Two kinds of quantizers in DP
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1. Quantizers: Measure and quantity nouns

(1) a. Mary bought two *gallons* of wine. [measure noun]
b. Mary bought *a lot* of wine.[quantity noun]
c. Mary bought *a number* of bottles of wine. [quantity noun]

2. A puzzle

(2) Barry Bonds hit *a career-best 73 home runs.*

Three anomalies in (2)

1. There is a singular article *a* with plural head noun.

   (3) * A cars was/were stolen.

2. A nominal modifier occurs to the left of a cardinal number.

   (4) a. * There were early three flights that day.
   b. There were three early flights that day.

3. Semantically *career-best* is modifying not *home runs* but *73* or *73 home runs.* That is, the cardinal number is obligatory:

   (5) * Barry Bonds hit a career-best home runs.

(6) Barry Bonds hit a career-high (of) 73 home runs.

Core idea

1. The three anomalies can all be explained by the assumption that *73 home runs* is a measure phrase:
   A. The measure phrase is singular due to peculiar syntactic and semantic properties of measure phrases.

B. The cardinal number '73' may have modifiers to the left because it is part of a measure phrase and not functioning as a count adjective.

C. The adjective *career best* semantically requires a measure phrase and a measure phrase is semantically 'incomplete' without a cardinal number specifier.

2. There is a strong analogy between the function of measure phrases and the function of count adjectives (see Figure 1). They belong to a class of expressions we will call **quantizers** (Krifka, 1987).

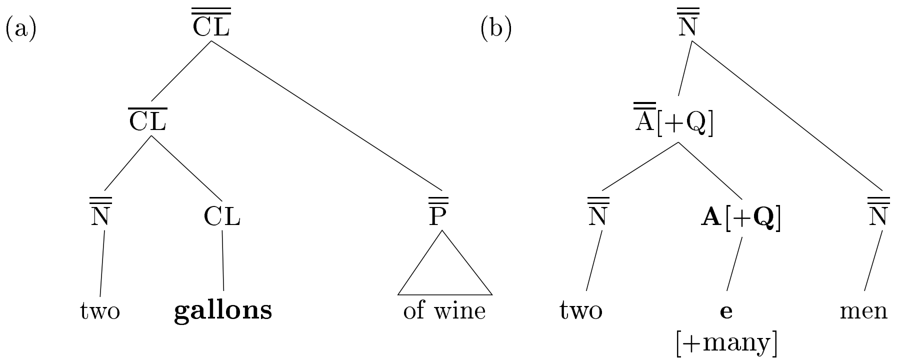


Figure 1. Syntacticized version of Krifka's incorporated classifier analysis: CL(classifier) = N[+F] or [+N,-V,+F]

Quantizers: The parallelism between count adjectives and measure phrases (Krifka, 1987**;** Nerbonne, 1995**) is syntacticized in Figure 1**

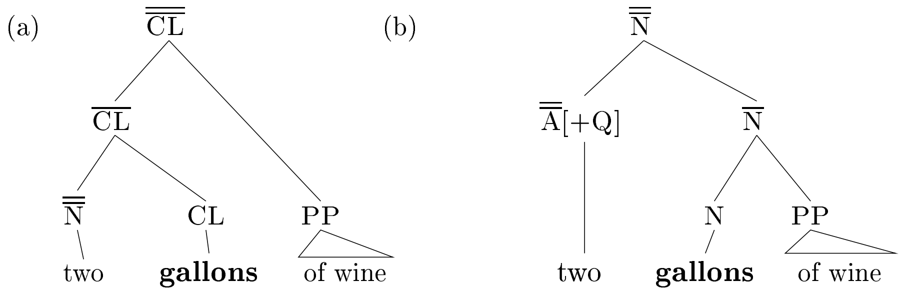
Definition of quantizers, adapted from Krifka (1987)

The predicate δ is **upward bounded** if and only if

$$\forall x[\delta(x) \rightarrow \exists y[\delta(y) \ \wedge \ \neg\delta(y \sqcup x)]\,]$$

The predicate δ is **downward bounded** if and only if

$$\forall x[\delta(x) \rightarrow \exists y[\delta(y) \ \wedge \ \neg\delta(y \sqcap x)]\,]$$



Measure specifier analysis

Count adjective analysis

Figure 2. Two analyses of measure constructions

Here, $\sqcap$ and $\sqcup$ schematize over meet and join in the plural lattices and the mass lattices.[1]

A predicate δ is *quantized* if and only if it is either upward bounded **or** downward bounded.

