Linguistic Realization of Measuring and Counting in the Nominal Domain:

A Cross-linguistic Study of Syntactic and Semantic Variations

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This thesis investigates how the knowledge of number is linguistically implemented, on the basis of a wide range of cross-linguistic data. I concentrate on cardinals, ordinals and fractions. However, the discussion in the thesis will also have broader consequences for other modifying elements in the nominal domain such as adjectives, relative clauses, possessor phrases, classifiers, etc., because the numerical expressions discussed in the thesis will be intertwined with those modifiers in the nominal domain. The thesis will also draw broader conclusions regarding the syntax and semantics of the nominal domain more generally, from a broad crosslinguistic perspective.

In Chapter 2, I examine a number of properties of multiplicative complex cardinals like ***three hundred*** *books*. The starting point in the discussion in this chapter will be recent work by Ionin and Matushansky (2006, 2018), who argue that in a multiplicative complex cardinal like "three hundred", the multiplier ("three") and the multiplicand ("hundred") have the same syntactic and semantic properties. I will point out some problems for Ionin and Matushansky's (2018) analysis of multiplicative complex cardinals, and argue that multiplicands are syntactic heads used for measurement, whereas multipliers are phrasal constituents appearing in the specifier position of a phrase headed by the multiplicand.

Chapter 3 will investigate additive complex cardinals like ***twenty one*** *books*. Ionin and Matushansky (2018) argue that additive complex cardinals generally involve a coordinate structure. In this regard, I argue that there are two types of coordination structure for additive complex cardinals, building on Ionin and Matushansky's (2018) analysis of additive complex cardinals and the discussion in Chapter 2. I will also show that additive complex cardinals in some languages behave differently depending on the presence/absence of

an overt coordinator. All the crosslinguistic data that will be discussed in Chapter 3 can be accounted for by assuming a non-coordinate structure of additive complex cardinals, in addition to the coordinate structure.

Chapter 4 investigates the derivational patterns of ordinals like *the **seventh** book*, on the basis of results of a broad cross-linguistic survey. Based on an examination of strategies of forming ordinals in both classifier and non-classifier languages, a common property of ordinals will be identified: ordinals behave like nominal expressions. I will also examine possible and impossible constituent orders concerning ordinals, and show that ordinal markers display the same pattern as numeral classifiers regarding (im)possible constituent orders in combination with nouns and numerals. Building on this similarity, I propose that ordinal markers and numeral classifiers occur in the same position in the extended nominal projection.

Chapter 5 examines linguistic expressions of fractions like ***two thirds** of the book*. It will be shown that the numerator and the denominator can include a covert/overt "part" noun in fractions on the basis of a cross-linguistic survey. I will show that the existence of the "part" element is not expected under Ionin and Matushansky's (2018) analysis of fractions and provide an alternative analysis for the syntax and semantics of fractions. Building on the proposed analysis, I will also argue that some languages allow for two types of structures of fractions: the left-branching structure and the cascading structure.

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Future readers might find the analyses developed in this thesis are completely/partially wrong, based on something still unknown today. I am more than happy to see those criticisms because it is an essential aspect of scientific research. (To be honest, I may feel depressed.) There is, however, one thing I can say with confidence and without doubt: I have been helped by so many people. Although this thesis investigates linguistic realization of measuring and counting, I must confess that the number of people to whom I am grateful is more than I can count. I have always expressed my gratitude on the spot (usually with bowing), and I believe everyone understands my appreciation for their help.

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Contents

Chapter 1

Introduction

1.1 Linguistic realization of number

Hauser et al. (2002) argue that our faculty of language shares something in common with our capacity of number. One candidate for the shared property is "recursion" that generates a potentially infinite set of discrete products from a finite set of elements. For instance, Chomsky (2008) points out a connection between the syntactic operation Merge and the arithmetic definition of natural numbers, as in (1).

(1) Chomsky (2008: 139)

> Suppose that a language has the simplest possible lexicon: just one LI, call it "one." Application of Merge to the LI yields { one }, call it "two". Application of Merge to { one } yields { one, { one }}, call it "three." And so on. In effect, Merge applied in this manner yields the successor function. It is straightforward to define addition in terms of Merge(X, Y), and in familiar ways, the rest of arithmetic.

Linguistic realization of number is thus an important area where we can explore the nature of the Faculty of Language as well as our capacity of number. However, like in many

other scientific fields, there is no magic maneuver we can use here to directly see the the essence of what we want to understand. In the present thesis, I therefore concentrate on some numerical expressions that are commonly observed in the numeral system of human languages, as a first approximation to the core property shared by the Faculty of Language and our capacity of number.

The goal of this thesis is to give an answer to the question how the knowledge of number is linguistically implemented. The thesis examines the numerical expressions given in (2) on the basis of a wide range of cross-linguistic data, in order to determine what kind of hierarchical structure and semantic denotation is available for them cross-linguistically.

(2) a. Multiplicative Complex Cardinals

Juan invitó [***tres cientos*** *estudiantes*]. [Spanish]
Juan invited three hundred students
'Juan invited **three hundred** students.'

b. Additive Complex Cardinals

Ivan je vidio [***dvadeset i pet***] *studenata.* [Serbo-Croatian]
Ivan is seen twenty and five students.GEN.PL.M
'Ivan saw **twenty five** girls.'

c. Ordinal Numbers

Zhangsan du le [***di san***] *ben shu.* [Mandarin Chinese]
Zhangsan read ASP ORD three CLS book
'Zhangsan read the third book.'

d. Fractional Numbers

Ayaka-wa sono keeki no [***san-bun no ni***]*-o tabeta.* [Japanese]
Ayaka-TOP that cake GEN three-BUN GEN two-ACC ate
'Ayaka ate **two thirds** of the cake.'

I will provide the details of the numerical expressions given in (2) in the next section.

Before that, I will first clarify the terms used in the thesis. I distinguish the following types of numerical expressions.

(3) a. **Numbers**: mathematical/arithmetic concepts.
(E.g. 3 + 4 = **7**)

b. **Numerals**: linguistic expressions corresponding to numbers.
(E.g. *Three plus four is* ***seven***. or counting numbers *one, two, three, four, ...*)

c. **Cardinals**: numerals used to express the cardinality of sets.
(E.g. ***seven*** *books*)

d. **Ordinals**: numerals used to express an ordering property.
(E.g. *the* ***seventh*** *book*)

e. **Fractions**: numerals used to express some quantity of individuals based on a part-whole relation.
(E.g. ***two thirds*** *of the book*)

Throughout the thesis, I represent numbers using double quotes (e.g. "three"), distinguishing them from numerals, represented in italics (*three*). For instance, "three" is a number, but *three* is a numeral in English. I use double quotes for numbers because Arabic figures (e.g. 1, 2, 3, etc.) are used for numbering of chapters, sections, examples and footnotes.

