that for genitive measurement structures any agreement must be with the measure noun and not the substance noun, as shown in the previous section. Thus, by all appearances the measure noun is the head of the NP in genitive measurement structures; designating the substance DP as the complement of this head is a natural but not logically necessary means of achieving this.

Having put forward our arguments in favor of a structural distinction between genitive and juxtaposed measurement structures, as diagrammed in (40), we next turn to the task of providing a compositional semantics that generates the appropriate interpretations for genitive and juxtaposed measurement structures with both absolute and proportional measure nouns.

4   The semantics of German measurement structures

Pursuant to the discussion in the previous section, we have landed on the representations in (40), repeated below, for genitive and juxtaposed measurement structures.

(40) a. genitive structure

```
                NP₁
              /      \
        sechzig      N₁′
                    /    \
                 N₁       DP
                  |      /   \
              Prozent  D      NP₂
                       |       |
                      der   Studierenden
```

b. juxtaposed structure

```
                NP₁
              /      \
          NP₁         NP₂
         /    \         |
    sechzig    N₁    Studierende
                |
             Prozent
```
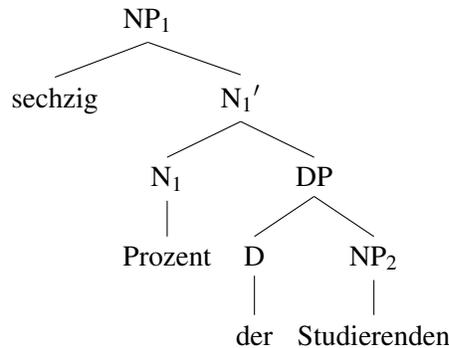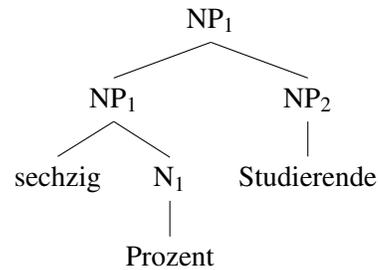
Crucially, in the genitive structure the substance DP is the complement to the measure noun, which has the numeral in its specifier, while in the juxtaposed structure the numeral and measure noun form a constituent to the exclusion of the substance NP. In this section we will discuss the semantic side of things, seeing how we derive the right semantic results given the proposed syntactic representations. Our analysis shares some core details with that of Ahn & Sauerland (2017), most notably the claim that in juxtaposed measurement structures (and only juxtaposed measurement structures), the measure NP (e.g., *dreißig Prozent*) undergoes covert movement and attaches along the clausal spine. However, an important area in which our analyses diverge is that unlike Ahn & Sauerland, we treat measure nouns as denoting quantifiers over degrees, as we will discuss in more detail shortly. While this permits some helpful simplifications to the syntactic-semantic analysis, the proposal is still very much in the spirit of Ahn & Sauerland 2017, and so we will not discuss in detail where precisely the two analyses do and do not converge.

4.1 Genitive structures

4.1.1 Measure nouns as degree-quantifiers

What is the denotation of a measure noun like *Kilo* or *Prozent*? Existing work on measurement has mostly followed Krifka (1989) in focusing exclusively on absolute measurements like *Kilo*. Such nouns have a variety of uses. As mentioned previously, one important use for measure nouns beyond measurement structures is in degree constructions, as in the following examples:

(57) a. Joanna is five <u>feet</u> tall.
      b. Becca is three <u>pounds</u> heavier than Janice.
      c. Harlan drank one <u>liter</u> less than Ben did.

By all appearances, in these uses measure NPs denote or quantify over *degrees*: *five feet* denotes or quantifies over degrees of height/length, and likewise for *three*

pounds and weight and *one liter* and volume. This is in contrast to these nouns' uses in measurement structures, where they seem to measure objects rather than simply quantify over degrees. This latter observation is made plain in Krifka's (1989) aforementioned analysis, in which ⟦gram⟧ takes a numeral n and individual x, returning true iff x weighs n grams:

(58) ⟦gram⟧$_{\text{Krifka}} = \lambda n \lambda x.\ \text{grams}(x) \geq n$

As was mentioned in Section 2, analyses differ in whether they treat degree uses of measure nouns as derived from measurement uses, vice versa, or neither. Krifka (1989) seemingly goes with the first option, leading to an analysis that struggles to account for the inherently relative nature of proportional measurement, as previously discussed. In this paper we will take the second option: measure nouns like *Kilo* and *Prozent* lexically quantify over degrees. Take, for example, *Kilo*. On our account, ⟦Kilo⟧ will take a set D of degrees of weight—the *restrictor set*—a numeral n, and another set D' of weight degrees—the *scope set*—and return true iff the scope is a subset of the restrictor and the highest degree in the scope is at least n kg. This is shown in (59):

(59) ⟦Kilo⟧ $= \lambda D \lambda n \lambda D'.\ D' \subseteq D \wedge \max(D') \geq n$ kg.

If ⟦Kilo⟧ quantifies over degrees of weight, then what sort of degrees do proportional measure nouns quantify over? It appears that there is some flexibility in this regard. Consider (60), which uses an *in terms of* phrase to set the contextually determined measurement (cf. Pasternak 2019a; for similar discussion of the use of *by* phrases like *by weight*, see Ahn & Sauerland 2015):

(60) In terms of {weight/volume}, 50% of what's in this bowl is rice.

If the measurement involved in (60) is in terms of weight, then the sentence asserts that the weight of the rice in this bowl is half of the weight of the total contents of the bowl. Meanwhile, if the measurement is in terms of volume, then the assertion is that the volume of the rice is half of the volume of the total contents. Depending on the relative density of the rice and the other contents of the bowl, these might not be the same truth conditions. Thus, while ⟦Kilo⟧ is lexically restricted to quantifying over degrees of weight, the denotations of proportional measure nouns are more flexible in the choice of degrees they quantifies over. More specifically, we take ⟦Prozent⟧ to be defined as in (61), where $n\%[d] = \frac{n}{100} \times d$:

(61) ⟦Prozent⟧ $= \lambda D \lambda n \lambda D'.\ D' \subseteq D \wedge \max(D') \geq n\%[\max(D)]$

In short, ⟦Prozent⟧ takes a restrictor set D, numeral n, and scope set D', and returns true iff the maximal degree in D' is $n\%$ of the maximal degree in D. Notice that the scale flexibility of *Prozent* and the inflexibility of *Kilo* fall out immediately:

degree multiplication of the sort seen in (61) is defined for various scales, while only degrees of weight can be equal to *n* kilograms.

At this point, the utility of defining measure nouns in this manner may be a bit opaque. To see the benefits of defining them this way, it will help to go through our compositional semantics in full.

4.1.2 Relating degree sets and individuals

Before going through the compositional semantics for genitive structures, a slight tweak needs to be made on the syntactic end. Consider the NP *dreißig Kilo der Äpfel* ('thirty kilos of the apples'). ⟦Kilo⟧ is a quantifier over degrees of weight, and we will follow Link (1983) in treating ⟦der Äpfel⟧ as a *plural individual* of type *e*, i.e., the "collection" (roughly speaking) of all and only the salient apples. But there is no way for these to semantically combine. With this in mind, we propose that there is a head MEAS that adjoins to *Kilo* and semantically converts it from something that trades in sets of degrees (of weight) to something that deals with individuals. Note that something like this is motivated on independent grounds: measure nouns have degree uses and measurement uses, and assuming we want a unified denotation for these nouns something must enable our switching from one to the other. (One could alternatively recast the denotation of MEAS as an operation of semantic coercion, but we will syntactify MEAS for convenience.)

Thus, the revised representation for genitive structures will be as in (62):

(62) Genitive structure (revised):

```
            NP                                  NP
          /    \                              /    \
    dreißig     N′                      dreißig     N′
              /    \                              /    \
            N       DP                          N       DP
          /  \     /  \                       /  \     /   \
      Kilo  MEAS der Äpfel              Prozent MEAS der Studierenden
```
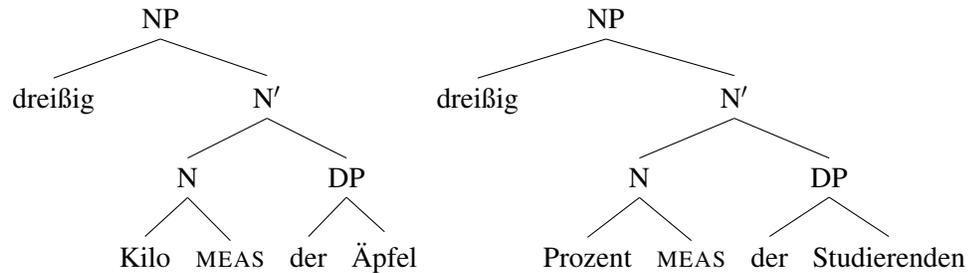
We will go through the semantic derivation for both of these NPs, starting with the absolute structure *dreißig Kilo der Äpfel*.