Examples:

1. *Three men* is quantized because if *three men'* is true of group w, then w is a group of three men and *three men'* is not true of any subgroups of w.
2. *At least three men* is quantized because there are groups w, such that *at least three men'* is true of w, and not true of any proper subgroups of w, namely groups of exactly three men.
3. *At most three men* is quantized because there are groups w, such that *at most three men'* is true of w, and not true of any proper supergroups of w, namely groups of exactly three men.
4. Arguments for *five gallons of milk*, *at most five gallons of milk*, and *at least five gallons of milk* are analogous.
5. These definitions work right only for lexically distributive predicates, which most common nouns are. If *men* is true

[1] Link (1983) introduced the idea of modeling the denotations of plurals by means of a join semi-lattice, a lattice based on a "join" operation ($\sqcup$ the group analogue of union on sets). Here we extend this to a "defective" lattice with a meet operation ($\sqcap$ analogous to set intersection), defining the meet of **a** and **b** as the group that is greatest lower bound of **a** and **b**, when this group exists. This leaves the meet undefined when **a** and **b** have no common members. The lattice is thus not complete.

of two groups, it is true is true of their subgroups and unions. However there are common nouns like *enemies* and *partners* which are inherently collective. Further work is needed to exclude these cases from the definition, but this will do as a first approximation.

Classifier-like quantity nouns: Another class of quantizers

(7) a. *A number of people* left.
b. *A herd of antelope* appeared.
c. *A lot of squeegees* were on loan.

Selkirk (1977) calls these Pseudopartitives

(8) $$\text{a lot of people}(g) \rightarrow \exists g'[\text{a lot of people}(g') \wedge \neg \text{a lot of people}(g \sqcap g')$$

(9) a. A number of men left.
b. * A number men left.
c. * Many of men left.
d. Many men left.

Pseudopartitives distinct from true partitives

(10) a. A number of the men left
a. Many of the men left

Examples

a bunch of examples, a lot of chocolates, a number of objections, a ton of applicants, a plethora of answers, a bouquet of flowers, a flight of steps, a group of children

1. Note that measure nouns may occur without number specifiers, but only with idiosyncratic meanings:

   (11) John drank gallons of milk. [$\neq$ some number of gallons, means a *lot* of gallons]

2. Note analogous facts for classifier nouns. Numbers involved in counting must be modified or specified in some way, either by being large or small, or being specific:

(12) a. John ate a number of bagels. [= many,a lot]
b. * John ate number of bagels.
c. * John ate numbers of bagels.
d. John ate that number of bagels. [$\neq$ a lot, necessarily]
e. John ate the same number of bagels Mary did. [$\neq$ a lot, necessarily]

Plan of the Talk

1. Syntactic and semantic arguments for structural features of the analysis Figure 2a.
2. Semantic motivations (following Krifka)
3. Extension of the measure phrase analysis to all quantizers
4. Consequences of analysis for examples like (2)
5. Quantizers versus Determiners in DP

3. Syntactic and Semantic Arguments

Salient differences between the analyses in Figure 2

1. In Figure 2a, the measure phrase *two gallons* is a constituent; in Figure 2b, it is not.
2. In Figure 2a, the PP *of wine* is embedded more shallowly than in Figure 2b,
3. In Figure 2a, the measure phrase *two gallons* is the head of the phrase. In Figure 2b, *gallons* is.
4. In Figure 2a, the measure phrase *two gallons* is functioning as a quantizer; in Figure 2b, it is not. Instead *two* is. (See the semantics in Figure 3).