I take it for granted that bare numerals are the most fundamental linguistic expression for numbers following (3). This thesis will give an answer to the question how cardinals, ordinals and fractions are derived from numerals linguistically.

The thesis concentrates on the numerical expressions given in (2). However, the discussion in the thesis will also have broader consequences for other modifying elements in the nominal domain such as adjectives, relative clauses, possessor phrases, classifiers, etc., because the numerical expressions discussed in the thesis will be intertwined with those modifiers in the nominal domain. The thesis will also draw broader conclusions regarding

the syntax and semantics of the nominal domain more generally, from a broad crosslinguistic perspective.

1.2 Organization of the thesis

In Chapter 2, I examine a number of properties of multiplicative complex cardinals like (4), in order to determine what kind of hierarchical structure is available for them.

(4) ***three hundred*** *books*

Multiplicative complex cardinals involve multiplication of numbers and consist of a multiplier and a multiplicand. In (4), *three* functions as a multiplier and *hundred* as a multiplicand.

The starting point in the discussion in this chapter will be recent work by Ionin and Matushansky (2006, 2018), who argue that in a multiplicative complex cardinal like "three hundred", the multiplier ("three") and the multiplicand ("hundred") have the same syntactic and semantic properties. I will point out some problems for Ionin and Matushansky's (2018) analysis of multiplicative complex cardinals, and pursue a hypothesis that multipliers and multiplicands are different both in the syntax and in the semantics. Specifically, I argue that multiplicands are syntactic heads used for measurement, whereas multipliers are phrasal constituents appearing in the specifier position of a phrase headed by the multiplicand. Furthermore, I show that multiplicands behave like measure words and numeral classifiers in several respects and that the presence of a multiplicand is sufficient for measurement in some classifier languages. I also examine typological variation regarding co-occurrence of multiplicands and numeral classifiers and argue that the variation can be captured under the analysis I argue for, where multiplicative complex cardinals can contain the silent *number* in some languages.

Building on the analysis proposed in Chapter 2, Chapter 3 will investigate additive complex cardinals like (5). This type of complex cardinals involves addition of numbers, as in (5). They may include an overt coordinator.

(5) a. ***twenty one*** *books* [English]

b. *Ivan je vidio* [***dvadeset i pet***] *studenata.* [Serbo-Croatian]
Ivan is seen twenty and five students.GEN.PL.M
'Ivan saw **twenty five** girls.'

Ionin and Matushansky (2018) argue that additive complex cardinals in general always involve a coordinate structure. In this regard, I argue that there are two types of coordination structure for additive complex cardinals, building on Ionin and Matushansky's (2018) analysis of additive complex cardinals and the discussion in Chapter 2. One is the coordination phrase where each conjunct is a noun phrase headed by the main noun. The other is the coordination phrase where each conjunct is a numerical phrase of type n. However, while Ionin and Matushansky (2018) argue that additive complex cardinals always have a coordinate structure, I argue that additive complex cardinals can also have a non-coordinate structure, which does not include the coordination head.

Furthermore, I will show that additive complex cardinals in some languages behave differently depending on the presence/absence of an overt coordinator, a pattern that is not expected under Ionin and Matushansky's analysis. I will show that all the crosslinguistic data that will be discussed in Chapter 3 can be accounted for by assuming a non-coordinate structure of additive complex cardinals, in addition to the coordinate structure.

Chapter 4 investigates the derivational patterns of ordinals as in (6) on the basis of results of a broad cross-linguistic survey spanning 92 languages.

(6) a. *the **seventh** book* [English]

b. *Zhangsan du le* [***di san***] *ben shu.* [Mandarin Chinese]
Zhangsan read ASP ORD three CLS book
'Zhangsan read the third book.'

Based on an examination of strategies of forming ordinals in both classifier and non-classifier languages, a common property of ordinals will be identified: ordinals behave like nominal expressions. I will suggest that an overt/covert element meaning 'number', which is also assumed in the analysis of multiplicative/additive complex cardinals, can be the source of the noun-hood of ordinals. I will also examine possible and impossible constituent orders concerning ordinals, and show that ordinal markers display the same pattern as numeral classifiers regarding (im)possible constituent orders in combination with nouns and numerals. Building on this similarity, I propose that ordinal markers and numeral classifiers occur in the same position in the extended nominal projection. This is another source of the noun-hood of ordinals. I will further argue that ordinals and cardinals can be derived from numerals in a similar fashion.

Chapter 5 examines linguistic expressions of fractions like (7). Cross-linguistically, fractions consist of a numerator and a denominator. In (7), *two* functions as a numerator and *thirds* as a denominator.

(7) ***two thirds** of the book*

It will be shown in this chapter that the numerator and the denominator can include a covert/overt "part" noun in fractions on the basis of a cross-linguistic survey. Based on the observation, I will show that the existence of the "part" element is not expected under Ionin and Matushansky's (2018) analysis of fractions and provide an alternative analysis for the syntax and semantics of fractions. Building on the proposed analysis, I further argue that Japanese uses the overt "part" noun *bun* in fractions. However, in some classifier languages

such as Burmese, Garo, Mokilese, etc, the existence of the "part" noun is marked only by an appropriate numeral classifier.

All in all, the results of the investigations carried out in the thesis suggest that bare numerals essentially obtain different functions such as multiplicative complex cardinals, additive complex cardinals, ordinals and fractions, by means of the following elements.

(8) a. The overt/covert nominal elements meaning 'number' (Ch.2, 3 & 4) and 'part' (Ch.5).

b. Syntactic heads used for measurement where numeral classifiers, multiplicands and ordinal markers appear.

Regarding the overt/covert nominal elements, I propose in Chapter 2 that multiplicative complex cardinals can contain the silent *number* in some languages. Also, Chapter 4 shows that some languages make use of the overt "number" noun to form ordinals. As will be discussed in Chapter 5, the "part" noun in fractions is also indispensable for numerals to function as the numerator and the denominator.

In addition to the overt/covert nominal elements, numerals also need some syntactic heads used for measurement, in order to obtain different functions. In Chapter 2, I propose that multiplicands are syntactic heads used for measurement, similarly to numeral classifiers. Chapter 4 also argues that ordinal markers are syntactic heads which occur in the same position as numeral classifiers in the extended nominal projection. These syntactic heads thus also play an important role in the different linguistic realizations of numbers.

