TESTING ONE, TWO, THREE:
THE SYNTAX AND SEMANTICS OF NUMERAL EXPRESSIONS

A Dissertation Outline Presented

by

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Dissertation Prospectus

Testing One, Two, Three:
The Syntax and Semantics of Numeral Expressions

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Numeral expressions in natural language are not well understood. While there has been research into the syntax and semantics of simplex numerals, primarily on cardinals and distributives, little else has been examined. Some key questions about numerals and their role in the grammar have been largely ignored in the literature; notable exceptions include Hurford (1987, 2003) and more recently Ionin and Matushansky (2004). These questions are outlined in (1).

(1) i. How are complex numerals built up from the simplex numerals? For instance, how is *three hundred and five* built up from *three*, *five*, and *hundred*?
ii. What is the internal structure of a numeral expression like *the three hundred and five books*?
iii. What is the semantics of the various types of numeral expressions, such as cardinals, ordinals, fractions, multiplicatives, and distributives, and their interrelationship?
iv. What is the role of numeral expressions comparatives and superlatives?

This dissertation proposes to extend the work on the syntax and semantics of numerals started in Zabbal (2005) and address the questions in (1). I will continue using data from English, French, Russian, Arabic, and Hebrew, and include data from several other languages, including Japanese (a classifier language) and Turkish (a number neutral language). The goal of this dissertation is to provide a unified semantic analysis of numeral expressions that explains their distribution and their function. I intend to focus principally on numeral expressions in the nominal domain, i.e., cardinals, ordinals, and fractions, and extend the analysis to the verbal domain for distributives and multiplicatives. A successful analysis should also be able to account for the distribution and function of numeral expressions in comparatives and superlatives.

I begin with the underlying assumption presented in (2).

(2) The linguistic expression of a mathematical number is a numeral devoid of any function other than counting. Within a phrase, a numeral is ascribed a specific semantic function, as a *cardinal*, *ordinal*, *fraction*, *multiplicative* or *distributive*, and the resulting phrase is a numeral expression reflecting that function. Regardless of its function, a numeral has the same internal syntax and semantics reflecting its mathematical origins. Its purpose in the grammar is simply to count: its function dictates what it counts and how.

This prospectus is divided into four sections. The first three sections are dedicated to the puzzles surrounding numeral expressions. In section 1, I discuss the syntactic puzzles that I addressed in Zabbal (2005) and will continue to address in my dissertation. Section 2 introduce the semantic puzzles that I will address. In section 3, I present data about the intrusion of numeral expressions in comparatives and superlatives. Section 4 offers a summary of the three competing accounts of numeral expressions.

1 Syntactic Requirements

A syntactic theory of numeral expressions needs to explain these three puzzles:

(3) i. the category of simplex and complex numerals
ii. the intrusion of case within complex numerals
iii. the syntactic position of numerals

In this section of the prospectus I present examples of each puzzle and provide my work towards a solution (Zabbal 2005).

1.1 Category

There are several theories on the market that make claims about the category of numerals, almost exclusively about cardinals (Jackendoff 1977, Selkirk 1977, Corbett 1978, Siegel 1980, Hopper and Thompson 1984, Hurford 1987, Giusti 1991, Ritter 1991, Zamparelli 1995, Li 1999, Gawron 2002, Ionin & Matushansky 2004, Zweig 2005). Traditional theories split into two perspectives. Some theories claim that, regardless of their internal complexity, numerals should be treated as syntactic atoms inserted under a functional head, NUM/Q (Ritter 1991, Giusti 1991, Zamparelli 1995). Other theories claim that numerals are phrasal NPs/APs in Spec-NUMP/QP (Jackendoff 1977, Selkirk 1977, Hurford 1987, Li 1999, Gawron 2002). There is no consensus as to whether numerals are adjectival or nominal, heads or phrases. The trend in research has been to restrict attention to the nominal domain and in particular to cardinals and measures with little work done on ordinals or fractions.

The most recent theory to make strong claims regarding the category of cardinals is Ionin and Matushansky (2004), who, following Jackendoff (1977), propose that cross-linguistically all simplex numerals are nouns. However, recent work (Zweig 2005, Zabbal 2005) suggests that the simplex numerals divide into two classes. One class of simplex numerals are the so-called *low numerals*, which correspond to low numbers and act as the multiplicand in a complex numeral, e.g., *seven* in *seven hundred*. These behave like adjectives. The other class of simplex numerals, the so-called *high numerals*, operate as the multiplier in a complex numeral, e.g., *hundred* in *seven hundred*, and behave like nouns.

Properties (4)-(8) illustrate some of the differences between these two numeral classes.

(4) *High Numerals can pluralize, Low numerals cannot*
a. John ate three
b. John ate a hundred
c. *John ate threes
d. John ate hundreds

(5) *Low Numerals can occur without a determiner, High Numerals cannot*
a. *John ate hundred eggs
b. *Hundred people gathered in the stadium
c. John ate three eggs
d. Three people gathered in the stadium

(6) *High Numerals can co-occur with the indefinite, Low Numerals cannot*
a. John ate a hundred eggs
b. A hundred people gathered in the stadium
c. *John ate a three eggs
d. *A three people gathered in the stadium

(7) *High and Low Numerals can co-occur with the definite determiner*
a. John ate the hundred eggs
b. The hundred people gathered in the stadium
c. John ate the three eggs
d. The three people gathered in the stadium

(8) *High Numerals can form iterative plurals (like measure nouns), Low Numerals cannot*
a. John bought hundreds and hundreds (and hundreds) of books
b. John bought liters and liters (and liters) of water
c. *John bought seven(s) and seven(s) of water

Moreover, in Zabbal (2005) I argue that complex numerals pattern like low numerals.