3.1. Arguments that measure phrases are constituents

Plain old distributional argument: measure phrases throughout the grammar

(13) a. a lot of milk
b. a lot tougher
c. sixty yards of silk
d. sixty yards long
e. sixty yards from the goal line

Anaphora

(14) Fred may have drunk **two liters**$_i$ of beer, but Bill drank at least **that much**$_i$ wine.

Complex measures

(15) a. sixty feet six inches of high-quality silk
b. count adjective analysis: sixty feet six [inches of high-quality silk]
c. measure specifier analysis: [sixty feet six inches] of high-quality silk

Internal NP Agreement

(16) a. That five gallons of milk came in handy. (Singular *that* is a big surprise on the count adjective analysis in Figure 2b)
b. Those five gallons of milk came in handy.

When plural functional measure terms like *gallons* combine with quantizers (like *two*), they **select for** number but do not **agree** in number. Their inherent number remains distinct from the number they select for.

3.2. Arguments for shallow embedding of PP[of]

Selkirk (1977)

(17) a. [[A number] [of articles t]] soon appeared about Watergate.
b. ?? [Articles with [pictures t]] soon appeared of John.

3.3. Arguments that measure phrases are heads

External Agreement Facts: Akmajian, et al. (1977)**, Selkirk** (1977)

(18) a. The herd of large African elephants was larger than I thought.
b. The herd of large African elephants were stampeding toward us.(Akmajian and Lehrer, 1977)
c. A herd of elephants were stampeding, weren't *they*?
d. A herd of elephants was stampeding, wasn't *it*?

Selectional Facts (Akmajian and Lehrer, 1977)

(19) a. A bottle of wine spilled.[property of liquid]
b. A bottle of wine broke. [property of bottles]

3.4. Arguments that measure phrases and count nouns are quantizers

The paradigm cases of quantizers are cardinal numbers like *three* and cardinality adjectives like *many*. Here we argue for similarities between measure phrases and these quantizers.

Null $\overline{\mathrm{N}}$ s

(20) a. How many donuts did you eat yesterday?
b. I only ate three.

(21) a. How much did Sue eat yesterday?
b. # She ate a whole box.
c. She ate 1500 calories.

d. How much chocolate did Sue eat?
e. She ate a whole box.

Null-head Generalization

(22) Among nouns and adjectives, only quantizers can license null nominal-heads.

Weak and Strong readings

(23) a. The protesters in the square were 500 strong. When the police arrived, $\left\{\begin{array}{l}\text{SOME demonstrators}\\ \text{\# Sm demonstrators}\\ \text{\# a demonstrator}\\ \text{ONE demonstrator}\\ \text{many demonstrators}\\ \text{a number of demonstrators}\end{array}\right\}$ left. (Many more stayed.)

b. Not much happened last week. $\left\{\begin{array}{l}\text{\# SOME demonstrators were}\\ \text{Sm demonstrators were}\\ \text{A demonstrator was}\\ \text{\# ONE demonstrator was}\\ \text{Many demonstrators were}\\ \text{A number of demonstrators were}\end{array}\right\}$ arrested.

(24) a. (23a) provides a strong (partitive) reading context. Some demonstrators = Some of the demonstrators
b. (23b) provides a weak reading context: Some demonstrators $\neq$ Some of the demonstrators
c. Strong reading for *a number of demonstrators* quite unexpected if determiner is *a*, but parallels strong reading for *many demonstrators* if *a number of demonstrators* is a bare quantized $\overline{\overline{\text{N}}}$.

Mass and Count quantification paradigm

(25) a. How much milk did Sue drink?
b. Sue drank a lot of milk.
c. How many burgers did Sue eat?
d. Sue ate a number of burgers.

		$\overline{\overline{\mathrm{N}}}$	$\overline{\overline{\mathrm{A}}}$
Adjectival Determiner	(1)	how much milk	how much longer
	(2)	that much milk	that much longer
	(3)	a little milk	a little longer
Nominal Determiner	(4)	a little bit of milk	a little bit longer
	(5)	5 yards of silk	5 yards long
	(6)	a lot of silk	a lot taller

Generalization

When the **quantizer** is nominal, *of* is required. When the **quantizer** is adjectival (including cardinal numbers), it is not.