There are still other issues that need to be investigated regarding linguistic realizations of numbers, such as the syntax and the semantics of "zero", approximative numbers, numerical expressions in time, days, months, years, etc, which will be left for future research. At any rate, it is my hope that this thesis provides an avenue to the nature of the Faculty of Language and our capacity of number.

Chapter 2

Multiplicative complex cardinals

2.1 Introduction

In this chapter, I examine a number of properties of multiplicative complex cardinals like (1), in order to determine what kind of hierarchical structure is available for them.

(1) a. *Ivan je pozvao* [***tri*** ***stotine*** *studenata*]. [Serbo-Croatian]
Ivan is invited three hundred.ACC.F student.GEN.PL.M
'Ivan invited [three hundred students].'

b. *Juan invitó* [***tres*** ***cientos*** *estudiantes*]. [Spanish]
Juan invited three hundred students
'Juan invited [three hundred students].'

c. *Taro-ga* [***san*** ***byaku***]*-nin no gakusei*]*-o syootai-sita.* [Japanese]
Taro-NOM three hundred-CLS GEN student-ACC invitation-did
'Taro invited [three hundred students].'

d. *Taro-ga* [*gakusei* ***san*** ***byaku***]*-nin-o syootai-sita.* [Japanese]
Taro-NOM student three hundred-CLS-ACC invitation-did
'Taro invited [three hundred students].'

In many languages, multiplicative complex cardinals such as "three hundred" consist of a multiplier and a multiplicand (Hurford (1975), Greenberg (1978)). The numeral "three" functions as a multiplier and "hundred" as a multiplicand in the examples above.[1] In Serbo-Croatian and Spanish, the main noun follows a multiplicative complex cardinal. Japanese is an obligatory classifier languages and cardinals are generally followed by a numeral classifier. Numeral classifier phrases can precede the main noun as in (1c) or follow it as in (1d). In this thesis, I refer to a noun modified by a numerical expression as "the main noun", regardless of whether a cardinal follows or precedes it, as illustrated in (2).

(2) *Multiplicative complex cardinals*

THREE	HUNDRED	STUDENT	[Order irrelevant]
Multiplier	Multiplicand	Main Noun	

The starting point in the discussion will be recent work by Ionin and Matushansky (2006, 2018), who show that multiplicative complex cardinals are not primitive units without complex structure. They also argue that in a multiplicative complex cardinal like "three hundred", the multiplier ("three") and the multiplicand ("hundred") have the same syntactic and semantic properties appearing in two types of syntactic structure, as will be discussed in the next section. In this chapter, I will point out some problems for Ionin and Matushansky's (2018) (henceforth I&M) analysis, arguing that the multiplier and the multiplicand are different syntactically and semantically, and propose a new analysis which preserves the spirit of I&M's analysis that multiplicative complex cardinals can in principle have two structures cross-linguistically. Specifically, I argue that in multiplicative complex cardinals, a multiplicand is a syntactic head used for measurement and a multiplier is a phrase appearing in the specifier position of the phrase headed by the multiplicand. Furthermore, I will

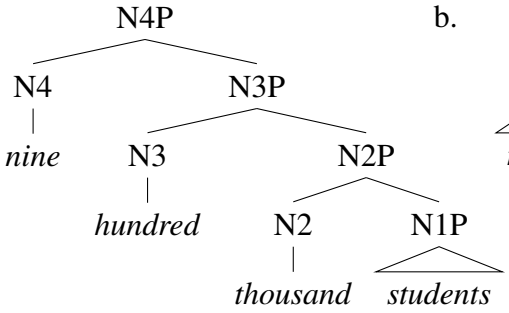
1. In this thesis, I use double quotation marks for number concepts and italics for numerical expressions. For instance, *three* denotes "three" in English. I use double quotes for number concepts because Arabic figures (e.g. 1, 2, 3, etc.) are used for numbering of chapters, sections, examples and footnotes.

show that multiplicands, measure words and numeral classifiers, all of which are syntactic heads used for measurement, behave alike in a number of respects.

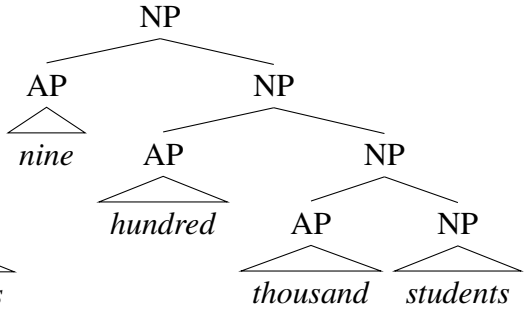
2.2 Ionin and Matushansky 2018

Ionin and Matushansky (2018) (henceforth I&M) propose that cardinals can in principle be case-assigning N heads or agreeing AP adjuncts, as in (3).

(3) a.



b.



If cardinals behave like nominals in a given language, the cardinals are analyzed as heads. When cardinals behave like adjectives in the sense that they agree with the main noun for gender, number and/or case, they are analyzed as phrasal adjuncts.

For them, adjectival cardinals are needed to capture the fact that some lower cardinals cross-linguistically behave like adjectives, exhibiting agreement with the noun. Ionin and Matushansky (2018: 54) assume that "nouns enter the derivation with their own set of ϕ-features and as a result cannot show agreement for gender." Given this assumption, the numeral "one" in (4), for instance, cannot be analyzed as a noun head because "had it been a noun, it wouldn't have shown agreement in gender" (Ionin and Matushansky (2018: 54)).

(4) *pro* *odnu* *stranu* [Russian]
about one.F.ACC country.ACC
'about one country' [Ionin and Matushansky (2018)]

What is important is that in their cascading structure in (3), multipliers and multiplicands

independently modify a noun phrase, and hence there is no single syntactic constituent that directly corresponds to a multiplicative complex cardinal. The meaning of a multiplicative complex cardinal is a derivative of the compositional semantics of a multiplier and a multiplicand under their analysis.

It should be noted that I&M do not explicitly discuss whether cardinals in (3) are heads or phrases in languages where adjectives do not show agreement, such as English. I will elaborate on this, arguing that multipliers are phrases whereas multiplicands are heads cross-linguistically.

With regard to semantics, Ionin and Matushansky (2006, 2018) propose that simplex cardinals are of type <<e,t>,<e,t>>, like property-denoting modifiers. The denotations of *three* and *hundred* are given in (5). As shown in (5), the only difference between *three* and *hundred* is the cardinality of S under their analysis.