(9) *Complex numerals cannot…*

a.	inflect for the plural	**three hundreds*
b.	co-occur with an indefinite	**a three hundred*
c.	form a pseudo-partitive	**John bought three hundred of books*
d.	form an iterative plural	**John bought three hundred and three hundred of books*

Simplex and complex numerals also appear to distribute like adjectival quantifiers.

(10) *Simplex and complex numerals distribute like adjectival quantifiers*

I carried	(the) few (the) many (the) three hundred (*the) several a lot/number of *all/every/each/most	potatoes kilos of potatoes	into the kitchen

Cross-linguistic study is clearly needed to make a firmer claim about cardinals. While the hope is that a generalization might be made regarding cardinals across languages, this may not be the case. In contrast, ordinals seem to be clearly adjectival and fractions clearly nominal.

1.2 Case

Complex numerals such as *seven hundred and five* appear to be plainly compositional though the exact nature of their composition is under contention. Compositionality is one argument in favor of complex numerals having syntactic structure. Another argument relies on the observation that in certain case-marking languages, case patterns are observed numeral-internally. This is shown in (11) for Modern Standard Arabic and (12) for Russian, where each of these noun phrases are marked for nominative structural Case.

(11) Modern Standard Arabic

a.

ʔarbaʕ-at-**u**	rijaal-**in**
four-FS-**NOM**	men-**GEN**

'4 men'

b.

ʔarbaʕ-at-**u**	ʔaalaaf-**in**	wa-	xams-**u-**	miʔat-**in**	rajul-**in**
four-FS-**NOM**	thousands-**GEN**	and	five-**NOM**	hundred-**GEN**	man-**GEN**

'4500 men'

c.

ʔarbaʕ-**u**	miʔat-**i**	ʔalf-**in**	rajul-**in**
four-**NOM**	hundred-**GEN**	thousand-**GEN**	man-**GEN**

'400,000 men'

(12) Russian

pjat-	desjat	tysjač	šest-	sot	četyrnadcat	rublej
5-SG.**NOM**	10-SG.**GEN**	1000-PL.**GEN**	6-SG.**NOM**	100-PL.**GEN**	14-SG.**NOM**	roubles-PL.**GEN**

'50614 roubles'

The puzzle here is the intrusion of case within complex numerals, a puzzle that has received little attention (Hurdford 1987, 2003; Franks 1994; Ionin and Matushansky 2004; Zweig 2005; Zabbal 2005). Numeral-internal case patterns strongly suggest that complex numerals do have syntactic structure, whatever it might be. This raises questions about the constituency of complex numeral expressions and how the internal structure of complex numerals in turn effects composition.

There are two related puzzles that have to do with case:

The first of these puzzles is an extension of the aforementioned puzzle. In Russian, there are two numeral-internal case patterns. The first case pattern was given above in (11) and (12). The noun phrase is in a nominative structural case position, but both nominative and genitive case surface within the numeral. This pattern is called *local agreement* (Hurford 2003, 60). The second case pattern is illustrated in (13).

(13) Russian (Hurford 2003, 61)

pjati-	desjati	tysjačam	šesti-	stam	četyrnadcati	rubljam
5-SG.**DAT**	10-SG.**DAT**	1000-PL.**DAT**	6-SG.**DAT**	100-PL.**DAT**	14-SG.**DAT**	roubles-PL.**DAT**

'50614 roubles'

In (13), the noun phrase is in a dative structural case position and as a consequence the only case that surfaces in the numeral is dative case. This pattern is called *global agreement*. Numerals in

Russian exhibit global case agreement when the noun phrase is dative: every simplex numeral in the complex numeral surfaces with the dative case.

The second of case puzzle has to do with the case assigned to the noun that is being counted in a cardinal expression. In a non-numeral expression, if the noun phrase receives nominative case then the case is reflected on the head noun. However, in numeral expressions, the counted noun never surfaces with nominative case but instead it surfaces with genitive, accusative, paucal, or partitive case. Furthermore, the case that surfaces on the counted noun seems to be governed by the numeral, in particular, by the numerals immediately adjacent to it. The variation of the case assigned to the counted noun and the dependence of this case on the numeral is illustrated in (14) and (15) (taken from Ionin and Matushansky 2004).

(14) Russian

a. dva šagA
two-NOM step-PAUC
'two steps'

b. dvadcat' šagov
twenty-NOM step-GEN.PL
'twenty steps'

c. dvadcat' dva šagA
twenty-NOM two-NOM step-PAUC
'twenty-two steps'

The examples in (14) show that the case of *šag* 'step' depends on whether *dva* 'two' or *dvadcat'* 'twenty' precedes it. Similarly in (15), the case of päärni/pärnid 'child' depends on the numeral that follows, 1-6 or 7+, respectively.