We previously defined ⟦Kilo⟧ as in (59), repeated below:

(59) $\llbracket \text{Kilo} \rrbracket = \lambda D \lambda n \lambda D'. D' \subseteq D \wedge \max(D') \geq n \text{ kg}.$

Next we define ⟦MEAS⟧. Semantically, ⟦MEAS⟧ takes something of the type of ⟦Kilo⟧, then it takes an individual (⟦der Äpfel⟧), and then a numeral (⟦dreißig⟧), and returns an $\langle e,t \rangle$-type predicate, the typical type for the denotation of an argument NP. (The denotation of the silent determiner will then fulfill its common duty of turning this predicate into a quantifier over individuals.)

So what actually is $[\![\text{MEAS}]\!]$? First, we need to get two preliminary definitions out of the way:

(63) a. For a given context c, μ^c is a contextually determined *measure function*, i.e., a function from individuals to degrees.

  b. For individual x and measure function μ, $\mu\langle x\rangle = \{d \mid \mu(x) \geq d\}$, i.e., the set of degrees no greater than $\mu(x)$.

For example, if μ^c is the weight measure function, then $\mu^c(x)$ will be the single degree that is x's weight, while $\mu^c\langle x\rangle$ will be the set of all degrees of weight that do not exceed x's weight.

As mentioned above, $[\![\text{MEAS}]\!]$ works by essentially switching the denotation of a measure noun like *Kilo* from something that trades in sets of degrees to something that trades in (possibly plural) individuals. Thus, in order to mediate between the two we need a mapping from individuals to sets of degrees. Notice that $\mu^c\langle\cdot\rangle$ does precisely this, since it takes an individual x and returns the set of degrees no greater than $\mu^c(x)$. $\mu^c\langle\cdot\rangle$ will thus serve as our mapping from individuals to sets of degrees. With this in mind, our denotation for $[\![\text{MEAS}]\!]$ will be as in (64). ($\sqsubseteq$ indicates the mereological part-whole relation: for example, if a is a collection of apples, and b is a subpart of that collection, then $b \sqsubseteq a$.)

(64) $[\![\text{MEAS}]\!]^c = \lambda M \lambda x \lambda n \lambda y.\ y \sqsubseteq x \wedge M(\mu^c\langle x\rangle)(n)(\mu^c\langle y\rangle)$

The argument M is the denotation of the measure noun to which MEAS adjoins (*Kilo/Prozent*), x is the (plural) individual that is the denotation of the substance DP (*der Äpfel/der Studierenden*), and n is the denotation of the numeral (*dreißig*). After composing with these three, the result is an $\langle e,t\rangle$-type predicate, as desired. Thus, as promised, $[\![\text{MEAS}]\!]$ works by using $\mu^c\langle\cdot\rangle$ as a mapping from individuals to sets of degrees and feeding these sets of degrees into the denotation of the measure noun to which it adjoins.[21]

Let's see how the denotation in (64) helps us derive the correct results in the case of *dreißig Kilo der Äpfel* and *dreißig Prozent der Studierenden*, starting with the former. The result of composing $[\![\text{MEAS}]\!]^c$ and $[\![\text{Kilo}]\!]$ can be seen in (65):

(65) $[\![\text{MEAS}]\!]^c([\![\text{Kilo}]\!]) = \lambda x \lambda n \lambda y.\ y \sqsubseteq x \wedge [\![\text{Kilo}]\!](\mu^c\langle x\rangle)(n)(\mu^c\langle y\rangle)$

---

21 There are well-known constraints on which measure functions are permissible with measurement structures: the choice of measurement must in some sense respect mereological part-whole relations (Krifka 1989, Schwarzschild 2006, Champollion 2017, Pasternak 2019a). Thus, *two pounds of cherries* is well-formed because a collection of cherries will always have a greater weight than any of its proper parts, while *#40°F of cherries* is ill-formed because a collection of cherries will not have a greater temperature than all of its proper parts. We set this constraint aside in this paper, but it can easily be incorporated into our analysis by being built into the definition of whatever head or coercion operation introduces the contextually-determined measure function.

$$= \lambda x \lambda n \lambda y. \; y \sqsubseteq x \wedge \mu^c \langle y \rangle \subseteq \mu^c \langle x \rangle \wedge \max(\mu^c \langle y \rangle) \geq n \text{ kg.}$$
$$= \lambda x \lambda n \lambda y. \; y \sqsubseteq x \wedge \mu^c (y) \leq \mu^c (x) \wedge \mu^c (y) \geq n \text{ kg.}$$

This next combines with the substance DP, *der Äpfel* ('the apples'). Operating within a Linkian framework, the denotation of this DP is a plural individual consisting of all and only the (salient) apples, which we simply notate as the-apples. This is followed by function application with $[\![\text{dreißig}]\!]$, which simply denotes the number thirty. This is shown in (66):

(66) $[\![\text{MEAS}]\!]^c ([\![\text{Kilo}]\!])([\![\text{der Äpfel}]\!])([\![\text{dreißig}]\!])$
     $= \lambda y. \; y \sqsubseteq \text{the-apples} \wedge \mu^c (y) \leq \mu^c (\text{the-apples}) \wedge \mu^c (y) \geq 30 \text{ kg.}$

Notice that because of the conjunct $\mu^c (y) \geq 30$ kg., the only possibility for μ^c that will lead to a well-formed interpretation for (66) is μ_{weight}. In this case, the denotation for the NP *dreißig Kilo der Äpfel* will be a predicate true of an individual *y* iff *y* is a sub-collection of apples, *y*'s weight is no greater than that of the sum total of apples, and *y*'s weight is at least thirty kilograms.

To see how this NP interpretation gets integrated into the denotation of the whole clause, we first need a syntactic structure. We will use as our representative sentence *Dreißig Kilo der Äpfel fielen* ('Thirty kilos of the apples fell'). Because for convenience's sake we are operating within an extensional, event-free semantics, the only semantically relevant portion of the clause is the θ-domain, i.e., *v*P. With this in mind, we take the syntactic structure for our *v*P (before subsequent movement of the subject) to be as in Figure 1.

The determiner D is a silent indefinite determiner, whose denotation is the standard existential generalized quantifier:

(67) $[\![\text{D}]\!] = \lambda P \lambda P'. \; \exists x [P(x) \wedge P'(x)]$

For our purposes $[\![\text{fielen}]\!]$ will be an $\langle e, t \rangle$-type predicate true of *x* iff *x* fell ($\lambda x. \; \text{fell}(x)$), with *v* being semantically vacuous. When the quantifier $[\![\text{D}]\!]$ takes $[\![\text{NP}]\!]$ as its first argument and $[\![\text{fielen}]\!]$ as its second, the resulting interpretation is as in (68):

(68) $[\![\text{Dreißig Kilo der Äpfel fielen}]\!] = 1$ iff
     $\exists y [y \sqsubseteq \text{the-apples} \wedge \mu^c (y) \leq \mu^c (\text{the-apples}) \wedge \mu^c (y) \geq 30 \text{ kg.} \wedge \text{fell}(y)]$

We thus predict truth iff there is some sub-collection of the apples that weighs no more than the apples, weighs thirty kilograms, and fell. Intuitively, these are the correct truth conditions.

We next move on to *Prozent*. We will use (8a), *Dreißig Prozent der Studierenden arbeiten* ('Thirty percent of the students work'), as our sample sentence. The *v*P for this sentence is shown in Figure 2. We first compose $[\![\text{MEAS}]\!]^c$ with $[\![\text{Prozent}]\!]$; the denotation for the latter is provided in (61), repeated below.

(61) $[\![\text{Prozent}]\!] = \lambda D \lambda n \lambda D'. \; D' \subseteq D \wedge \max(D') \geq n\% [\max(D)]$
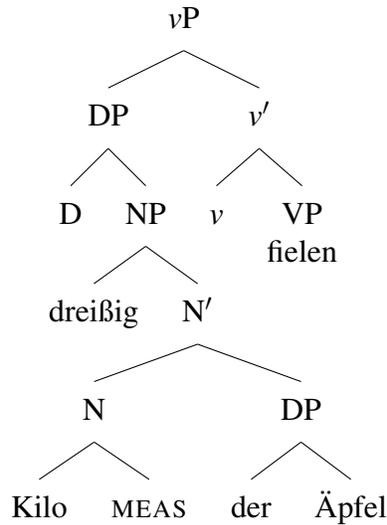
Figure 1   LF tree, *Dreißig Kilo der Äpfel fielen* ('Thirty kilos of the apples fell').