(5) a. $[\![\textit{three}]\!] = \lambda P_{<e,t>} . \lambda x_e . \exists S_{<e,t>} . [\Pi(S)(x) \wedge |S| = 3 \wedge \forall s \in S . [P(s)]]$

b. $[\![\textit{hundred}]\!] = \lambda P_{<e,t>} . \lambda x_e . \exists S_{<e,t>} . [\Pi(S)(x) \wedge |S| = 100 \wedge \forall s \in S . [P(s)]]$

In (5), S is a cover of a plural individual x (Higginbotham (1981), Schwarzschild (1994)). S is a cover of x if x is the sum of all members of S (i.e. $\sqcup S = x$). Moreover, members of S do not overlap with each other due to the presence of Π. Π stands for a partition function as defined in (6).[2]

(6) $\Pi(S)(x)$ is true iff

i. S is a *cover* of x, and

ii. $\forall z, y \in S\ [z = y \vee \neg\exists a\ [a \leq_i z \wedge a \leq_i y]]$

The second condition in (6) means that members of S do not share any parts. This pre-

2. As will be discussed in Section 4 below, I also assume the partition function Π for the semantics of multiplicands. This means that the main noun modified by a multiplicative complex cardinal is semantically singular, as in I&M's analysis.

vents the members of S from being counted twice. A sample semantic computation of a multiplicative complex cardinal is given below.

(7) $[\![$ [*three* [*hundred books*]] $]\!]$

$= \lambda x_e \,.\, \exists S_{<e,t>} \,.\, [\Pi(S)(x) \wedge |S| = 3 \wedge$

$\forall s \in S \,.\, [\exists S'_{<e,t>} \,.\, [\Pi(S')(s) \wedge |S'| = 100 \wedge \forall s' \in S' \,.\, [book'(s')]]]]$

The noun phrase in (7) denotes a set of individuals x such that "x is a plural individual divisible into three nonoverlapping individuals p_i such that their sum is x and each p_i is divisible into one hundred nonoverlapping individuals p_k such that their sum is p_i, and each p_k is a book" (Ionin and Matushansky (2018: 14)).

In the next section, I will provide some data that are unexpected under Ionin and Matushansky's (2018) analysis.

2.3 Constituency of multiplicands and multipliers

I&M's analysis can capture many properties of complex cardinals. However, I will show that there are data which are unexpected under their analysis. The first data concern I&M's assumption that there is no single syntactic constituent that directly corresponds to a multiplicative complex cardinal. In other words, the main noun does not appear outside of a complex cardinal phrase in I&M's analysis. The second issue concerns their assumption that multipliers and multiplicands can be either phrases or heads. I will show that multipliers and multiplicands behave differently regarding wh-replacement. This difference between multipliers and multiplicands is not expected under I&M's analysis.

2.3.1 Left-branch extraction

Under I&M's analysis, a multiplicative complex cardinal should not behave as a single constituent since there is no syntactic constituent which directly corresponds to a multi-

plicative complex cardinal in (3). However, this prediction is not borne out. Let us consider left-branch extraction (LBE) in Serbo-Croatian. Some languages such as Latin and most Slavic languages allow movement of the leftmost constituent of an NP (Ross (1986)). Sentences in (8) are examples of LBE in Serbo-Croatian, taken from Bošković (2005).

(8) a. *Visoke*$_1$ *je on vidio* [Δ_1 *djevojke*]. [Serbo-Croatian]
tall is he seen girls
'Tall girls, he saw.'

b. *Lijepe*$_1$ *je on vidio* [Δ_1 *djevojke*]. [Serbo-Croatian]
beautiful is he seen girls
'Beautiful girls, he saw.' [Bošković (2005)]

What is important is that in Serbo-Croatian, a multiplicative complex cardinal can undergo LBE.

(9) a. *Ivan je pozvao* [*tri stotine studenata*]. [Serbo-Croatian]
Ivan is invited three hundred.ACC.F students.GEN.M
'Ivan invited three hundred students.'

b. [*Tri stotine*]$_1$ *je Ivan pozvao* [Δ_1 *studenata*].
three hundred.ACC.F is Ivan invited students.GEN.M
'Three hundred students, Ivan invited.' [Aida Talić (p.c.)]

Following standard assumptions, I assume that LBE can be applied only to a phrasal constituent. The acceptability of (9b) shows that a multiplier and a multiplicand can form a phrasal constituent, excluding the overt main noun. Notice also that *je* in (9b) is a second position clitic; as such it can follow only one constituent (see Bošković (2001) and references therein). The presence of *je* in (9b) then also indicates that (9b) is not derived by multiple LBE, where *tri* and *stotine* would undergo LBE separately.[3]

3. Bošković (2015) discusses a construction that he claims involves full NP fronting and scattered deletion,

Recall that *tri* and *stotine* in (9) are analyzed as noun heads under I&M's (2018) analysis because they do not exhibit agreement with the main noun (cf. (3a)). Under Ionin and Matushansky's analysis, the noun modified by the multiplicative complex cardinal in (9) will then have the structure in (3a). However, if the cardinals in (9) were noun heads as in (3a), it would be expected that they could not undergo LBE, which is a phrasal movement. The expectation is not borne out.

It is also worth noting here that the acceptability of (9b) is unexpected under I&M's (2018) analysis even if the cardinals in question are treated as adjectival adjuncts (cf. (3b)). Attributive adjectives can undergo LBE in Serbo-Croatian, as shown in (8). However, when a noun is modified by two attributive adjectives, LBE of the two adjectives is impossible (Bošković (2005)).

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given in (i).

(i) a. [*Onu žutu*] *je kupio* [*kuću*]. [Serbo-Croatian]
that yellow is bought house
'He bought a yellow house.' [Bošković (2015: 425)]

b. [*Onu žutu* ~~*kuću*~~] *je kupio* [~~*onu žutu*~~ *kuću*].

One may consider that (9b) could also be an instance of the scattered deletion construction. However, (9b) behaves differently from (i). As discussed in Bošković (2015), one of the main characteristics of the scattered deletion construction is that the remnant must be backgrounded and left in situ as in (ii). As shown in (iii), this is not the case with LBE.

(ii) a.?*[*Onu žutu*] *mu kuću pokazuje.* [Serbo-Croatian: NP-fronting + Scattered deletion]
that yellow him house is-showing

b. [*Onu žutu*] *mu pokazuje kuću.*
that yellow him is-showing house
'He is showing him that yellow house.' [Bošković (2015: 421)]

(iii)a. [*Žutu*] *mu kuću pokazuje.* [Serbo-Croatian: LBE]
yellow him house is-showing

b. [*Žutu*] *mu pokazuje kuću.*
yellow him is-showing house
'He is showing him the yellow house.' [Bošković (2015: 421)]

(9b) patterns with LBE in this respect, as in (iv). The same holds for other tests discussed in Bošković (2015). ((9b) always patterns with LBE rather than with the scattered deletion construction.)