(15) Inari Sami

a. kyehti / kulmâ / nel'i / vittâ / kuttâ päärni
two three four five six child-ACC.SG
'Two/three/four/five/six children'

b. čiččâm / kávci / ovce / love / ohtnubáloh / kyehtnubáloh / čyeti… pärnid
seven eight nine ten eleven twelve hundred child-PART.SG
'Seven/eight/nine/ten/eleven/twelve/one hundred children'

This case dependency poses a challenge to any theory that proposes additional structure between the rightmost numeral and the counted noun. This puzzle could be explained as a linearity effect at PF, as suggested in Zabbal (2005), but this seems highly stipulative.

1.3 Constituency and Position

Another puzzling aspect of numerals is their precise syntactic position in the noun phrase. There are two diagnostics that could potentially aid me here: nominal ellipsis and count/mass anaphora. The data in (16) seems to suggest at least a partial answer to this question.

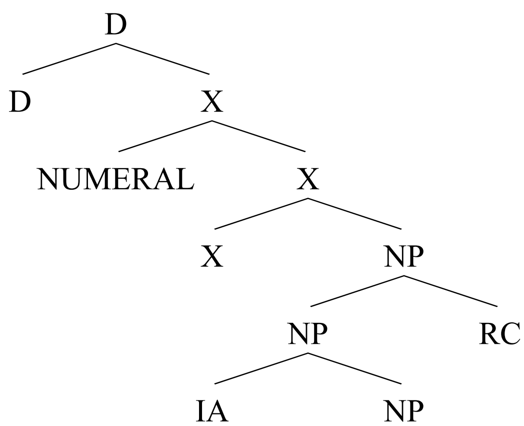
(16) a. Mary bought two dresses and Sue bought three Δ (Δ = dresses)
b. Mary bought two red dresses and Sue bought three Δ (Δ = red dresses)
c. *Mary bought a red dress and Sue bought a blue Δ (Δ = dress)
d. *Mary bought two red dresses and Sue bought three blue Δ (Δ = dresses)

While ellipsis is possible below the numeral in (16a,b), in English it is impossible to elide below the intersective adjective (16c,d). If we assume the intersective adjective is part of the phrase introducing the counted noun, then this suggests the numeral is above that phrase. The data in (17) (Ora Matushansky, personal communication) is less clear. It suggests that numerals attach above the relative clause.

(17) a. John bought three books that Mike wrote and Bob bought two Δ
(Δ = books that Mike wrote)
b. John bought three books that Mike wrote and Bob bought two Δ that Mary wrote
(Δ = books)

This suggests the structural representation in (18), in which ellipsis can target NP but nothing higher. My intention is to pursue this line of reasoning and see where it leads.

(18)



The remaining data deals with count and mass anaphora *that many*$_i$ and *that much*$_i$ (*that few*$_i$ and *that little*$_i$). It is meant to probe the constituency of numerals in the noun phrase and show that numerals have the same position as the so-called adjectival quantifiers *many/much* (*few/little*).

(19) *Count Anaphora*
a. John bought *three hundred*$_i$ marbles and Mary bought *that many*$_i$ chocolates
b. #John bought *three hundred*$_i$ marbles and Mary bought *those*$_i$ chocolates
c. *Four*$_i$ French diplomats visited *that many*$_i$ Russian ambassadors
d. #*Four*$_i$ French diplomats visited *those*$_i$ Russian ambassadors

The anaphor seems to be *that many* and not simply the demonstrative *that*. The role of *that* and *many* is unknown. While this evidence is inconclusive, I hope to develop this further as a probe for constituency. The data with mass anaphora is given in (20) and it shows that the measure phrase is closely bound to the numeral.

(20) *Mass Anaphora*

a. John drank [three]$_i$ pints of beer and Mary drank that many$_i$ glasses of wine
b. *John drank [three]$_i$ pints of beer and Mary drank that much$_i$ glasses of wine
c. John drank [three pints]$_i$ of beer and Mary drank that much$_i$ wine
d. *John drank [three pints]$_i$ of beer and Mary drank that many$_i$ wine
e. John drank [[three]$_i$ pints]$_j$ of beer, Mary drank that many$_i$ glasses of wine, Chuck drank that much$_j$ cider, and Bill ate that many$_i$ cheese doodles.

2. Semantic Puzzles

A compositional semantics for numeral expressions needs to consider these issues:

(21) i. The meaning of addition in complex numerals such as *three hundred <u>and</u> five*
ii. The meaning associated to the various semantic functions that a numeral expression might have; in particular, the meaning of ordinals and fractions and how this meaning composes with the rest of the noun phrase.

In this section of the prospectus I make precise each of these issues. It should be noted that these issues and the questions that arise out of them are far more open the syntactic puzzles mentioned above.

2.1 Addition in Complex Numerals

Complex numerals are built up from simplex numerals using two morphosyntactic structures, a structure reflecting multiplication and one reflecting addition. Subtraction, though available in certain languages, is cross-linguistically rare and every language with subtraction also expresses multiplication and addition. So a complex numeral like *two hundred and twenty* in the cardinal expression *two hundred and five books* is built up using one instance of multiplication in *two hundred* = 2 × 100, which has no overt morphological marker, and addition *two hundred and five* = 200 + 5, which is marked morphologically by *and*.