The result of this composition can be seen in (69):

(69) $[\![\textsc{meas}]\!]^c([\![\text{Prozent}]\!]) = \lambda x \lambda n \lambda y.\ y \sqsubseteq x \wedge [\![\text{Prozent}]\!](\mu^c\langle x\rangle)(n)(\mu^c\langle y\rangle)$
    $= \lambda x \lambda n \lambda y.\ y \sqsubseteq x \wedge \mu^c\langle y\rangle \subseteq \mu^c\langle x\rangle \wedge \max(\mu^c\langle y\rangle) \geq n\%[\max(\mu^c\langle x\rangle)]$
    $= \lambda x \lambda n \lambda y.\ y \sqsubseteq x \wedge \mu^c(y) \leq \mu^c(x) \wedge \mu^c(y) \geq n\%[\mu^c(x)]$

This then composes with $[\![\text{der Studierenden}]\!]$ and $[\![\text{dreißig}]\!]$ in an unsurprising fashion, leading to the denotation in (70):

(70) $[\![\textsc{meas}]\!]^c([\![\text{Prozent}]\!])([\![\text{der Studierenden}]\!])([\![\text{dreißig}]\!])$
    $= \lambda y.\ y \sqsubseteq \text{the-students} \wedge \mu^c(y) \leq \mu^c(\text{the-students}) \wedge$
    $$\mu^c(y) \geq 30\%[\mu^c(\text{the-students})]$$

In this case, the contextually-determined measure function is cardinality, i.e., the function that takes a (plural) individual and returns the number of non-plural ("atomic") individuals of which it is composed.[22] Thus, (70) is a predicate true of *y* iff *y* is part of the students, *y* has a cardinality no greater than that of the students, and the cardinality of *y* is thirty percent of that of the students. This then composes

---

22 In fact, with proportional measure nouns and plural substance NPs/DPs cardinality seems to be the *only* viable measure function, though as shown above this is not the case for mass substance NPs/DPs. Bale & Barner (2009) and Wellwood (2014) make similar observations about nominal comparatives, which similarly make use of a contextually determined measure function. These authors offer differing attempts at explaining this; we set the issue aside.
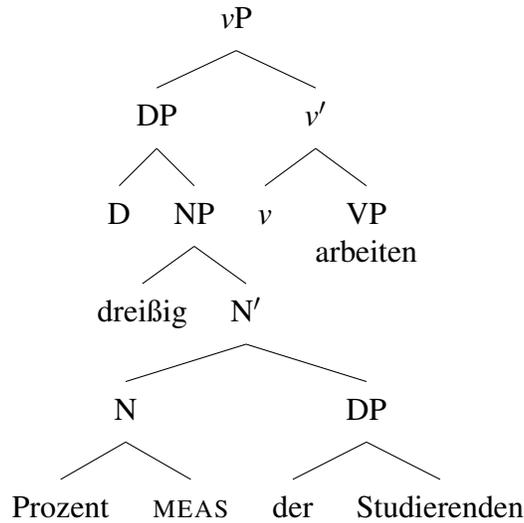
Figure 2   LF tree, *Dreißig Prozent der Studierenden arbeiten* ('Thirty percent of the students work').

with the indefinite determiner, which then composes with the verb *arbeiten*, leading to the final denotation in (71):

(71) $[\![$Dreißig Prozent der Studierenden arbeiten$]\!] = 1$ iff
$\exists y[y \sqsubseteq \text{the-students} \wedge \mu^c(y) \leq \mu^c(\text{the-students}) \wedge$
$$\mu^c(y) \geq 30\%[\mu^c(\text{the-students})] \wedge \text{work}(y)]$$

We thus predict truth iff there is a sub-collection of students whose cardinality is no greater than that of the students, whose cardinality is at least thirty percent of that of the students in total, and who works. These are, in fact, the desired truth conditions.

4.2   Juxtaposed structures

Next, we move on to juxtaposed structures. First, we will discuss an important aspect of the semantics of juxtaposed structures that we have not previously discussed in this paper: their focus-sensitivity. After discussing the focus-sensitivity of juxtaposed structures, the basic Roothian framework in which we will operate (Rooth 1985, 1992), and the broad strokes of how this will permit an analysis of juxtaposed measurement structures, we will then turn to a fully compositional semantics.

4.2.1 Focus-sensitivity and alternative semantics

As noted by Ahn & Sauerland (2015, 2017), the interpretation of juxtaposed measurement structures in German (as well as analogous structures in other languages) depends on the placement of prosodic focus. First, consider (72).

(72)   Dreißig Prozent [westfälische   Studierende   ]$_F$ arbeiten hier.
       thirty   percent [Westphalian.NOM students.NOM]$_F$ work   here
       'Thirty percent of the workers here are Westphalian students.'

Here and throughout, subscripted F indicates prosodic focus; thus, in (72) the whole substance NP *westfälische Studierende* ('Westphalian students') is focused.

    If juxtaposed structures were not focus-sensitive, we would expect (72) to have the same truth conditions even if prosodic focus were restricted to *westfälische* ('Westphalian'). However, this is not the case, as illustrated in (73):

(73)   Dreißig Prozent [westfälische   ]$_F$ Studierende   arbeiten hier.
       thirty   percent [Westphalian.NOM]$_F$ students.NOM work   here
       'Thirty percent of the student workers here are Westphalian.'

Suppose that the company has one hundred employees in total, that fifty of these employees are students, and that of these fifty student employees, fifteen are Westphalian. In this case, the sentence with wide prosodic focus on *westfälische Studierende* is false—only fifteen percent of the total workforce consists of Westphalian students—while the sentence with narrow focus on *westfälische* is true, since thirty percent of the fifty-person student workforce is Westphalian.

    Importantly, this semantic distinction seems to only arise for proportional measure nouns: not only do juxtaposed structures not semantically differ from genitive structures with absolute measure nouns, as discussed above, but as can be seen in (74) their truth conditions are not dependent on prosodic focus.

(74)   a. Dreißig Kilo [rote   Äpfel   ]$_F$ fielen.
           thirty   kilos [red.NOM Apples.NOM]$_F$ fell
           'Thirty kilos of red apples fell.'

      b. Dreißig Kilo [rote   ]$_F$ Äpfel   fielen.
           thirty   kilos [red.NOM]$_F$ Apples.NOM fell
           'Thirty kilos of red apples fell.'

An adequate analysis of juxtaposed structures must account for this distinction in truth-conditional dependence on prosody, as well as the aforementioned semantic identity of genitive and juxtaposed absolute measurement structures.

    In order to properly account for this focus-sensitivity, we will utilize a Roothian framework for the semantics of focus (Rooth 1985, 1992). As a demonstration of

the framework, we first show how it operates with the focus-sensitive adverb *only*. Consider the sentences in (75):

(75) a. Joanna only visits [Boston]$_F$ on Wednesdays.

b. Joanna only visits Boston [on Wednesdays]$_F$.

Both (75a) and (75b) seemingly presuppose that Joanna visits Boston on Wednesdays; if she does not, they are infelicitous. However, the two sentences assert different things: (75a) asserts that Joanna does not visit any other (salient) city on Wednesdays, while (75b) asserts that Joanna does not visit Boston on any day other than Wednesdays. The fact that the two sentences differ only in the assignment of focus shows that *only* is indeed focus-sensitive.

So how do we account for these truth-conditional distinctions? Rooth observes that a convenient way of thinking about the semantics of focus is in terms of *alternatives*: a constituent with a focused sub-constituent makes salient a set of what can loosely be described as alternative possible structures in which the focused constituent is replaced with something else. In addition to an ordinary denotation $[\![\cdot]\!]$, a constituent has as its *focus interpretation* $[\![\cdot]\!]_f$ the set of these alternatives. This is roughly illustrated in (76):

(76) a. $[\![\text{Joanna visits [Boston]}_F \text{ on Wednesdays}]\!]_f \approx$

$$\left\{ \begin{array}{l} \text{Joanna visits Boston on Wednesdays,} \\ \text{Joanna visits New York on Wednesdays,} \\ \text{Joanna visits Baltimore on Wednesdays,} \\ \dots \end{array} \right\}$$

b. $[\![\text{Joanna visits Boston [on Wednesdays]}_F]\!]_f \approx$

$$\left\{ \begin{array}{l} \text{Joanna visits Boston on Wednesdays,} \\ \text{Joanna visits Boston on Thursdays,} \\ \text{Joanna visits Boston on Fridays,} \\ \dots \end{array} \right\}$$

Note that while the alternatives in (76) happen to be propositions, this is not always the case: if a constituent has an ordinary meaning of type α, its alternatives will also be of type α. Thus, $\langle e,t \rangle$-type predicates, for example, have alternatives that are not propositions, but other $\langle e,t \rangle$-type predicates.

The next step is to integrate these alternatives into the compositional semantics. Let C be a free variable over sets of alternatives. When the node $\sim C$ is adjoined to a given structure, the resulting structure has the same ordinary denotation as the sister of $\sim C$, but a requirement is also imposed that C be identical to the focus interpretation of its sister:[23]

---

23 Rooth's actual requirement is that C be a (possibly proper) *subset* of the focus interpretation of its sister. This is an interesting distinction, but for our purposes not an important one.

(77) Given the structure $[_Y \sim C \text{ X }]$, $[\![Y]\!]$ is defined iff $C = [\![X]\!]_f$. Where defined, $[\![Y]\!] = [\![X]\!]$.