(iv) [*Tri stotine*] *je Ivan studenata pozvao.* [Serbo-Croatian]
three hundred.ACC.F is Ivan students.GEN.M invited
'Three hundred students, Ivan invited.' (Željko Bošković, p.c.)

(10) * *Visoke lijepe je on vidio* [Δ Δ *djevojke*]. [Serbo-Croatian]
tall beautiful is he watches girls
'He is watching tall beautiful girls.' [Bošković (2005: 2)]

If the multiplier and the multiplicand in (9b) were adjectival adjuncts, the acceptability of (9b) would also be unexpected. One may argue that (9b) is derived by movement of the main noun out of the cardinal expression followed by movement of the remnant phrase. However, if this kind of remnant movement were available in Serbo-Croatian, it is not clear why (10) is unacceptable. This is because (10) should also be analyzed as involving movement of the main noun, followed by remnant fronting.[4]

Given these considerations, I conclude the multiplicative complex cardinal in (9b) is a single phrasal constituent. (9b) then raises a problem for I&M's (2018) analysis, in which multiplicative complex cardinals cannot be the target of a syntactic operation as a single constituent.

2.3.2 Nominal ellipsis

Nominal ellipsis also provides an argument against I&M's (2018) cascading structure. In (11b) and (11c), the second sentence has an elided part.[5]

(11) Spanish: Gabriel Martínez Vera, p.c.

a. *Juan tomó seiscientas fotos, y Maria tomó* ***tres cientas*** *fotos.*
Juan took six.hundred pictures and Maria took three hundred pictures
'Juan took six hundred pictures, and Maria took three hundred pictures.'

4. For arguments against the remnant movement analysis more generally, see Bošković (2005), Stjepanović (2010, 2011), Despić (2011), Talić (2017) and references therein.
5. Spanish uses analytical forms such as *dos cientos*, *tres cientos* except for *quinientos* 'five hundred'.'

b. *Juan tomó seiscientas fotos, y Maria tomó tres cientas* Δ.
Juan took six.hundred pictures and Maria took three hundred
'Juan took six hundred pictures, and Maria took three hundred pictures.'

c. *Juan tomó seiscientas fotos, y Maria tomó tres* Δ.
Juan took six.hundred pictures and Maria took three
* 'Juan took six hundred pictures, and Maria took three hundred pictures.'
'Juan took six hundred pictures, and Maria took three pictures.'

The elided part in (11b) can receive the same interpretation as the one in (11a). On the other hand, the ellipsis in (11c) cannot mean "three hundred pictures". Instead, it is interpreted as "three pictures". The contrast between (11b) and (11c) is unexpected under I&M's analysis. On I&M's analysis, the cascading structure in (12) should be available for the multiplicative complex cardinals in (11).

(12) [$_{NP}$ THREE [$_{NP}$ HUNDRED [$_{NP}$ PICTURES]]] [I&M]

Under their analysis, the ellipsis in (11b) can be derived from the structure in (12) by deleting the main NP (PICTURES). However, we may then also expect that the same deletion operation can be applied to the intermediate NP consisting of the multiplicand and the main NP, resulting in the ellipsis in (11c). This in fact is possible for adjectives in Serbo-Croatian. In (13), the object noun phrase in the second sentence is interpreted as "a small square table".

(13) Serbo-Croatian: Željko Bošković, p.c.

Ivan je kupio veliki četvrtasti sto, a Petar je kupio mali Δ.
Ivan is bought big square table and Peter is bought small
'Ivan is bought a big square table and Peter is bought a small square table'

Given these data, it seems to me that I&M need an account for the fact that the ellipsis in

(11c) cannot mean "three hundred pictures".[6]

6. Regarding nominal ellipsis in English, some of my consultants found that although there is a contrast between (1b) and (1c), it is not completely impossible for *two* in (1) to be interpreted as "two hundred books". In (1c), */^{OK} means that there is speaker variation regarding the acceptability of the intended reading. (Ionin and Matushansky (2006: 338) also reported a similar observation in a footnote.)

(i) a. *John read three hundred books, but Mary read two hundred books.*
b. *John read three hundred books, but Mary read two hundred* Δ.
c. */^{OK} *John read three hundred books, but Mary read two* Δ.

This may suggest that at least for some speakers, English multiplicative complex cardinals may have the cascading structure as in (12).

What is more interesting is that for higher multiplicands, the ellipsis becomes easier crosslinguistically. Even for the speakers who cannot obtain the intended reading of (iic), nominal ellipsis with higher multiplicands such as *thousand* and *million* is more acceptable, as in (iii) and (iv) (Nicolaus Schrum, p.c.).

(ii) a. *Company X hired six hundred people, and Company Y hired seven hundred people.*
b. *Company X hired six hundred people, and Company Y hired seven hundred* Δ. (Δ = people)
c. */^{OK} *Company X hired six hundred people, and Company Y hired seven* Δ. (Δ = *hundred people*)

(iii) a. *Company X hired six thousand people, and Company Y hired seven thousand people.*
b. *Company X hired six thousand people, and Company Y hired seven thousand* Δ. (Δ = people)
c. ^{OK} *Company X hired six thousand people, and Company Y hired seven* Δ. (Δ = thousand people)

(iv) a. *Company X hired six million people, and Company Y hired seven million people.*
b. *Company X hired six million people, and Company Y hired seven million* Δ. (Δ = people)
c. ^{OK} *Company X hired six million people, and Company Y hired seven* Δ. (Δ = million people)

The same pattern seems to hold in Slavic languages. Below are example from BCS.

(v) Serbo-Croatian: Ivana Jovović, p.c.

a. *Ivan je pozvao cetiri stotine studenata, a Petar je pozvao tri* Δ.
Ivan CL invited four hundred students, and Petar CLS invited three
* 'Ivan invited four hundred students, and Petar invited three hundred students.'
'Ivan invited four hundred students, and Petar invited three students.'
b. *Ivan je pozvao cetiri hiljade studenata, a Petar je pozvao tri* Δ.
Ivan CL invited four thousand students, and Petar CLS invited three
? 'Ivan invited four thousand students, and Petar invited three thousand students.'
c. *Ivan je pozvao cetiri miliona studenata, a Petar je pozvao tri* Δ.
Ivan CL invited four million students, and Petar CLS invited three
^{OK} 'Ivan invited four million students, and Petar invited three million students.'