Count quantification paradigm

		Determiner		Nominal
(1)		a number	of	burgers
(2)	*	a number		burgers
(3)		many		burgers
(4)	*	many	of	burgers
(5)		a lot	of	burgers
(6)	*	a lot		burgers
(7)		a/one dozen		burgers
(8)	*	a/one dozen	of	burgers
(9)		dozens	of	burgers
(10)	*	dozens		burgers
(11)		hundreds	of	burgers
(12)	*	hundreds		burgers
(13)		a/one hundred		burgers
(14)	*	a/one hundred	of	burgers
(15)		a/one hundred and one		burgers
(16)	*	a/one hundred and one	of	burgers
(17)		a couple	of	burgers
(18)		a couple		burgers

4. Semantic Motivations for analysis

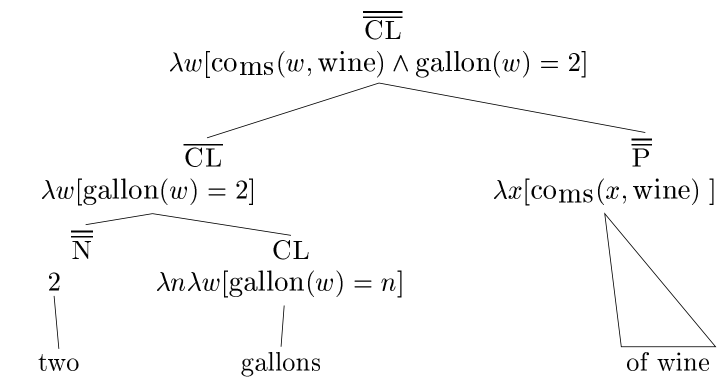


Figure 3. **Semantics for 2 gallons of wine** (Measure specifier analysis)

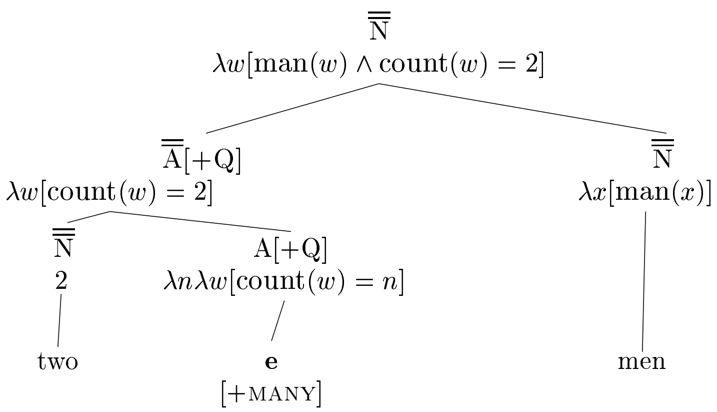


Figure 4. **Semantics for 2 men**

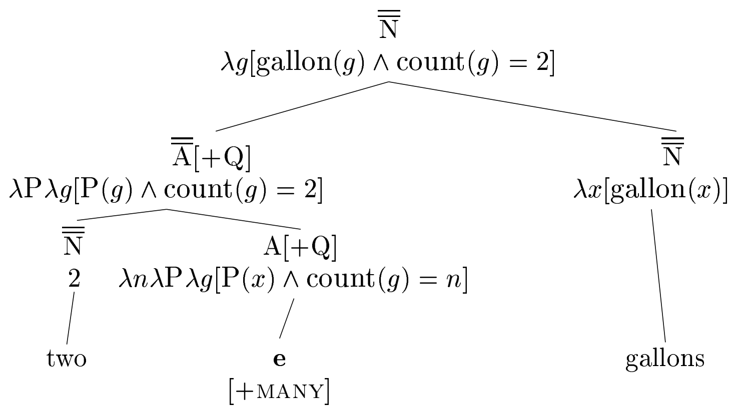


Figure 5. **Wrong analysis for measure phrase reading of 2 gallons**

(26) a. The relation $\mathrm{co}_{\mathrm{ms}}$ (*consists of*, mass version) is a meaning of the preposition *of*:

1. a rod of iron
2. a house of brick
3. a block of wood
4. The casing is made of fiberglass.

b. This analysis treats the *of*- phrase as a subcategorized-for PP argument of the measure noun, consistent with the view that case-marking prepositions have meanings redundant with the role meanings they mark.

a. The role is semantically obligatory. The null-head meaning of *five gallons* would be represented with a free property variable:

$$\lambda w[\ \mathrm{co}_{\mathrm{ms}}(w, \mathrm{P})\ \wedge \mathrm{gallon}(w) = 2]$$

(27) Note: In Figure 3, *two is not functioning as a count adjective.* It is just an argument of the head noun. In other words, *two gallons* is not built by a subtree like that in Figure 5.