Now take our sentences from (75) above. Suppose these sentences have an LF structure along the lines of (78):[24]

(78)

Joanna visits Boston on Wednesdays
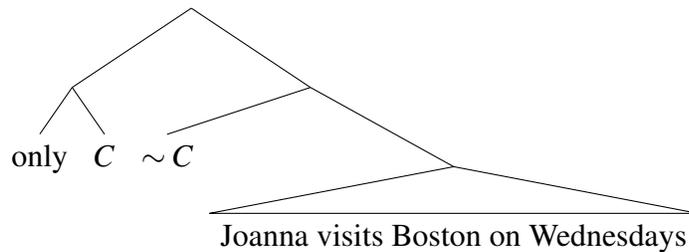
Suppose further that $[\![only]\!]$ is as roughly paraphrased in (79):

(79) $[\![only]\!] = \lambda C \lambda p : p$ is true. $\forall q \in C[p$ does not entail $q \Rightarrow q$ is false$]$

No matter where focus is placed, the propositional argument p of $[\![only]\!]$ will be saturated by the proposition true iff Joanna visits Boston on Wednesdays. But because of the conditions imposed by $\sim C$. the C argument of $[\![only]\!]$ will depend on the placement of focus in the rest of the clause. Take, for example, (75a), with focus on *Boston*. For this sentence, C will be set to the set of alternatives in (76a). The predicted denotation will thus presuppose that Joanna visits Boston on Wednesdays, and assert that none of these alternatives is true except for those entailed by Joanna visiting Boston on Wednesdays. In other words, Joanna doesn't visit any other city on Wednesdays. *Mutatis mutandis* for (75b) and (76b), where we again expect a presupposition that Joanna visits Boston on Wednesdays (p is the same), but this time the assertion is that Joanna does not visit Boston on any other day. These are indeed the desired truth conditions.

Now the question arises of how this general approach can help us understand the semantics of juxtaposed measurement structures. As noted previously, and as will soon be discussed in greater detail, in our analysis the measure NP (e.g., *dreißig Prozent*) moves from the measurement structure and attaches to the clausal spine. So in the case of (73), which has focus only on *westfälische* ('Westphalian'), the structure will look something like (80) (though this will be revised shortly):

---

24 Rooth actually treats *only* in these sentences as scoping above the VP but not above the subject. Since this means the subject must outscope $\sim C$, and thus that focus on the subject cannot impact the focus alternatives fed to $[\![only]\!]$, this accounts for the fact that (x-a), where focus is on the subject, does not have an interpretation akin to (x-b):

(x)   a. [Joanna]$_F$ only visits Boston on Wednesdays.
      b. Only Joanna visits Boston on Wednesdays.

(80) [$_{\text{NP}}$ 30 Prozent] λ_1 [$_{\text{DP}}$ D t_1 [$_{\text{NP}}$ [westfälische]$_{\text{F}}$ Studierende]] arbeiten hier

In our analysis of genitive structures, we took there to be a head MEAS—alternatively analyzed as a semantic operation of coercion—that converted ⟦Prozent⟧ from something that quantified over degrees to something that measured individuals. In juxtaposed structures, on the other hand, MEAS is absent, and measure nouns like *Prozent* retain their degree-quantificational denotations. The denotation of (80) up to and including lambda-abstraction by λ_1 will be (the characteristic function of) a set of degrees, which is again introduced by means of a contextually-determined measure function μ^c, and which again is determined to be cardinality in this example. More specifically, the result of lambda abstraction will be a degree predicate true of a degree d iff at least d-many Westphalian students work here:

(81) ⟦λ_1 [$_{\text{DP}}$ D t_1 [$_{\text{NP}}$ [westfälische]$_{\text{F}}$ Studierende]] arbeiten hier⟧ $\approx$
λd. at least d-many Westphalian students work here

The set of degrees in (81) will be the scope set for *Prozent*. But what about the restrictor set? In fact, in the syntactic structure in (40b), *nothing* saturates this internal argument of *Prozent*. Something must be done in order to fix this. This, we argue, is where focus-sensitivity comes in. Perhaps unsurprisingly, the focus interpretation of the scope of *dreißig Prozent* post-lambda abstraction will look roughly as in (82):

(82) ⟦λ_1 [$_{\text{DP}}$ D t_1 [$_{\text{NP}}$ [westfälische]$_{\text{F}}$ Studierende]] arbeiten hier⟧$_f$ $\approx$
$$\left\{ \begin{array}{l} \lambda d.\ \text{at least } d\text{-many Westphalian students work here,} \\ \lambda d.\ \text{at least } d\text{-many Bohemian students work here,} \\ \lambda d.\ \text{at least } d\text{-many French students work here,} \\ \ldots \end{array} \right\}$$

In other words, the alternative set consists of degree predicates of the form λd. d-many P students work here, where P is some predicate that is an alternative to ⟦westfälische⟧.

This alternative set is not the right type to serve as the restrictor of *Prozent*—the restrictor must be a set of degrees, while this is a set *of sets* of degrees. However, we can get an object of the right type if we take the grand disjunction—that is, the union—of this set of degree predicates. What this grand disjunction ends up being depends on one's theory of alternatives, i.e., what can be substituted for P. In the ordinary (non-focus) semantics, we take ⟦westfälische⟧ to be the $\langle e,t \rangle$-type predicate λx. west(x), where west(x) is true iff x is Westphalian. This then restricts ⟦Studierende⟧ ($= \lambda x$. students(x)) by predicate modification, i.e., conjunction, leading to λx. west$(x) \wedge$ students(x). Now suppose that among the alternatives

in $[[\text{westfälische}]_F]_f$ is the vacuously true predicate $\lambda x.\ \top$.[25] Conjoining this with $\lambda x.\ \text{students}(x)$ leads to no restriction at all: we just get back $\lambda x.\ \text{students}(x)$. In this case, among the alternatives in (82) will be $\lambda d.$ at least d-many students work here. This is guaranteed to be a superset of every other member of (82): if at least d-many P students work here, then it must also be the case that at least d-many students work here. Since this degree predicate is a superset of every other one in the set of alternatives, the grand disjunction of the alternative set will simply return the degree set $\lambda d.$ at least d-many students work here.

With this in mind, suppose that we revise our syntactic structure as follows:

(83) $[_{NP}$ 30 Prozent DIS $C]$ $[\sim C\ \lambda_1\ [_{DP}\ D\ t_1\ [_{NP}\ [\text{westfälische}]_F\ \text{Studierende}]]$ arbeiten hier]

$[\![\text{DIS}]\!]$ takes the alternative set C and returns the grand disjunction of this set, i.e., $\lambda d.$ at least d-many students work here. Let's call this set D_S. The denotation up to and including the lambda abstractor λ_1 remains $\lambda d.$ at least d-many Westphalian students work here; call this D_{WS}. Thus, the interpretation for the whole sentence will be the following:

(84) $[\![\text{Prozent}]\!](D_S)(30)(D_{WS}) = 1$ iff
$D_{WS} \subseteq D_S \wedge \max(D_{WS}) \geq 30\%[\max(D_S)]$

This asserts the following: the set of cardinalities not exceeding the number of Westphalian students who work here is a subset of the set of cardinalities not exceeding the number of students who work here, and the maximal degree in the former is thirty percent of the maximal degree in the latter. In other words, thirty percent of the students who work here are Westphalian. We are thus left with the desired focus-sensitive reverse interpretation.

Now consider what happens when we replace the proportional measure noun *Prozent* with the absolute measure noun *Kilo*. The LF for (74b) will be as in (85):

(85) $[_{NP}$ 30 Kilo DIS $C] \sim C\ \lambda_1\ [_{DP}\ D\ t_1\ [_{NP}\ [\text{rote}]_F\ \text{Äpfel}]]$ fielen

This time, the contextually determined measure function μ^c will be μ_{weight}, for the same reason as in genitive structures: if we were to use any other measure function

---

25 This may not be as odd as it sounds. In work on scalar implicatures, which are also sensitive to alternatives, it is commonly thought that one can generate alternatives by looking at alternate versions of a given structure with various constituents "pruned" from the tree (see, e.g., Fox & Katzir 2011). In the case of a restricting modifier like *westfälische*, its pruning will naturally lead to $[\![\text{Studierende}]\!]$ being unrestricted. Including a vacuously true predicate in $[\![\text{westfälische}]\!]_f$ does essentially the same work: rather than being "removed", the focused constituent's denotation is rendered vacuous. The same effect could also be achieved by requiring that alternative sets be closed under disjunction/union. Yet another way of achieving this effect would be to instead include something like $\lambda x.\ \text{human}(x)$ among the alternatives. Since all students are human, a similar unrestricted interpretation will result.

the resulting degree predicate could not be an argument to $[\![\text{Kilo}]\!]$. The denotation up to and including lambda abstraction will be (86):

(86) $[\![\lambda_1 \, [_{\text{DP}} \, \text{D} \, t_1 \, [_{\text{NP}} \, [\text{rote}]_{\text{F}} \, \text{Äpfel}]] \, \text{fielen}]\!] \approx$
$\qquad\qquad\qquad \lambda d. \text{ the cumulative weight of fallen red apples is at least } d$

Call this degree predicate D_{RA}. The focus interpretation for this constituent will be a set of degree predicates of the form λd. the cumulative weight of fallen P apples is at least d, where P is a member of $[\![[\text{rote}]_{\text{F}}]\!]_f$. Assuming again that $\lambda x. \top$ is among these alternatives in $[\![[\text{rote}]_{\text{F}}]\!]_f$, among the alternatives to (86) will be λd. the cumulative weight of fallen apples is at least d; call this D_{A}. D_{A} will also be a superset of every other member of the alternatives, meaning the grand disjunction of the alternative set ($[\![\text{DIS}]\!](C)$) will be D_{A}. Thus, the scope set of $[\![\text{Kilo}]\!]$ will be D_{RA}, and the restrictor set will be D_{A}. We thus get the following as the final denotation:

(87) $[\![\text{Kilo}]\!](D_{\text{A}})(30)(D_{\text{RA}}) = 1$ iff:
$\quad D_{\text{RA}} \subseteq D_{\text{A}} \wedge \max(D_{\text{RA}}) \geq 30 \text{ kg}.$

We predict truth iff the set of weight degrees not exceeding the weight of fallen red apples is a subset of the set of weight degrees not exceeding the weight of fallen apples, and the maximal degree in the former is at least thirty kilograms. In other words, at least thirty kilograms of red apples fell.