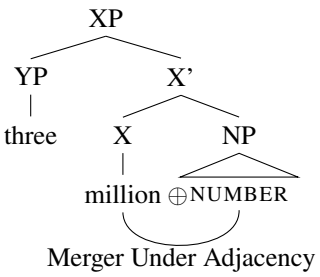
The present analysis may be able to explain this pattern regarding nominal ellipsis. There is a cross-linguistic tendency for higher multiplicands such as "thousand" and "million" to be more nominal in comparison to lower multiplicands like "ten" and "hundred". Based on this cross-linguistic tendency, I assume that in the adjunction structure, a higher multiplicand and the silent NUMBER can optionally undergo a version of Merger Under Adjacency operation (Marantz (1984) Bobaljik (1994)), as represented in (vi).

2.3.3 Split topicalization

Another potential problem for the cascading structure in (3) comes from split topicalization in German. As shown in (14c), the main noun alone can undergo split topicalization, leaving a multiplicative complex cardinal in situ. However, the main noun and a multiplicand cannot move together, leaving a multiplier in situ, as shown in (14d).

(14) German: Sabine Laszakovits, p.c.

(vi)



I assume that nominal ellipsis involves PF-deletion of the target constituent. After the morphological merger operation takes place, the complex unit consisting of the multiplicand and the noun phrase headed by the silent NUMBER can be the target of PF-deletion, while leaving the multiplier in tact. Under the current analysis, the contrast between "hundred" and other higher multiplicands regarding nominal ellipsis can be reduced to the availability of the merger operation. The availability of the relevant merger operation may correspond to the nominal status of a given multiplicand.

It should be noted that there is another complication regarding the ellipsis test. When numerals higher than "four" in Serbo-Croatian are used as a multiplier, it becomes much easier to delete the multiplicand "hundred" together with the main noun, as in (vii). (Compare (vii) with (va) above.)

(vii) Serbo-Croatian: Ivana Jovović, p.c.
Ivan je pozvao sedam stotina studenata, a Petar je pozvao osam Δ.
Ivan CL invited seven hundred students, and Petar CLS invited eight
OK 'Ivan invited seven hundred students, and Petar invited eight hundred students.'

Basically, higher numerals are more nominal. This may give rise to the contrast between lower multipliers and higher multipliers regarding nominal ellipsis. However, I leave a more detailed investigation of this for future research. It is worth noting here that Spanish also seems to show the contrast between lower multipliers and higher multipliers, as shown in (viii).

(viii) Spanish: Gabriel Martínez Vera, p.c.

a. *Juan compró setecientos libros y María compró tres* Δ.
Juan bought seven.hundred books and Maria bought three
* 'Juan bought seven hundred books and Maria bought three hundred books.'
'Juan bought seven hundred books and Maria bought three books.'

b. *Juan compró setecientos libros y María compró ocho* Δ.
Juan bought seven.hundred books and Maria bought eight
OK 'Juan bought seven hundred books and Maria bought eight hundred books.'

a. *Hans kaufte* [***acht tausend*** *Bücher*].
Hans bought eight thousand books
'Hans bought eight thousand books.'

b. [***Acht tausend*** *Bücher*]$_1$ *kaufte Hans* Δ_1
eight thousand books bought Hans

c. *Bücher*$_1$ *kaufte Hans* [***acht tausend*** Δ_1]
books bought Hans eight thousand

d. *[***Tausend*** *Bücher*]$_1$ *kaufte Hans* [***acht*** Δ_1]
thousand books bought Hans eight

Split topicalization in German has received a lot of attention in the literature (van Riemsdijk (1989), Fanselow and Ćavar (2002), van Hoof (2006), among many others). The problem here is that the unacceptability of (14d) seems to be unexpected under I&M's analysis, regardless of the details of the analysis of split topicalization. Under I&M's analysis the object phrase in (14) has the structure in (15).

(15) [$_{\text{NP}}$ EIGHT [$_{\text{NP}}$ THOUSAND [$_{\text{NP}}$ BOOKS]]] [I&M]

The acceptability of (14b) and (14c) shows that either the topmost NP in (15) or the lowest NP (i.e. the main noun) can be a target of topicalization in German. We may then expect that the intermediate NP in (15) can also undergo topicalization. (It should also be noted that I&M propose that both multipliers and multiplicands are of type $\langle\langle e,t\rangle,\langle e,t\rangle\rangle$.) It is thus not clear how to account for the unacceptability of (14d) under I&M's analysis.

2.3.4 *Wh*-questions

Another problem for I&M's (2018) analysis comes from *wh*-questions involving complex cardinals. In many languages, multipliers can be questioned by using *wh*-items. In (16), the topmost multiplier of a complex cardinal is replaced by a *wh*-word while keeping the other

digits.

(16) **Context 1:** One day, John told Mary that he invited 8976 students to their wedding party. Two weeks later, Mary forgot the exact number of the invited students, but she was able to remember digits up to the hundreds place.

a. *Maria zastanawia się* [***ilu*** *tysięcy dziewięciuset siedemdziesięciu sześciu*]
Mary wonders SE WH 1000 900 70 6

studentów Jan zaprosił na imprezę. [Polish]
students John invited to party

b. *Marija se pita* [***koliko*** *hiljada devetsto sedamdest šest*] *studenata je Ivan*
Mary SE wonders WH 1000 900 70 6 students is Ivan

pozvao na zabavu. [Serbo-Croatian]
invited to party.

c. *Mary xiangzhidao John yaoqing* [***ji*** *qian jiubai qishi liu*]*-ge xuesheng*
Mary wonders John invited WH 1000 900 70 6-CLS students

lai paidui. [Chinese]
to party

d. *Mary-wa John-ga paatii-ni* [***nan****-zen kyuuhyaku nanazyuu roku*]*-nin-no*
Mary-TOP John-NOM party-LOC WH-1000 900 70 6-CLS-GEN

gakusei-o syootai-sita ka kangae-teiru. [Japanese]
student-ACC invite-did Q wonder-ASP

e. *Mary fragt sich* [***wieviel*** *tausend neun-hundert sechs-und-sieb-zig*] *Studenten*
Mary ask self WH thousand nine-hundred six-and-seven-ten students

John zur Party eingeladen hat. [German]
John to.the party invited have

f. *María se pregunta* [***qué*** *mil novecientos setenta y seis*] *estudiantes invitó*
Maria SE wonders WH 1000 900 70 and 6 students invited

Juan a la fiesta. [Spanish]
Juan to the party.