The properties distinguishing measure nouns from other nouns

1. Their logical type ($\langle$ e, $\langle$ e, t $\rangle$ $\rangle$ versus $\langle$ e, t $\rangle$)
2. They take numerical "specifiers" lower in the tree than they take complements.

3. We assume these two facts are linked: Only after a measure noun combines with its numerical specifier is a phrase created that has the same type as other nouns. Therefore *two gallons* should have the same combinatorial possibilities as other nouns, including combining with noun complements.

Evidence for special type status of measure constructions

(28) a. an unbelievably bad two gallons of wine
  b. two unbelievably bad gallons of wine
  c. * a two unbelievably bad gallons of wine
  d. Two unbelievably bad gallons of wine were served.
  e. * Two unbelievably bad gallons of wine was served.
  f. An unbelievably bad two gallons of wine was served.
  g. ? An unbelievably bad two gallons of wine were served.
  h. a beautiful six weeks (Jackendoff (1977), citing Jespersen)

Account

1. Both the count adjective and the measure specifier structures in Figure 2 are possible.
2. In example (28a), the analysis of Figure 2a is required, *two* functions as a measure specifier and *two gallons* is unspecified for number, as is *unbelievably bad two gallons*.
3. In example (28b), the analysis of Figure 2b is required, *two* functions as a count adjective and *two unbelievably bad two gallons* is plural.
4. Thus (28c) is ruled out as a number agreement clash.

Contexts blocking the count adjective structure

(29) a. ? six beautiful feet six inches of wool
  b. a beautiful six feet six inches of wool

Measure Phrase contexts

(30) a. ? six unbelievable feet tall
  b. an unbelievable six feet tall

Semantics of count adjective analysis of *two gallons*

(31) $\lambda x[\mathrm{co}_{\mathrm{ct}}(x, \lambda w[\mathrm{gallon}(w) = 1]) \wedge \mathrm{count}(x) = 2]$

5. Extension of measure analysis to quantity nouns: $\overline{\text{D}}$ quantizers

(32) a. * The a number of men who escaped were never recaptured.
b. The many men who escaped were never recaptured.
c. * That a group of men were arrested.
d. That five gallons of wine was superb.