Two things are worth noting about this denotation. The first is that, as desired, the truth conditions are the same as for genitive structures: we predict truth iff the apples that fell are at least thirty kilograms. The second is that we also successfully predict focus to not have any impact on truth conditions. After all, the focus-insensitive scope set is all that matters with respect to comparison to 30 kg., and the disjunction of the scope's alternatives will always be a superset of the scope set itself, so assigning focus differently will not affect truth conditions.[26]

This concludes our basic overview of the semantics of juxtaposed measurement structures, including integration with the semantics of focus. We next show how this is done in a step-by-step compositional semantics.

4.2.2   Compositional semantics for juxtaposed structures

We now move on to the full compositional semantics. We will only go through the full bottom-up composition for proportional measure nouns, and at the end we will briefly discuss the result of replacing the proportional measure noun with an absolute

---

26 The fact that the disjunction of the scope's alternatives will always be a superset of the scope set is dependent on the common view that for any constituent A, $[\![\text{A}]\!]$ is always among A's focus alternatives; in other words, the regular denotation is always among the focus alternatives. As a result, the grand disjunction will always be a superset of the regular denotation.
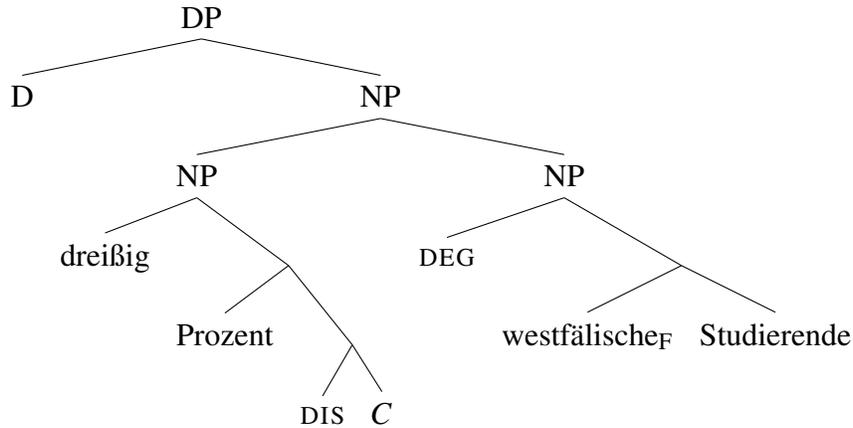
Figure 3   Pre-movement DP, *dreißig Prozent westfälische Studierende*.

measure noun. Our example sentence will be (73), *Dreißig Prozent westfälische Studierende arbeiten hier*, with focus only on *westfälische*.

Much like with genitive structures, some minor syntactic tweaks to our juxtaposed structures are in order. First, as discussed above, we include *C* (the set of focus alternatives) and DIS (which takes *C* and returns its union) in the restrictor of *Prozent*. But a second tweak needs to be made: ⟦dreißig Prozent⟧ is a quantifier over degrees, while *westfälische Studierende* is an ⟨*e,t*⟩-type predicate, meaning that there is a type mismatch between the two. We thus need something to relate individuals to degrees, in a manner parallel to MEAS in genitive structures. With this in mind, we will use the head DEG, which adjoins to the substance NP and introduces a degree argument. Note that as with MEAS, one could similarly replace the syntactic heads DIS and DEG with operations of semantic coercion, but again as with MEAS we will stick to representing these as syntactic heads for concreteness.

The revised DP syntax for juxtaposed measurement structures will thus look as in Figure 3. Note that this representation still obeys the syntactic desiderata discussed earlier in the paper: the numeral and measure noun are still an NP constituent to the exclusion of the substance NP, and the substance NP is still a bare NP adjoined to the measure NP. We have merely expanded the syntax slightly in order to account for the semantic observations.

With respect to the sentential syntax, we continue to ignore issues of tense, aspect, and modality, and thus stick to the θ-domain *v*P, illustrated in Figure 4. As discussed above, *dreißig Prozent* is extracted from the subject DP and attaches to the clausal spine; we will see why this happens shortly.
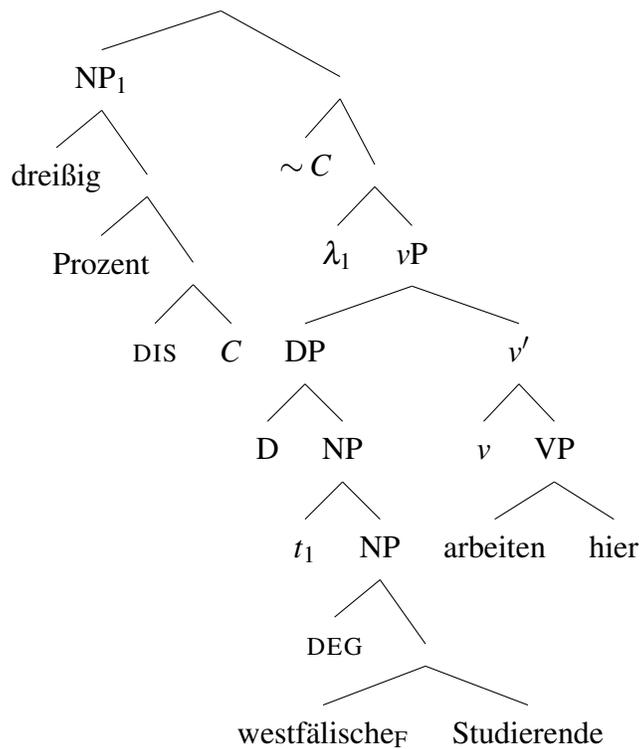
Figure 4 Post-movement tree, *Dreißig Prozent [westfälische]_F Studierende arbeiten hier* ('Thirty percent of student workers here are Westphalian').

Next we perform the compositional semantics, starting with the substance NP. We take $[\![\text{westfälische}]\!]$ to be the $\langle e,t \rangle$-type predicate $\lambda x.\ \text{west}(x)$, and $[\![\text{Studierende}]\!]$ to be $\lambda x.\ \text{students}(x)$, true of any plurality of students. These compose by predicate modification, i.e., conjunction:

(88) $[\![\text{westfälische Studierende}]\!] = \lambda x.\ \text{west}(x) \wedge \text{students}(x)$

Next up is DEG. $[\![\text{DEG}]\!]$ takes a predicate P—the denotation of the substance NP— and returns a relation between degrees d and individuals x that is true iff x is a P and the result of applying the contextually determined measure function μ^c to x is at least d. This is shown in (89):

(89) $[\![\text{DEG}]\!]^c = \lambda P \lambda d \lambda x.\ P(x) \wedge \mu^c(x) \geq d$

This applies to $[\![\text{westfälische Studierende}]\!]$ via normal function application:

(90) $[\![\text{DEG}]\!]^c([\![\text{westfälische Studierende}]\!]) =$
$$\lambda d \lambda x.\ \text{west}(x) \wedge \text{students}(x) \wedge \mu^c(x) \geq d$$

We now are in a place to understand why the measure NP must be extracted from the juxtaposed structure. The denotation of the measure NP is of type $\langle \langle d,t \rangle, t \rangle$—it is a degree-quantifier—while the denotation of the substance NP is type $\langle d, \langle e,t \rangle \rangle$. This gives us a type mismatch, but a familiar one: the substance NP is looking for something of type d, which is the type of object that the measure NP quantifies over. Thus, the measure NP undergoes QR, leaving a trace of type d, which saturates the degree argument of the substance NP. This degree argument saturation is shown in (91), where g is the variable assignment parameter:

(91) $[\![t_1 \text{ DEG westfälische Studierende}]\!]^{g,c} =$
$$\lambda x.\ \text{west}(x) \wedge \text{students}(x) \wedge \mu^c(x) \geq g(1)$$

Since the denotation of our juxtaposed NP is of type $\langle e,t \rangle$, it can serve as the first argument of our indefinite determiner D, leading to the following interpretation for the subject DP:

(92) $[\![\text{D}]\!]([\![t_1 \text{ DEG westfälische Studierende}]\!]^{g,c}) =$
$$\lambda P'.\ \exists x[\text{west}(x) \wedge \text{students}(x) \wedge \mu^c(x) \geq g(1) \wedge P'(x)]$$

This then composes with the rest of the vP, which denotes the predicate $\lambda x.\ \text{work-here}(x)$:

(93) $[\![\text{DP}]\!]^{g,c}([\![\text{arbeiten hier}]\!]) = 1$ iff
$$\exists x[\text{west}(x) \wedge \text{students}(x) \wedge \mu^c(x) \geq g(1) \wedge \text{work-here}(x)]$$

This proposition is true iff there is a plurality of Westphalian students whose cardinality is at least the degree assigned to index 1, and who works here. λ_1 then lambda-abstracts over index 1:

49

(94) $[\![\lambda_1 \text{ D } t_1 \text{ DEG westfälische Studierende arbeiten hier}]\!]$
$= \lambda d. \exists x[\text{west}(x) \wedge \text{students}(x) \wedge \mu^c(x) \geq d \wedge \text{work-here}(x)]$

As desired, this gives us a degree predicate true of a degree d iff at least d-many Westphalian students work here. As before, let us call this degree predicate D_{WS}.