'Mary wonders which N John invited N-thousand nine hundred seventy six students.'

The data in (16) show that a multiplier of a complex cardinal can be questioned by using a wh-element.[7] Given this, under I&M's analysis, we may expect that a multiplicand can also be questioned because they assume that multipliers and multiplicands are homogeneous syntactically and semantically. Let us now consider the following context.

(17) **Context 2**: John told Mary that he invited 8976 students to their wedding party, and two weeks later Mary forgot the exact number of the invited students. However, she was able to remember that there are thousands of invited students, and one digit of the number is 8. Now, she is wondering which multiplicand has 8 as its multiplier.

In this context, the set of relevant alternatives will be something like: {8xxx students, x8xx students, xx8x students, xxx8 students}. Crucially, in all of the languages in (16), it is impossible to question only a multiplicand in a complex cardinal by using a wh-element while keeping its multiplier intact, even in the context given above. (18) is an unacceptable example from Spanish, and the same is true for all the other languages in (16), too.

(18) Spanish [Romance]: Gabriel Martínez Vera, p.c.

María se pregunta* [*ocho* ***qué*] *estudiantes invitó Juan a la fiesta.*
Maria SE wonders 8 WH students invited Juan to the party
'Mary wonders what U (U ∈ {hundred, thousand, million, etc.}), John invited 8 U students.

The observation is that multiplicands cannot be questioned by using a wh-element. It is not clear how to capture this contrast between multipliers and multiplicands under I&M's (2018) analysis.

It is important to note that the impossibility of questioning multiplicands is not related to the so-called Edge Generalization on wh-questions given in (19).

7. Languages vary with regard to the availability of wh-questions of a multiplier. For instance, German does not allow wh-questions of a multiplier, whereas Japanese and Chinese allow wh-questions of a multiplier in any position in a given complex cardinal. I leave investigation of this variation for future research.

(19) *Edge Generalization*: Heck (2008: 88)

If α pied-pipes β, then α must be at the edge of β.

According to the Edge Generalization, only a wh-element located in the edge of a constituent can pied-pipe the constituent. An example of the Edge Generalization is given in (20). In (20b), *whom* cannot pied-pipe the constituent because it is not in the edge.

(20) English: Cable (2007: 271)

a. *I wonder* [*whose pictures*] *John bought?*

b. **I wonder* [*pictures of whom*] *John bought?*

There is reason to believe that the contrast between multipliers and multiplicands regarding wh-questions is not due to the Edge Generalization. As shown in (21), it is possible to question an inner multiplier by using a wh-element. The contrast between (21) and (18) is not expected by the Edge Generalization.

(21) *María se pregunta* [*ocho mil* ***qué*** *ciento setenta y seis*] *estudiantes*
Maria SE wonders 8 1000 WH 100 70 and 6 students
invitó Juan a la fiesta. [Spanish]
invited Juan to the party
'Mary wonders which N John invited eight thousand N-hundred seventy six students.'

The same contrast between multipliers and multiplicands regarding wh-questions is also observed in classifier languages. In Japanese, it is possible to question a multiplier in the middle position of a given multiplicative complex cardinal, as in (22).

(22) Japanese

a. *Mary-wa John-ga paatii-ni* [*has-sen* ***nan****-byaku nana-zyuu*
Mary-TOP John-NOM party-LOC eight-thousand WH-hundred seven-ten

roku]*-nin-no gakusei-o syootai-sita ka kangae-teiru.* [Japanese]
six-CLS-GEN student-ACC invite-did Q wonder-ASP

'Mary wonders which N John invited eight thousand N hundred seventy six students.'

b. *Mary-wa John-ga paatii-ni* [*has-sen kyuu-hyaku* ***nan****-zyuu*
Mary-TOP John-NOM party-LOC eight-thousand nine-hundred WH-ten

roku]*-nin-no gakusei-o syootai-sita ka kangae-teiru.* [Japanese]
six-CLS-GEN student-ACC invite-did Q wonder-ASP

'Mary wonders which N John invited eight thousand nine hundred N-ten six students.'

However, even for Japanese, it is impossible to ask multiplicands by using a wh-element as shown in (18.jap).

(23) **Mary-wa John-ga paatii-ni* [*hachi-****nan***]*-nin-no gakusei-o syootai-sita*
Mary-TOP John-NOM party-LOC 8-WH-CLS-GEN student-ACC invite-did

ka kangae-teiru. [Japanese]
Q wonder-ASP

'Mary wonders what U (U $\in$ {thousand, million, etc.}), John invited 8 U students.

The same pattern also holds for Mandarin Chinese. The unavailability of wh-questions of multiplicands is quite robust across languages. I will argue in Section 2.4.4 that the contrast between multipliers and multiplicands regarding wh-questions can in fact be analyzed based on their syntactic differences; multipliers are phrasal elements, whereas multiplicands are syntactic heads, crosslinguistically.

One may also consider that the contrast between multipliers and multiplicands regarding wh-questions is related to their semantics, but not syntax. However, I&M's analysis

cannot resort to the semantic properties of these elements, to explain the contrast in question. I&M propose that noncomplex cardinals are of type $\langle\langle e,t\rangle,\langle e,t\rangle\rangle$. Their denotations of *three* and *hundred* are repeated here as (24). The only difference between *three* and *hundred* is the cardinality of S under their analysis.

(24) a. $[\![\ \textit{three}\ ]\!] = \lambda P_{<e,t>} . \lambda x_e . \exists S_{<e,t>} . [\Pi(S)(x) \wedge |S| = 3 \wedge \forall s \in S . [P(s)]]$

b. $[\![\ \textit{hundred}\ ]\!] = \lambda P_{<e,t>} . \lambda x_e . \exists S_{<e,t>} . [\Pi(S)(x) \wedge |S| = 100 \wedge \forall s \in S . [P(s)]]$

As (24) shows, multipliers and multiplicands have the same type of denotation under I&M's analysis. The contrast between multipliers and multiplicands regarding wh-questions then also cannot be explained by the semantics of numerals under I&M's analysis.

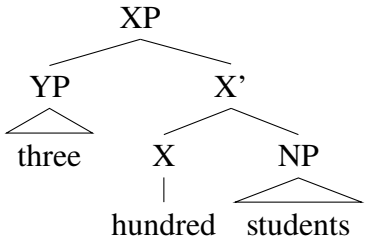
2.4 Proposal

In the previous section, I showed that I&M's (2018) analysis faces some problems. The problems discussed in the previous section are related to their assumption that multipliers and multiplicands independently modify a noun phrase and hence there is no syntactic constituent that directly corresponds to a multiplicative complex cardinal. In this section, I propose an analysis that does not rely on this problematic assumption. The proposal will, however, keep the gist of I&M's analysis in (3). In other words, I argue that multiplicative complex cardinal constructions can in principle have two different structures, in the spirit of I&M.