The status of this *and* is a complete mystery. It is clear that this *and* is neither a Boolean *and* nor a non-Boolean *and* (Krifka 1990). In Zabbal (2005), I treated it as altogether separate from the regular semantics and argued that this additive *and* is a representation of addition on the natural numbers. I claimed that this additive *and* was merely homophonous to Boolean and non-Boolean *and* in the ordinary language.

This issue needs further investigation. On the one hand, the solution presented in Zabbal (2005) is simple and provides a ready explanation for why additive *and* does not behave in the conventional sense. However, if typological evidence informs us that languages systematically mark addition with conjunction, there may be more to the story. As always, more data is needed.

Additive *and* has two interesting properties. It forces disjointness but does not allow for a distributive effect, contrary in both respects to the behavior of the conjunction *and* in English. If we consider the cardinal expression *two hundred and five books*, a plausible interpretation of its meaning as a coordinate structure would be *two hundred books and five books*. This is in fact proposed by Ionin and Matushansky (2004).

(22) $[\![\text{two hundred and five books}]\!]^{w,g}$

$= [\![\text{two hundred books}]\!]^{w,g} \oplus [\![\text{five books}]\!]^{w,g}$

$= \{ x = y \oplus z \mid y \in [\![\text{two hundred books}]\!]^{w,g} \wedge z \in [\![\text{five books}]\!]^{w,g} \wedge AT(y) \cap AT(z) \neq \varnothing \}$

A semantic requirement for this interpretation is that the two hundred books be disjoint from the five books so that we recover the meaning of two hundred and five different books. For cardinal expressions this disjointness always holds. This differs from the available split reading that noun phrases can sometimes receive (Heycock and Zamparelli 2003), illustrated in (23).

(23) His friends and colleagues came to the party
a. A set of people each of whom is his friend *and* his colleague came to the party
b. A set of people each of whom is his friend *or* his colleague came to the party

Another difference is that while a conjoined noun phrase can have a distributive reading, additive numerals lack a distributive reading altogether. (24) illustrates this difference. Coordinate *and* receives a disjoint distributive reading in (24a) but additive *and* clearly does not in (24b).

(24) a. Linguists and philosophers stormed the auditorium from the north entrance and the south entrance, respectively
= Linguists stormed the auditorium from the north entrance and philosophers stormed the auditorium from the south entrance
b. #Two hundred and twenty soldiers stormed the castle from the north road and the south road, respectively
≠ Two hundred soldiers stormed the castle from the north road and twenty soldiers stormed the castle from the south road

2.2 Semantic Function

Intuitively, the relationship between the numeral and the noun phrase in a numeral expression is one of counting or measuring. What is less clear is precisely what is being counted. This is not always transparent and need not be a direct counting of individual entities, even in the domain of what is conventionally called cardinality. For each type of numeral expression, there is a sense in which something is being counted. Ordinals for instance count the position in an ordered list, where the ordering seems to be presupposed. This ordering is clearly not a part of the meaning of a cardinal expression. Fractions count the cells that a unit has been partitioned into and they appear to behave much like measures. Multiplicatives are part of the verbal domain and count out events much like cardinals count out entities.

In my dissertation I will examine the semantics of these various types of numeral expressions in order to formalize the meaning of each type and also to search for an underlying relationship that goes beyond counting. It has been suggested (Ionin and Matushansky 2004) that cardinality is the primitive meaning from which the meaning of other the numeral expressions, e.g., ordinals, is derived.

A variety of examples of cardinal and ordinal meanings are presented in (25) and (26). In what follows, I limit my discussion to these numeral expressions and leave fractions, multiplicatives, and distributives of which I know little for future consideration.

(25) *Cardinals*

a. Sergeant York captured one hundred and thirty two enemy soldiers
b. John sampled three wines
c. Four thousand ships passed through the lock
d. Mary drank five pints of beer
e. The flood lasted forty days
f. Halley's comet passes every seventy-six years

Examples (25a-f) illustrate the uses of cardinal numerals. In (25a), the cardinal expresses the number of individual enemy soldiers. (25b) illustrates the counting of varieties of wine and not individual bottles of wine. At a wine tasting, there might be dozens of bottles of wine but only three kinds of wine. (25c) (Krifka 1990) illustrates event counting. The cardinal expresses the number of events in which a ship passed through the lock. The number of distinct ships is not at issue and the same ship may be counted multiple times if it passes through the lock more than once. In (25d), the cardinal expresses the measure of beer in pints that Mary consumed. It does not count dubious individuals like pint-entities. (25e) is an example of a cardinal that specifies the span of an interval of time. It measures the duration of the flood in units of days. In (25f), *every seventy-six years* refers to a set intervals, each one with a duration of *seventy-six years*. The sense here is that *every* is quantifying over a domain of intervals. The grammaticality of the sentence is also dependent on the quality of the predicate. The predicate *passes* is compatible with the distributive meaning contributed by *every*. From the perspective of cardinals and cardinal meaning, it is not clear that (25e) and (25f) have different semantics.