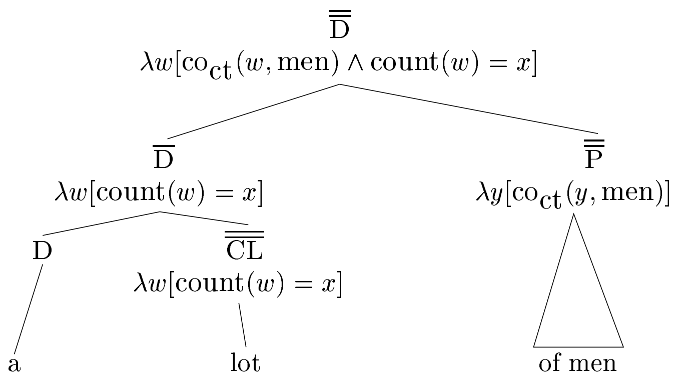


Figure 6. **Semantics for a lot of men**. Presupposition: $x \geq$ **many**

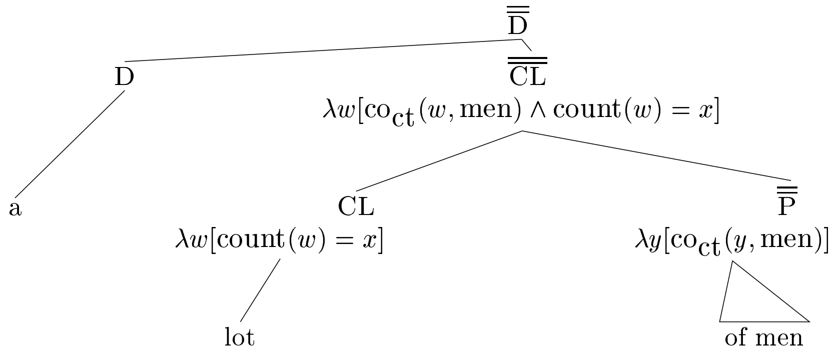


Figure 7. **Alternative analysis for a lot of men**. Presupposition: $x \geq$ **many**

Evidence for the analysis in Figure 6

(33) a. A lot of stories appeared about Watergate.
b. A group of stories appeared about Watergate.
c. * A lot of demonstrators was arrested. [external plural agreement, internal singuler]
d. a lot tougher [adjective specifier]
e. A lot of demonstrators were indicted. A lot were never charged. [Null-headed nominals]

Semantic evidence for the special status of *number*

(34) a. John's rather large number of objections (Jackendoff, 1977)
b. # A valuable number of glasses were broken.
c. An number of valuable glasses were broken.
d. A valuable group of glasses was broken.
e. A group of valuable glasses were broken.
c. John drank the same number of glasses Mary did.
c. # John drank the same five gallons of milk Mary did.

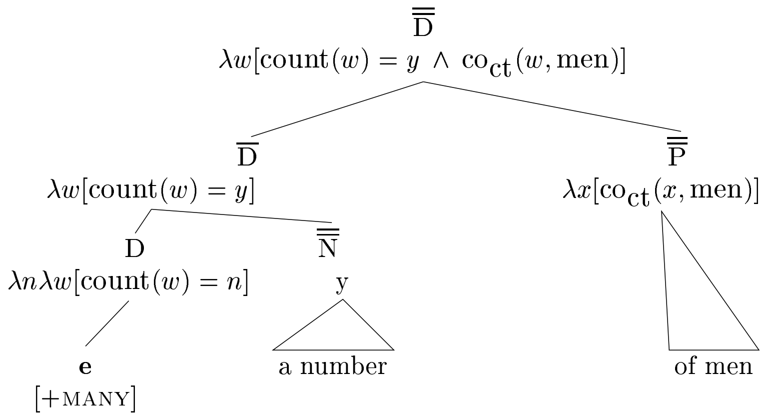


Figure 8. **Analysis for *a number of men*.** Assumes choice function treatment of indefinites (Winter 1987). Presupposition: y is a number and $y \geq$ many.