Next we reach the node $\sim C$. Recall that this node has no direct compositional impact, but has the effect of setting the variable C to its sister's set of focus alternatives. As shown in (95), the alternative set is the set of all "versions" of (94) in which $[\![\text{westfälische}]\!]$ is replaced with some member of $[\![\text{westfälische}]\!]_f$:

(95) $C = \{\lambda d. \exists x[P(x) \wedge \text{students}(x) \wedge \mu^c(x) \geq d \wedge$
$\text{work-here}(x)] \mid P \in [\![\text{westfälische}]\!]_F]\!]_f\}$

As discussed above, assuming that $\lambda x. \top$ (or a similarly unrestrictive predicate, cf. fn. 25) is a member of $[\![\text{westfälische}]\!]_f$, then the following degree predicate will be a member of C, and (for reasons discussed previously) will be a superset of every other member of C:

(96) $\lambda d. \exists x[\text{students}(x) \wedge \mu^c(x) \geq d \wedge \text{work-here}(x)]$

This degree predicate, which again we refer to as D_{S}, is true of a degree d iff at least d-many students work here. Since D_{S} is a superset of every other member of C, it is thus the case that $\bigcup C = D_{\text{S}}$.

Next we move on to the composition of the measure NP. First, $[\![\text{DIS}]\!]$, defined in (97a), applies to C; the result is D_{S}.

(97) a. $[\![\text{DIS}]\!] = \lambda C. \bigcup C$
      b. $[\![\text{DIS}]\!](C) = \lambda d. \exists x[\text{students}(x) \wedge \mu^c(x) \geq d \wedge \text{work-here}(x)] = D_{\text{S}}$

The degree quantifier $[\![\text{Prozent}]\!]$ then takes as its arguments, in order, D_{S}, $[\![\text{dreißig}]\!]$, and D_{WS}. As we saw above, this leads to the desired truth conditions: namely, true iff (at least) thirty percent of the student workers here are Westphalian.

What happens if instead of putting focus only on *westfälische*, we put it on the whole substance NP, *westfälische Studierende*? Here we again derive the desired interpretation, which is that thirty percent of the employees are Westphalian students. The denotation up to and including lambda abstraction will be the same, and the result will again be D_{WS}, true of a degree d iff at least d-many Westphalian students work here. However, the set of focus alternatives will be different. More specifically, they will be as in (98a), which is equivalent to (98b):

(98) a. $\{\lambda d. \exists x[P(x) \wedge \mu^c(x) \geq d \wedge \text{work-here}(x)]$
$\mid P \in [\![\text{westfälische Studierende}]\!]_F]\!]_f\}$
      b. $\{\lambda d. \exists x[P(x) \wedge P'(x) \wedge \mu^c(x) \geq d \wedge \text{work-here}(x)]$
$\mid P \in [\![\text{westfälische}]\!]_F]\!]_f \wedge P' \in [\![\text{Studierende}]\!]_F]\!]_f\}$

We have already supposed that $\lambda x.\ \top$ (or something similarly non-restrictive, cf. fn. 25) is a member of $[\![[\text{westfälische}]_F]\!]_f$; let us suppose the same of $[\![[\text{Studierende}]_F]\!]_f$. In this case, the particular alternative in which $P = P' = \lambda x.\ \top$ will be (99a), equivalent to (99b):

(99)   a. $\lambda d.\ \exists x[\top \wedge \top \wedge \mu^c(x) \geq d \wedge \text{work-here}(x)]$
       b. $\lambda d.\ \exists x[\mu^c(x) \geq d \wedge \text{work-here}(x)]$

This degree predicate—call it D_{work}—is true of a degree d iff at least d-many individuals work here. Once again, this will be a superset of every other member of the set of alternatives, meaning that the grand disjunction—and thus the first argument of $[\![\text{Prozent}]\!]$—will be D_{work}. The interpretation of the sentence as a whole will thus be as follows:

(100) $[\![\text{Prozent}]\!](D_{\text{work}})(30)(D_{\text{WS}}) = 1$ iff
         $D_{\text{WS}} \subseteq D_{\text{work}} \wedge \max(D_{\text{WS}}) \geq 30\%[\max(D_{\text{work}})]$

We thus predict truth iff the set of degrees no greater than the cardinality of Westphalian student workers is a subset of the set of degrees no greater than the cardinality of total workers, and the maximal degree in the former is at least thirty percent of the maximal degree in the latter. In other words, thirty percent of the workers here are Westphalian students.

     Next, consider (74b), *Dreißig Kilo [rote]$_F$ Äpfel fielen* ('Thirty kilograms of red apples fell'), with focus only on *rote* ('red'). The structure for this sentence is as in (101):

(101)   [dreißig Kilo DIS C] $\sim C\ \lambda_1$ [$_{\text{DP}}$ D t_1 DEG [rote]$_F$ Äpfel] fielen

The interpretation up to and including lambda abstraction will thus be the following:

(102) $[\![\lambda_1$ [$_{\text{DP}}$ D t_1 DEG [rote]$_F$ Äpfel] fielen$]\!] =$
                        $\lambda d.\ \exists x[\text{red}(x) \wedge \text{apples}(x) \wedge \mu^c(x) \geq d \wedge \text{fell}(x)]$

The contextually determined measure function here is μ_{weight}; nothing up to this point requires this, but this is the only choice that will allow composition with $[\![\text{Kilo}]\!]$ later on. Thus, (102) is true of a degree of weight d iff some plurality of red apples weighing at least d fell. Call this degree predicate D_{RA}.

     We next compute the set C of focus alternatives. These will look like (103):

(103) $C = \{\lambda d.\ \exists x[P(x) \wedge \text{apples}(x) \wedge \mu^c(x) \geq d \wedge \text{fell}(x)] \mid P \in [\![[\text{rote}]_F]\!]_f\}$

Once again, if $\lambda x.\ \top$ is an alternative in $[\![[\text{rote}]_F]\!]_f$, then among the alternatives in C will be (104), which will also be a superset of every other alternative:

(104) $\lambda d.\ \exists x[\text{apples}(x) \wedge \mu^c(x) \geq d \wedge \text{fell}(x)]$

This predicate—call it D_A—is true of a weight degree d iff the plurality of apples that fell weighed at least D. The degree predicates are fed into $[\![\text{Kilo}]\!]$ along with the numeral, leading to the following interpretation:

(105) $[\![\text{Kilo}]\!](D_A)(30)(D_{RA}) = 1$ iff
        $D_{RA} \subseteq D_A \wedge \max(D_{RA}) \geq 30$ kg.

We thus predict truth iff the weight degrees no greater than the cumulative weight of fallen red apples are a subset of the weight degrees no greater than the cumulative weight of fallen apples (red or otherwise), and the maximal degree in the former is at least thirty kilograms. In other words, we predict truth if and only if thirty kilograms of red apples fell. Notice that we have also successfully derived the observation that genitive and juxtaposed measurement structures do not have distinct truth conditions when the measure noun is absolute.

And what happens if the focus is on *rote Äpfel* ('red apples'), rather than just *rote* ('red')? Once again, the denotation up to lambda abstraction is the same (D_{RA}), but the focus alternatives are different. In particular, they will be as in (106a), equivalent to (106b):

(106)   a. $\{\lambda d.\ \exists x[P(x) \wedge \mu^c(x) \geq d \wedge \text{fell}(x)] \mid P \in [\![[\text{rote Äpfel}]_F]\!]_f\}$
        b. $\{\lambda d.\ \exists x[P(x) \wedge P'(x) \wedge \mu^c(x) \geq d \wedge \text{fell}(x)]$
                                    $\mid P \in [\![[\text{rote}]_F]\!]_f \wedge P' \in [\![[\text{Äpfel}]_F]\!]_f\}$

Making the same assumptions as before, this time $\bigcup C$ will be the degree predicate in (107):

(107) $\lambda d.\ \exists x[\mu^c(x) \geq d \wedge \text{fell}(x)]$

(107) is true of a degree of weight d iff the cumulative weight of things that fell is at least d. Let us call this degree predicate D_{fell}.

The resulting denotation for the sentence as a whole will be as follows:

(108) $[\![\text{Kilo}]\!](D_A)(30)(D_{\text{fell}}) = 1$ iff
        $D_{RA} \subseteq D_{\text{fell}} \wedge \max(D_{RA}) \geq 30$ kg.

We thus predict truth iff the weight degrees no greater than the cumulative weight of fallen red apples is a subset of the weight degrees no greater than the cumulative weight of fallen things in general, and the maximum degree in the former is at least thirty kilograms. Therefore, we once again predict truth iff thirty kilograms of red apples fell: focus does not lead to any difference in truth conditions.

Before wrapping up, let's turn back to the issue of the Conservativity Hypothesis formulated in (5), repeated below:

(5)   **Conservativity Hypothesis (CH):** If a quantificational relation Q between two sets A and B is expressed within a clause S and there is a DP in S such

that both *Q* and *A*, but not *B* can be determined by the semantic content of the DP, then *Q* must be conservative.