(26) *Ordinals*

a. The hundred and fifth candidate won a prize
b. Foul! There is a twelfth player on the football field
c. The Romans executed every tenth slave
d. Mary drank the fifth pint of beer in under a minute
e. Mary finished fourth

Examples (26a-e) illustrate the uses of ordinals. Each example assumes a salient ordering that is part of the ordinal meaning. (26a) assumes an ordering of candidates. The ordinal picks out the candidate who occupies the position 105 in this ordering. The candidates position in the order is specified, not the number of candidates. (26b) illustrates that the ordinal places an emphasis on the position in the ordering and not on the individual involved. In this example, the ordinal does not refer to a particular football player. In American football, only eleven players per team can be on the field during play. If a team has twelve or more players on the field during play, the team incurs a foul, called the twelfth man rule. No particular player is penalized. The team is held accountable for a twelfth man on the field. In (26c), the ordinal gets a sloppy reading. The quantifier *every* in *every tenth slave* ranges over a domain that includes slaves whose position in the ordering is a multiple of ten. (26d) combines the ordinal with a measure word. In contrast with the cardinal measure (26d), in this example the ordinal assumes that there is an ordering of single pints of beer and it picks out the pint that is fifth.

The example in (26e) should be addressed independently because here we see the ordinal used in the verbal domain. Again, it clearly assumes an ordering but it seems to assume an ordering on either events of finishing or on entities who finished.

3 Numerals and Degrees

Numeral expressions can intrude in comparatives and superlatives. When they do, they seem to either take the place of degrees (in the case of cardinals) or modify the degree expressed in the construction (in the case of ordinals and multiplicatives). My interest in the interaction between numerals and comparatives/superlatives has to do with the distribution of numerals. What is it about meaning of certain numeral expressions that allows them to intrude productively in these constructions? Examples are provided in (27) and (28).

(27) Comparatives
- a. John is heavier than Mary
- b. John is <u>twenty pounds</u> heavier than Mary (<u>give or take two pounds</u>)
- c. John ate more cookies than Mary
- d. John ate <u>three</u> more cookies than Mary
- e. John ate <u>three</u> cookies more than Mary

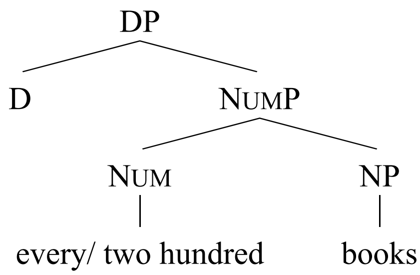
(28) Superlatives
- a. John is the fastest boy in the class
- b. John is the <u>third</u> fastest boy in the class
- c. John, Bill, and Mary are the smartest kids in the class
- d. John, Bill, and Mary are the <u>three</u> smartest kids in the class

As part of an investigation into the nature of cardinals and ordinals, a look at the interaction of numeral expressions with degree constructions might shed light into their semantics and into the relationship between cardinal expressions and degrees. In particular, a compositional analysis of this interaction could further our understanding of where numeral expressions fit in the syntax and subsequently compose in the semantics.

4 Competing Theories

Ritter (1991) proposes the structure in (29) for numerals in the noun phrase. The choice of this position is based on several coinciding observations revolving around a syntactic analysis of the Semitic Construct State (Borer 1999; Ritter 1988, 1991). Numerals in Hebrew and Arabic have a surface form and position like construct state nominals and they have the same distribution as certain quantifiers, like kol 'every', which also seem to enter in construct with adjacent nouns.

(29)



There are two important points to make here. First, this theory would require we treat numerals as morphological compounds situated in the functional head NUM. This proposal requires that complex numerals be analyzed as syntactic atoms and, consequently, it provides no insight into numeral-internal case patterns or the clearly compositional nature of complex numerals.

Nevertheless, there is evidence that the morphology has access to complex numerals. There are processes which nominalize numerals to the extent that (i) they refer without the presence of an overt or elided noun, as in (30a,b); (ii) they coincide with the indefinite, as in (30c); and (iii) they form compound-like modifiers with measure phrases, as in (30d).

(30)
a. There are four **twos** in this deck of cards and eight **Δ** in that one.
b. Two **threes** make **six**
c. He had a **twenty-seven** tattooed on his arm.
d. I purchased two hundred **85-pound** sacks of grain

Ionin and Matushansky (2004) focus on how to construct complex cardinals in the syntax so that they can be interpreted compositionally and so that the case internal to numerals is accounted for. Their account assumes that all numerals are nominal heads selecting a noun phrase complement. A summary of the syntax and semantics they propose is presented in (31).

(31) Ionin and Matushansky

Syntax. Cardinals are generated as nominal heads N^0 which take NP complements, to which they assign case. In a conjoined structure, the complement of each NP numeral expression right-node raises.