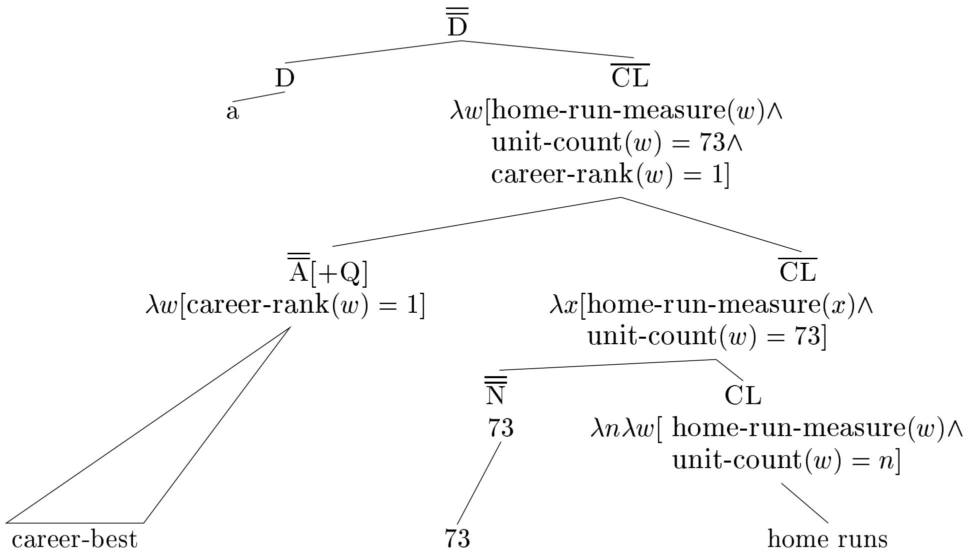


Figure 9. **Semantics for *a career best 73 home runs***

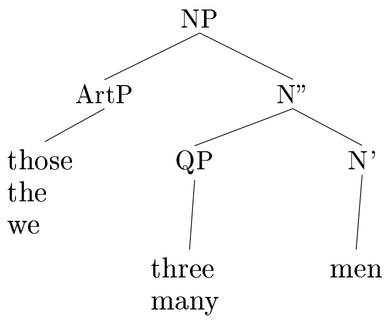


Figure 10. **Two layers of NP specifiers (Selkirk, Jackendoff)**

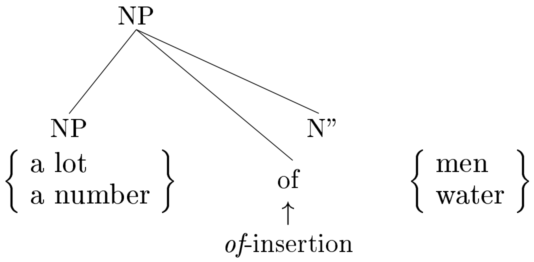


Figure 11. **Analysis of pseudopartitives (Selkirk, Jackendoff)**

7. Quantizers versus Determiners

(35)
$$\left.\begin{array}{l}\text{a. The}\\ \text{b. We}\\ \text{c. All}\\ \text{d. John's}\end{array}\right\}\ \text{three friends arrived together.}$$

7.1. Jackendoff-Selkirk Analysis

(36)
$$\begin{array}{lll} N''' \longrightarrow & \left\{\begin{array}{l} N[\text{genitive}]''' \\ Art''' \end{array}\right\} & N'' \\ N'' \longrightarrow & \left\{\begin{array}{l} N[\text{pseudopartitive}]''' \\ Q''' \end{array}\right\} & (A''')*\ N'' \end{array}$$

(37) A rule of *of*-insertion (deletion Bresnan (1973)) handles the placement of *of* in pseudopartitives (see Figure 11).

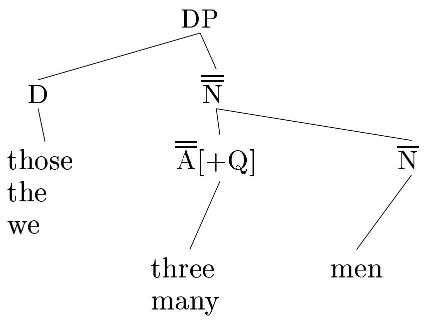


Figure 12. The DP Hypothesis provides two layers of NP specifiers

(38) (a) $\overline{\overline{\mathrm{D}}} \longrightarrow \overline{\mathrm{D}}$ ($\overline{\overline{\mathrm{P}}}$) pseudopartitives, partitives
(restrictor)

(b) $\overline{\mathrm{D}} \longrightarrow \mathrm{D}$ ($\overline{\overline{\mathrm{N}}}$)
(quantizer)
(restrictor)

Function	Type
Restrictor	$\langle$ e, t $\rangle$
Quantizer	$\langle$ e, t $\rangle$
G. Determiner	$\langle \langle$ e, t $\rangle, \langle \langle$ e, t $\rangle$, t $\rangle \rangle$
R. Determiner	$\langle$ e, $\langle$ e, t $\rangle \rangle$

8. Conclusion: Types of Quantizers

1. **Adjectival Quantizers**
   1. Number + A[+many] (obligatorily specified empty adjective)
   2. Quantity Adjectives: Bresnan's Q (1973); *many, much, more*[+cnt], *more*[+ms]
3. **Nominal Quantizers**
   1. **Measure Nouns**(obligatorily specified count nouns): Their unusual number agreement and distributional properties have been linked to their type: They take a number specifier in order to become relational nouns unspecified for number.
   2. **Quantity Nouns**: These are semantically separable into two types:

1. Those that denote groups or masses of stuff (*group*, *lot*) with quantity restrictions. These are nouns that are like classifiers.
2. Those that denote a quantity (*number*), which may be analyzed as determiner specifiers of an empty determiner.