Essentially, CH dictates that if a quantifier and its restrictor are DP-internal and the scope is external to that DP, the quantification must be conservative. But notice that among all of the quantificatiers in all of the structures utilized in our analysis, the only one that falls within the domain of this rule is the silent indefinite determiner, whose restrictor is the DP-internal measurement structure and whose scope is the rest of the *v*P. (Importantly, CH does not apply to the extracted measure NP in juxtaposed structures, since after QR this NP is no longer DP-internal.) The determiner's denotation is simply existential quantification, which is indeed conservative (cf. (2)). Thus, our analysis accords with the Conservativity Hypothesis.

In summary, we have provided a semantics for juxtaposed measurement structures that successfully derives the quantificational reversal phenomenon observed with proportional measure nouns. We have also accounted for the focus-sensitivity of proportional juxtaposed structures, as well as the fact that absolute juxtaposed structures don't seem to semantically differ from genitive structures, nor do they show focus-sensitivity effects. Conveniently, the analysis is also compatible with the Conservativity Hypothesis as formulated in (5).

5 Conclusion

In this paper, we have provided evidence that while genitive and juxtaposed measurement structures have identical truth-conditional interpretations with absolute measure nouns, they have differing interpretations with proportional measure nouns. More specifically, we have shown that genitive structures with proportional measure nouns have conservative interpretations, while the juxtaposed structures with the same measure nouns have seemingly non-conservative interpretations, an apparent exception to the famed Conservativity Hypothesis. We have argued that this semantic distinction is born from a structural distinction between genitive and juxtaposed structures: in the former, the substance DP is the complement to the measure noun, while in the latter the substance NP is adjoined to the measure NP, with the latter undergoing QR outside of the DP to a position along the clausal spine. We then provided a compositional semantics for both genitive and juxtaposed measurement structures that generates the right interpretations, correctly predicting a distinction in the case of proportional measure nouns (including focus-sensitivity in juxtaposed structures), with no such distinction with absolute measure nouns. This analysis also happened to be compatible with the version of the Conservativity Hypothesis formulated in (5).

As previously mentioned, Ahn & Sauerland (2017) note that non-conservative interpretations of proportional measurement structures can be observed in a wide

variety of languages. It is thus natural to wonder how well the analysis of German measurement structures in this paper extends to these other languages. This will require fine-grained analysis of the syntactic structure and semantic interpretation of measurement structures cross-linguistically, promising to generate important insights in the underexplored area of DP-internal syntax-semantics.

A   Corroborating judgments for proportional measurement structures

Informal judgment data indicate that the availability of non-conservative construals is not uniform across German dialects (see fn. 5 above). To corroborate that among Berlin speakers the core judgements are widely shared, we carried out a questionnaire study. The study used a forced-choice paradigm. Our study compared two conditions differentiated only by context: the conservative and the non-conservative context, both of which are illustrated in (109). In both contexts, participants were offered three sentences and the participants were instructed to mark the sentence that offers the best description of the context paragraph. They were asked to always mark exactly one sentence.

As (109) shows, the three alternatives offered belong to the following three target structures: the nominative juxtaposed structure, and the genitive structure both without and with a definite determiner. We constructed 24 items in total, with no fillers. We used pseudo-randomized lists, wherein both the order of items and the order of the three alternative target sentences varied.

(109)   **Non-Conservative Context:** *In Berlin, 60,000 people commute by bike. Of those, 15,000 are civil servants.*

Conservative Context: *In Berlin, there are 60,000 civil employees. 15,000 of them commute by bike.*

a. **Nom:** 25 Prozent Beamte   fahren mit dem Fahrrad zur Arbeit.
    25 percent servant.NOM go   with the   bike   to.the work

b. **Gen:** 25 Prozent Beamter   fahren mit dem Fahrrad zur Arbeit.
    25 percent servant.GEN go   with the   bike   to.the work

c. **Def:** 25 Prozent der   Beamten   fahren mit dem Fahrrad zur Arbeit.
    25 percent the.GEN Beamte.GEN go   with the   bike   to.the work

Twenty undergraduate students in Berlin participated in the study. Half of the participants received the list in the original order, the other half received it in the reverse order. The result is summarized in Figure 5. In the non-conservative contexts the sentence with juxtaposed structure is most frequently chosen, while in the conservative context that Definite genitive context is most frequently chosen. This
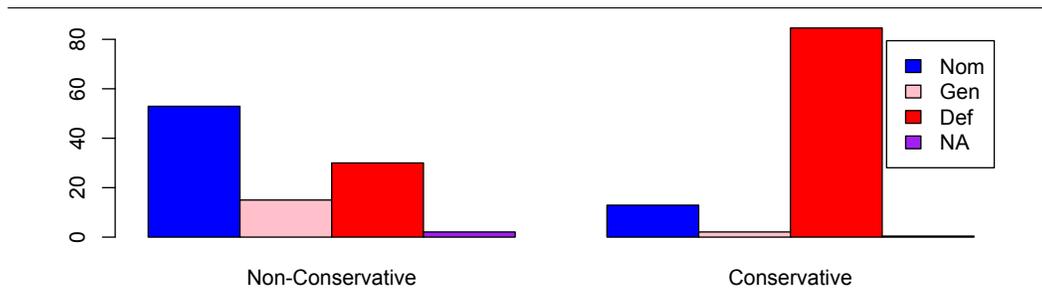
54

Figure 5   Result of sentence choice experiment in a non-conservative vs. conservative context in % of all responses.

result confirms our expectation that speakers prefer the juxtaposed structure with the non-conservative context and the genitive structure in the conservative context.

The results also indicate that the choice is less clear-cut in the non-conservative context, which may relate to greater speaker difficulty in understanding the non-conservative context, higher speaker uncertainty about the interpretation of the juxtaposed structure, or speaker variation. We leave it up to future research to investigate further which combination of these factors contribute to this result.

References

Abney, Steven P. 1987. *The English noun phrase in its sentential aspect*. Cambridge, MA: MIT PhD dissertation.

Ahn, Dorothy & Uli Sauerland. 2015. The grammar of relative measurement. In Sarah D'Antonio, Mary Moroney & Carol Rose Little (eds.), *Semantics and Linguistic Theory (SALT) 25*, 125–142. Ithaca, NY: CLC Publications, Cornell University.

Ahn, Dorothy & Uli Sauerland. 2017. Measure constructions with relative measures: Towards a syntax of non-conservative construals. *The Linguistic Review* 34(2). 215–248.

Alexiadou, Artemis. 2014. *Multiple Determiners and the Structure of DPs*. Amsterdam, The Netherlands: John Benjamins Publishing Company.

Alexiadou, Artemis, Liliane Haegeman & Melita Stavrou. 2007. *Noun Phrase in the Generative Perspective*. Berlin, Germany: Mouton de Gruyter.

Bale, Alan & David Barner. 2009. The interpretation of functional heads: Using comparatives to explore the mass/count distinction. *Journal of Semantics* 26(3). 217–252.

Barker, Chris. 1998. Partitives, double-genitives, and anti-uniqueness. *Natural Language & Linguistic Theory* 16(4). 679–717.

Barwise, Jon & Robin Cooper. 1981. Generalized quantifiers and natural language. *Linguistics and Philosophy* 4(2). 159–219.

Bayer, Josef. 1996. *Directionality and Logical Form*. Dordrecht, The Netherlands: Kluwer.

Bhatt, Rajesh & Roumyana Pancheva. 2004. Late merger of degree clauses. *Linguistic Inquiry* 35(1). 1–45.

Brasoveanu, Adrian. 2008. Measure noun polysemy and monotonicity: Evidence from Romanian pseudopartitives. In Anisa Schardl, Martin Walkow & Muhammad Abdurrahman (eds.), *Proceedings of NELS 38*, 139–150. Amherst, MA: Graduate Linguistic Student Association (GLSA), University of Massachusetts Amherst.

Carlson, Gregory N. 1977. *Reference to kinds in English*. Amherst, MA: University of Massachusetts Amherst PhD dissertation.

Champollion, Lucas. 2017. *Parts of a Whole: Distributivity as a Bridge Between Aspect and Measurement*. Oxford: Oxford University Press.

Champollion, Lucas & Manfred Krifka. to appear. Mereology. To appear in Paul Dekker and Maria Aloni (eds.), *Cambridge Handbook of Semantics*, Cambridge University Press. Draft cited from `lingbuzz/002099`.

Chierchia, Gennaro. 1998. Reference to kinds across languages. *Natural Language Semantics* 6(4). 339–405.

Corver, Norbert. 1998. Predicate movement in pseudopartitive constructions. In Artemis Alexiadou & Christopher Wilder (eds.), *Possessors, predicates and movement in the determiner phrase*, 215–257. Amsterdam, The Netherlands: John Benjamins.

Dudenredaktion. 2009. *Duden. Die Grammatik (vol. 4)*. Der Duden in Zwölf Bänden. Mannheim: Bibliographisches Institut/Brockhaus 8th edn.

Dudenredaktion. 2016. *Duden. Die Grammatik (vol. 4)*. Der Duden in Zwölf Bänden. Mannheim: Bibliographisches Institut/Brockhaus 9th edn.