Semantics. Cardinals are modifiers of type ⟨et, et⟩, whose semantics is a straightforward application of partitions: $[\![n]\!] = \lambda P \in D_{\langle et \rangle} . \lambda x \in D_e . \exists S = \Pi(x) \, [\, |S| = n \wedge \forall s \in S.\, P(s) \,]$

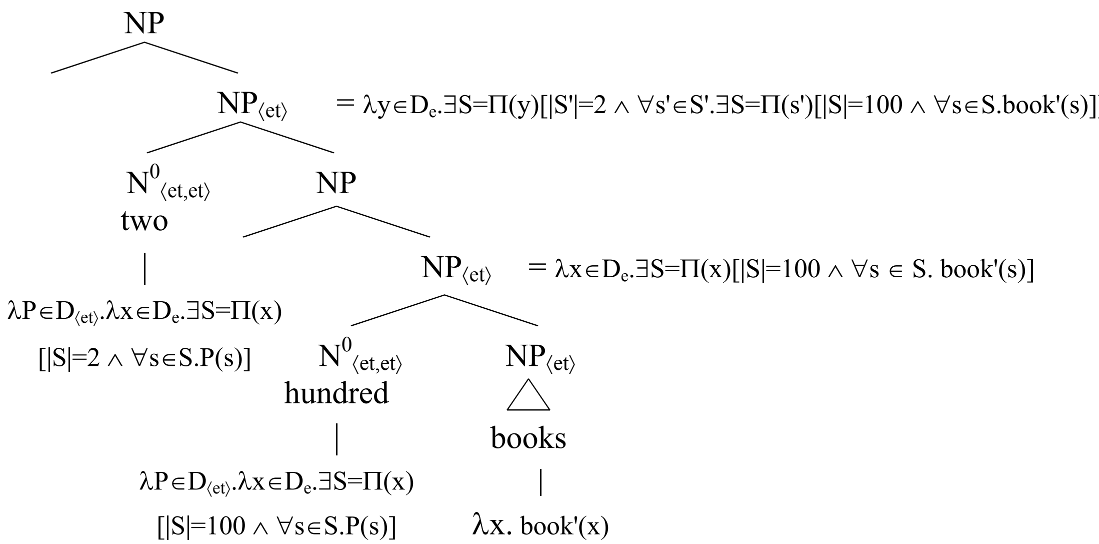
The partition $\Pi(X)$ is defined as a set of (possibly plural) individuals such that:

(i) $+\Pi(X) = X$ (cover)

(ii) $\forall z,y \in \Pi(X) \, [\, z=y \vee \neg\exists a \, [\, a \leq z \wedge a \leq y \,]\,]$ (disjoint)

The structure in (32) is an example of a multiplicative structure in this theory.

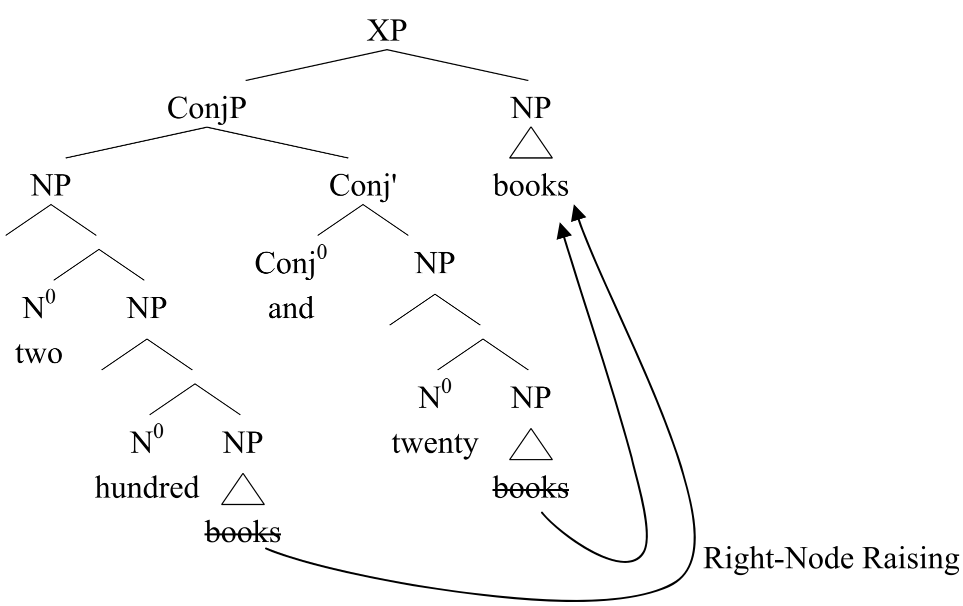
(32) Two hundred books



This structure is recursive. Each simplex numeral n is interpreted as the set of plural individuals such that each plural individual x can be partitioned into n sub-individuals $x_1,\ldots,x_n$. This directly encodes cardinality into the simplex numerals.

The additive structure is presented in (33). Here *two hundred books* is the same as in (32). The noun phrase *twenty books* has a similar structure. The two NPs are conjoined and the common NP *books* right-node raises outside the conjunction.

(33) Two hundred and twenty books



This account fails to describe the semantics of the conjunction *and* in the additive structure. The authors analyze this *and* as an instance of Link's (non-Boolean) sum formation operator ⊕ over two sets of plural individuals. The formal details are few. The denotation in (34) is mine and it is meant to describe what I believe their semantics must look like.