9. Appendix: Measure Phrases

A hodge podge of topics connected iwth the analysis of measures.

A question that arises with regard to the treatment advocated here is what do we do with cases where measure phrases must denote measures:

(39) John ran six miles.

A reasonable answer is simply to use the meaning we have already assumed:

$$\text{ran}(\text{john},\ \lambda x[\text{miles}(x) = 6])$$

That is, we model measures as properties of stuff, in this case, a property of a path John took in his run.

Another more difficult example:

(40) This car fits six people

Here there is no entailment of the existence of six people. Ageain, we us the measure property:

$$\text{fit}(\text{this car},\ \lambda x[\text{people}(x) = 6])$$

In this case, the measure is a property of a car. Correspondingly, we need a meaning of *people* that gives a measure function measuring volume. Such coercions are a fascinating topic beyond the bounds of this brief survey. Here we just assume something has provided the right measure function.

Another question. Can measure functions really map directly from objects to numbers? The answer is certainly: not always. Attributes have to come in at some point. Thus one and the same coffee table can be 4 feet high and 2 feet deep. Thus, the *feet* function has to be able to return different numbers, depending on the attribute, so two different properties of stuff are involved:

$$\lambda x[\text{feet}(x, \text{height}) = 4]$$
$$\lambda x[\text{feet}(x, \text{depth}) = 2]$$

Obviously adjectives like *wide* and *deep* need to somehow bind the attribute specification of a measure phrase:

(41) a. This cabinet is 4 feet high.
b. $[\text{feet}(\text{this cabinet}, \text{height}) = 4]$

But this is a little unsatisfactory, because it's not clear what the semantics of the adjective contributes to this representation. We briefly defer resolution of this issue.

Now that we know about attributes, note that there also need to be conventional pragmatically available bindings of attribute when there is no adjective available to overtly specify the attribute, such as in pseudopartitives

(42) a. sixty feet of wool
b. $\lambda x[\text{feet}(x, \text{wool-measuring-attribute}) = 60 \ \wedge \ \text{co}_{ms}(x, \text{wool})]$

This also suggests revising the previous example:

(43) a. John ran six miles
b. ran(john, $\lambda x[\text{miles}(x, \text{travel-distance}) = 6]$)

Another question. Is this the right ontology? We seem to have given units first class status in this analysis. Aren't units properties of measures? That is, for

(44) a. This board is 12 inches long.
a. This board is one foot long.

Isn't the same measure implicated in both judgements?

We can think of units as measures of measures, and we can disabbreviate the analysis used thus far as follows:

$$\lambda x \exists \mu[\ \text{wool-measuring-attribute-measure}(x) = \mu \wedge$$
$$\text{feet}(\mu) = 60 \ \wedge \ \text{co}_{ms}(x, \text{wool})]$$

So we recast attributes as functions from stuff to measures and units as functions from measures to numbers.

This lets us say *12 inches* references the same measure as *one foot* and as a bonus gives us a natural treatment of measure adjectives like *deep*; *deep* can simply be a relation between individuals and measures:

$$\lambda\mu\lambda x[\,\mathrm{depth}(x) = \mu]$$

This leads to a view of measure phrases as serving two different functions:

1. They are properties of measures when the attribute isn't specified:

$$\lambda\mu[\,\mathrm{feet}(\mu) = 60]$$

2. They are properties of individuals when the attribute is specified:

$$\lambda x\exists\mu[\,\text{wool-measuring-attribute-measure}(x) = \mu\ \wedge\ \mathrm{feet}(\mu) = 60]$$

We have already seen examples of the first use.

The second is exemplified by degree specification of adjectives:

(45) a. This cabinet is 4 feet deep.
b. $\exists\mu[\,\mathrm{depth}(\text{this cabinet}) = \mu\ \wedge\ \mathrm{feet}(\mu) = 4]$

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