Eschenbach, Carola. 1995. *Zählangaben–Maßangaben: Bedeutung und konzeptuelle Interpretation von Numeralia*. Wiesbaden, Germany: Deutscher Universitätsverlag.

von Fintel, Kai & Edward L. Keenan. 2018. Determiners, conservativity, witnesses. *Journal of Semantics* 35(1). 207–217.

von Fintel, Kai & Lisa Matthewson. 2008. Universals in semantics. *The Linguistic Review* 25(1–2). 139–201.

Fox, Danny & Roni Katzir. 2011. On the characterization of alternatives. *Natural Language Semantics* 19(1). 87–107.

Gajewski, Jon. 2008. More on quantifiers in comparative clauses. In Tova Friedman & Satoshi Ito (eds.), *Semantics and Linguistic Theory (SALT) 18*, 340–357. Ithaca, NY: CLC Publications, Cornell University.

Georgi, Doreen & Gereon Müller. 2010. Noun-phrase structure by reprojection. *Syntax* 13(1). 1–36.

Grestenberger, Laura. 2015. Number marking in German measure phrases and the structure of pseudo-partitives. *The Journal of Comparative Germanic Linguistics* 18(2). 93–138.

Heim, Irene & Angelika Kratzer. 1998. *Semantics in Generative Grammar*. Oxford, UK: Blackwell.

Henderson, Robert. 2017. Swarms: Spatiotemporal grouping across domains. *Natural Language & Linguistic Theory* 35(1). 161–203.

Ionin, Tania, Ora Matushansky & Eddy G. Ruys. 2006. Parts of speech: Toward a unified semantics for partitives. In Christopher Davis, Amy Rose Deal & Youri Zabbal (eds.), *Proceedings of NELS 36*, 357–370. Amherst, MA: Graduate Linguistic Student Association (GLSA), University of Massachusetts Amherst.

Jackendoff, Ray. 1977. *X-bar syntax: A study of phrase structure*. Cambridge, MA: MIT Press.

Keenan, Edward L. & Denis Paperno (eds.). 2012. *Handbook of Quantifiers in Natural Language*. Heidelberg, Germany: Springer.

Keenan, Edward L. & Jonathan Stavi. 1986. A semantic characterization of natural language determiners. *Linguistics and Philosophy* 9(3). 253–326.

Keizer, Evelien. 2007. *The English Noun Phrase: The Nature of Linguistic Categorization*. Cambridge, UK: Cambridge University Press.

Koptjevskaja-Tamm, Maria. 2001. 'A piece of the cake' and 'a cup of tea': Partitive and pseudo-partitive nominal constructions in the Circum-Baltic languages. In Östen Dahl & Maria Kotjevskaja-Tamm (eds.), *The Circum-Baltic Languages: Grammar and typology*, 523–568. Amsterdam, The Netherlands: John Benjamins.

Krifka, Manfred. 1989. Nominal reference, temporal constitution and quantification in event semantics. In Renate Bartsch, Johan van Benthem & Pever van Emde Boas (eds.), *Semantics and Contextual Expressions*, 75–116. Dordrecht: Foris.

Ladusaw, William A. 1982. Semantic constraints on the English partitive construction. In D.P. Flickinger, M. Macken & N. Wiegand (eds.), *Proceedings of WCCFL 1*, 231–242. Stanford, CA: Stanford Linguistics Association.

Link, Godehard. 1983. The logical analysis of plurals and mass terms. In R. Bäuerle, C. Shwarze & A. von Stechow (eds.), *Meaning, Use, and Interpretation of Language*, 302–323. Walter de Gruyter & Co.

Löbel, Elisabeth. 1986. *Apposition und Komposition in der Quantifizierung: Syntaktische, semantische und morphologische Aspekte quantifizierender Nomina im Deutschen*. Berlin: Walter de Gruyter.

Löbel, Elisabeth. 1990. D und Q als funktionale Kategorien in der Nominalphrase des Deutschen. *Linguistische Berichte* 127. 232–264.

Merchant, Jason. 1996. Object scrambling and quantifier float in German. In K. Kusumoto (ed.), *Proceedings of NELS 26*, 179–194. Amherst, MA: Graduate Linguistic Student Association (GLSA), University of Massachusetts Amherst.

Meyer, Marie-Christine & Uli Sauerland. 2009. A pragmatic constraint on ambiguity detection: A rejoinder to Büring and Hartmann and to Reis. *Natural Language & Linguistic Theory* 27(1). 139–150.

Ott, Dennis. 2012. *Local Instability: Split Topicalization and Quantifier Float in German*. Berlin, Germany: de Gruyter.

Ott, Dennis. 2015. Symmetric merge and local instability: Evidence from split topics. *Syntax* 18(2). 157–200.

Partee, Barbara H. & Vladimir Borschev. 2012. Sortal, relational, and functional interpretations of nouns and Russian container constructions. *Journal of Semantics* 29(4). 445–486.

Pasternak, Robert. 2019a. A lot of hatred and a ton of desire: intensity in the mereology of mental states. *Linguistics and Philosophy* 42(3). 267–316.

Pasternak, Robert. 2019b. Unifying partitive and adjective-modifying *percent*. *Snippets* 37. 77–79.

Pasternak, Robert. 2020. Compositional trace conversion. Leibniz-Center for General Linguistics (ZAS), Ms.

Romoli, Jacopo. 2015. A structural account of conservativity. *Semantics-Syntax Interface* 2(1). 28–57.

Rooth, Mats. 1985. *Association with focus*. Amherst, MA: University of Massachusetts Amherst PhD dissertation.

Rooth, Mats. 1992. A theory of focus interpretation. *Natural Language Semantics* 1(1). 75–116.

Rothstein, Susan. 2009. Individuating and measure readings of classifier constructions: Evidence from Modern Hebrew. *Brill's Journal of Afroasiatic Languages and Linguistics* 1(1). 106–145.

Sauerland, Uli. 2014a. Intermediate scalar implicatures. In S. Pistoia-Reda (ed.), *Pragmatics, Semantics and the Case of Scalar Implicatures*, 72–98. Basingstoke, UK: Palgrave Macmillan.

Sauerland, Uli. 2014b. Surface non-conservativity in German. In C. Piñón (ed.), *Empirical Issues in Syntax and Semantics 10*, 125–142. Paris, France: CSSP.

Schachtl, Stefanie. 1989. Morphological case and abstract case: Evidence from the German genitive construction. In *Syntactic Phrase Structure Phenomena in Noun Phrases and Sentences*, 99–112. Amsterdam, The Netherlands: John Benjamins.

Schwarzschild, Roger. 2006. The role of dimensions in the syntax of noun phrases. *Syntax* 9(1). 67–110.

Schwarzschild, Roger. 2008. The semantics of comparatives and other degree constructions. *Language and Linguistics Compass* 2(2). 308–331.

Scontras, Gregory. 2014. *The semantics of measurement*. Cambridge, MA: Harvard University PhD dissertation.

Scontras, Gregory. to appear. Measure phrases. To appear in *The Wiley Companion to Semantics*.

Selkirk, Lisa. 1977. Some remarks on noun phrase structure. In P. Culicover, T. Wasow & A. Akmajian (eds.), *Studies in Formal Syntax*, 285–316. New York, NY: Academic Press.

Solt, Stephanie. 2015. Q-adjectives and the semantics of quantity. *Journal of Semantics* 32(2). 221–273.

Spathas, Giorgos. 2019. Plural anaphoric reference and non-conservativity. *Snippets* 37. 95–96.

Spector, Benjamin. 2013. Bare numerals and scalar implicatures. *Language and Linguistics Compass* 7(5). 273–294.

Tănase-Dogaru, Mihaela. 2007. Pseudo-partitives and (silent) classifiers in Romanian. In Sylvia Blaho, Camelia Constantinescu & Erik Schoorlemmer (eds.), *Proceedings of ConSOLE XV*, 295–320. Leiden, The Netherlands: Leiden University.

van Riemsdijk, Henk. 1989. Movement and regeneration. In P. Beninca (ed.), *Dialect Variation and the Theory of Grammar*, 105–135. Dordrecht, The Netherlands: Foris.

van Riemsdijk, Henk. 1998. Categorial feature magnetism: The endocentricity and distribution of projection. *Journal of Comparative Germanic Linguistics* 2(1). 1–48.

Wellwood, Alexis. 2014. *Measuring predicates*. College Park, MD: University of Maryland PhD dissertation.

Zhang, Niina Ning. 2012. Projecting semantic features. *Studia Linguistica* 66(1). 58–74.

Zifonun, Gisela, Ludger Hoffmann & Bruno Strecker. 1997. *Grammatik der deutschen Sprache (3 volumes)*. Berlin: de Gruyter.

Zuber, Richard. 2004. A class of non-conservative determiners in Polish. *Lingvisticae Investigationes* 27(1). 147–165.

Uli Sauerland
Leibniz-Center for General Linguistics (ZAS)
Schützenstraße 18
10117 Berlin, Germany
uli@alum.mit.edu

Robert Pasternak
Leibniz-Center for General Linguistics (ZAS)
Schützenstraße 18
10117 Berlin, Germany
mail@robertpasternak.com