(34) $[\![\text{two hundred and twenty books}]\!]^{w,g}$
$= [\![\text{two hundred books}]\!]^{w,g} \oplus [\![\text{twenty books}]\!]^{w,g}$
$= \{ x = y \oplus z \mid y \in [\![\text{two hundred books}]\!]^{w,g} \wedge z \in [\![\text{twenty books}]\!]^{w,g} \wedge AT(y) \cap AT(z) \neq \varnothing \}$
$= \{ x = y \oplus z \mid y \in [\lambda y.\exists S{=}\Pi(y)\ [|S'|{=}2 \wedge \forall s' \in S'.\exists S{=}\Pi(s')\ [|S| = 100 \wedge \forall s \in S.book'(s)]]]$
$\wedge\ z \in [\lambda z.\exists S{=}\Pi(z)\ [|S| = 20 \wedge \forall s \in S.book'(s)]] \wedge AT(y) \cap AT(z) \neq \varnothing \}$

What (34) says is that the denotation of *two hundred and twenty books* is the set of individuals x such that each x is the sum of two non-intersecting plural individuals, y and z, where y is in the denotation of *two hundred books* and z is in the denotation of *twenty books*. It is necessary that the conjuncts do not intersect, i.e., that they do not share atomic parts, $AT(y) \cap AT(z) \neq \varnothing$. Otherwise the statement *John bought two hundred and twenty books* could be true in a model in which John bought two hundred and ten books. More precisely, if $x = y \oplus z$ denotes the sum of y and z and y and z have ten books in common, then the sum x will only contain 210 different individual books and not 220 different individual book. Clearly, this is unwanted.

To explain the disjoint meaning of the conjuncts, Ionin and Matushansky claim that this is the same disjoint reading obtained in a conjoined plural NP construction illustrated in (35) (Heycock and Zamparelli 2003).

(35) His friends and colleagues came to the party
a. A set of people each of whom is his friend *and* his colleague came to the party
b. A set of people each of whom is his friend *or* his colleague came to the party

Ionin and Matushansky claim that the *split* reading in (35b) is the one attributed to conjunction in complex numerals like *two hundred and twenty books*. In section 2, I showed that this type of an account is untenable.

The strength of this theory lies primarily in its ability to account for morphological case patterns that are dependent on the right-most numeral in a numeral expression, without stipulating further mechanisms in PF. The evidence from Russian and Inari Sami is repeated below.

(36) Russian
a. dva šagA
two-NOM step-PAUC
'two steps'
b. dvadcat' šagov
twenty-NOM step-GEN.PL
'twenty steps'
c. dvadcat' dva šagA
twenty-NOM two-NOM step-PAUC
'twenty-two steps'

(37) Inari Sami

a.

kyehti /	kulmâ /	nel'i /	vittâ /	kuttâ	päärni
two	three	four	five	six	child-ACC.SG

'Two/three/four/five/six children'

b.

čiččâm /	kávci /	ovce /	love /	ohtnubáloh /	kyehtnubáloh /	čyeti…	pärnid
seven	eight	nine	ten	eleven	twelve	hundred	child-PART.SG

'Seven/eight/nine/ten/eleven/twelve/one hundred children'

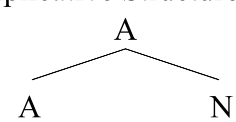
Ionin and Matushansky (2004) provide a straightforward account of this puzzle: the last numeral always selects the NP containing the counted noun so it governs the case of that noun phrase. In other words, case assignment works linearly in this theory.

I will use the analysis that I put forth in Zabbal (2005) as a starting point. This analysis is stated in three parts intended primarily to provide a syntax for cardinals and ordinals. The first part of the analysis describes how complex numerals are built up from simplex numerals.

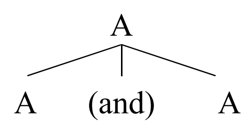
(38) Forming Complex Numerals

Syntax. Simplex numerals divide into two classes, *low numerals* and *high numerals*. The former are adjectival and the latter nominal. Complex numerals are built up in the syntax using the two structures illustrated below, representing multiplication and addition. The resulting complex numeral is also adjectival (cf. Hurford 1987, 2003; Zweig 2004).

a. Multiplicative Structure



b. Additive Structure



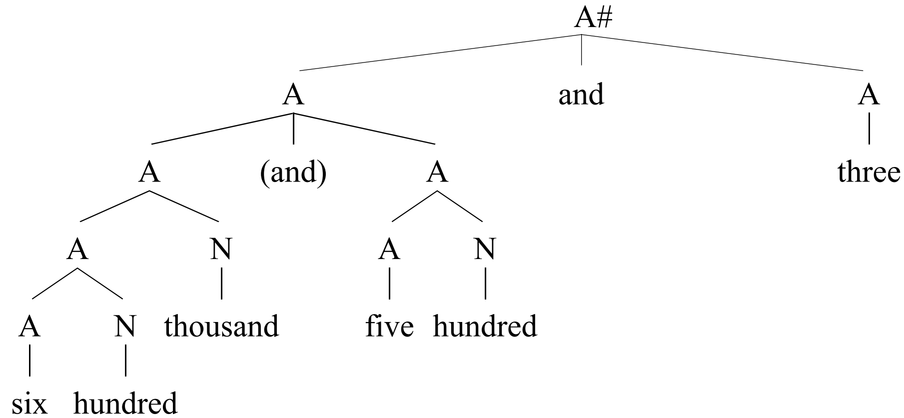
Semantics. Our formal language consists of four types s, e, t, and n, corresponding to the type of numerals. The semantics contains the domain $\mathscr{D}_n \subseteq \mathbb{N}$ on which the operations of multiplication $\cdot$ and addition + are naturally defined. Given a low numeral A and a high numeral N, where $[\![A]\!]^{w,g}, [\![N]\!]^{w,g} \in \mathscr{D}_n$, if $[\![A_1]\!]^{w,g} = x$, $[\![A_2]\!]^{w,g} = y$, and $[\![N]\!]^{w,g} = z$, then:

(i) $[\![A_1\ N]\!]^{w,g} = x \cdot y \in \mathscr{D}_n$

(ii) $[\![A_1\ (\text{and})\ A_2]\!]^{w,g} = x + z \in \mathscr{D}_n$

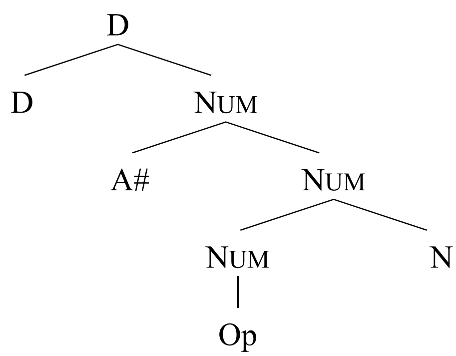
The *low numerals* include *one*, *two*, *three*, …., *ten*, and the *high numerals* include *hundred*, *thousand*, *million*, etc., i.e., the multipliers. Low and high numerals combine in multiplicative (38a) and additive structures (38b). An example is given in (39).

(39) six hundred thousand five hundred and two (600,503)



The second proposal describes the position of the numeral in the noun phrase and the locus of its semantics, the functional head NUM. Evidence for this projection is in Ritter (1988, 1991, 1992).

(40) <u>Locus of the Semantics</u>
Syntax. The functional head NUM merges with its noun phrase complement N and with a numeral specifier A#.



Semantics. The functional head NUM contains an overt or covert operator, which denotes a two-place relation and mediates the composition between the numeral A# and the noun phrase N. In other words, NUM is the locus for cardinal and ordinal interpretations.

These first two proposals describe what numerals are, how they are constructed in the syntax, where they are located in the noun phrase, and how they interact with the lexical noun N. The next and last proposal explains the internal case pattern of complex numerals, as well as why the lexical noun following the numeral never bears nominative case.

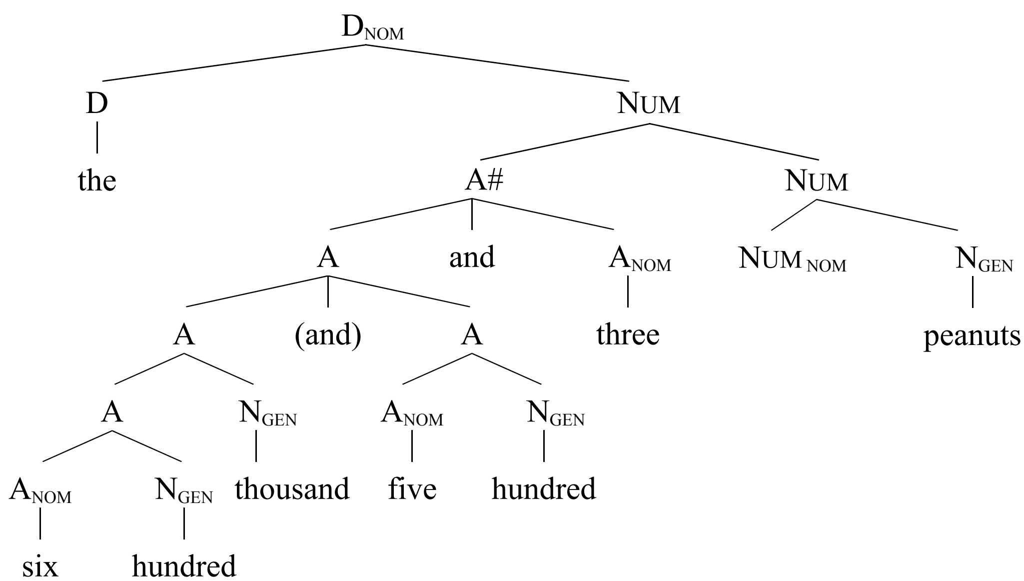
(41) <u>Case Agreement and Assignment</u>
Case. The structural case assigned to a noun phrase containing a numeral values the head of that noun phrase, NUM. There is spec-head agreement between the numeral A# and head NUM. Case agreement is morphologically realized on each terminal head A in A#. Each head A in A# assigns structural case to its complement N. NUM assigns structural case to its noun phrase complement N.

The structures associated with multiplication and addition in (38) are repeated below in (42) with case agreement (marked AGR) and case assignment (marked GEN) indicated on each node.

(42) a. Multiplicative Structure b. Additive Structure

In a structure like (39), the case that appears on each low numeral A is the product of spec-head agreement between the A# and the case-valued head Num. Low numerals assign genitive case to the high numeral N they select. To give an illustration of all three proposals at work, consider the noun phrase *the six hundred thousand five hundred and three peanuts*, presented in (43).

(43) The six hundred thousand five hundred and three peanuts



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