First, I assume that multipliers and multiplicands are different, syntactically and semantically. To be more precise, I propose that multiplicands are syntactic heads used for measurement. On the other hand, multipliers are phrases appearing in the specifier position of a phrase headed by a multiplicand. Under the proposed analysis, *three hundred students* in English has the structure given in (25) (to be discussed in detail below). What is

important is that multipliers and multiplicands are syntactically different from each other.[8]

(25)



In (25), the multiplicand is a syntactic head taking the main NP as its complement. Structurally, (25) is similar to I&M's (2018) analysis given in (3) in the sense that a multiplicand takes the main NP as its complement. However, the present analysis departs from I&M's analysis with regard to the syntactic status of multipliers and multiplicands. I propose that multipliers are phrases whereas multiplicands are heads in multiplicative complex cardinals, cross-linguistically.

Regarding semantics, I propose that a multiplicand used in multiplicative complex cardinals includes a measurement function μ, similarly to measure words and numeral classifiers.[9]

I assume that multipliers are of type n, as in (26a), whereas multiplicands such as *hundred* are of type $\langle\langle e,t\rangle,\langle n,\langle e,t\rangle\rangle\rangle$, as in (26b). *Hundred* functioning as a multiplicand includes the measurement function μ in the denotation (cf. Krifka (1995)). Multiplicands also have a restriction on the cardinality of the set of atomic individuals in the cover S. The main noun modified by a multiplicative complex cardinal is semantically singular, just like in I&M's analysis. (See Ionin & Matushansky (2018) for supporting evidence on this

8. I will not provide a detailed analysis of the categorial status of numerals, leaving it for future research. It has been observed that there is a categorial scale that while lower cardinals are more adjectival, higher cardinals are more nominal in some languages. However, the boundary is not discrete, but "squishy" (Corbett (1978)).

9. Here, I am not claiming that multiplicands are identical to measure words and numeral classifiers. They have some shared properties such as the presence of μ and a restriction on members of the cover S, but can vary in other respects. I will discuss typological implications regarding similarities between multiplicands and classifiers in Section 2.5.

point.) In (26b), I make use of the partition function Π, which is also used in I&M's analysis (cf. (8)).

(26) a. $[\![\textit{three}]\!] = 3$

b. $[\![\textit{hundred}]\!]$

$= \lambda P.\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x)=n \wedge \forall y \in S.[\underbrace{|\{z:\ z \leq_{at} y\}| = 100}_{\text{Cardinality Restriction}} \wedge \forall z \leq_{at} y.[P(z)]]]$

As shown in (26), multipliers and multiplicands are semantically different from each other.[10,11] The denotation of the topmost XP in (25) is given in (27).

(27) $[\![[_{XP} \textit{three hundred students}]]\!]$

$= \lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = 3 \wedge \forall y \in S.[|\{z:\ z \leq_{at} y\}| = 100 \wedge \forall z \leq_{at} y.[\text{student'}(z)]]]$

One crucial difference between the current proposal and I&M's (2018) analysis is that the former assumes that multipliers and multiplicands are different syntactically and semantically.

I assume that multiplicative complex cardinals can also occur in an adjunction structure that includes the complementation structure given in (25) as an adjunct modifier, as

10. In this sense, the proposed analysis is similar, at least in spirit, to a series of works by Rothstein (2013, 2017), where multipliers and multiplicands have different semantic types. However, the present analysis is also different from Rothstein's analysis in several crucial aspects. For instance, Rothstein assumes that multiplicands are of type $\langle n,\langle e,t\rangle\rangle$, not $\langle\langle e,t\rangle,\langle n,\langle e,t\rangle\rangle\rangle$. Moreover, my proposal given in (26b) does not include any arithmetic functions such as $\times$, unlike Rothstein's. I&M argue against Rothstein's assumption regarding the presence of arithmetic functions in semantics. However, this issue does not arise under the current analysis. It should also be noted that Rothstein's work does not spell out the syntactic status of multipliers and multiplicands. Explicating the syntactic nature of these elements is one of the intended contributions of the present thesis.

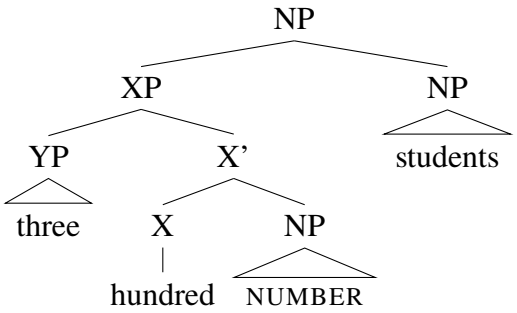
11. It should be noted that the numeral "ten" behaves more like multipliers than multiplicands in several respects. Some examples are given below.

(i) a. *a* {**three* | **ten* | *hundred* | *thousand* | *million*} *books*
b. *several* {**three* | **ten* | *hundred* | *thousand* | *million*} *books*

This pattern may arise because "ten" in English is at the edge of the range of numerals that can be used as a multiplier. The numeral "ten" also tends to be morphologically fused with a multiplier crosslinguistically. I have to leave a detailed analysis of the peculiarities of "ten" for future research. See also footnote 4 above for variation across multiplicands regarding nominal ellipsis.

shown in (28) (i.e., like I&M, I assume that two structures are in principle available).

(28)



In (28), the multiplicand takes the silent numerical noun NUMBER as its complement, instead of overt common nouns such as *students* (see Kayne (2005) and Zweig (2006) for an independent argument for the presence of the silent numerical noun). However, the structural relation between the multiplier and the multiplicand is the same as in (25). The multiplier occurs in the specifier position of the phrase headed by the multiplicand.

With regard to the semantics, I assume that the silent NUMBER is interpreted as a property of being a number (i.e. λx[number'(x)]). The topmost XP in (28) has the following denotation.[12]

(29) $[\![[_{XP}$ *three hundred* NUMBER] $]\!]$

$= \lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = 3 \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 100 \wedge \forall z \leq_{at} y.[number'(z)]]]$

Following Rothstein (2013, 2017), I assume that the topmost XP in (28) can be converted into a singular term of type n by the $\cap$ function (Chierchia (1985)). In (29), each atomic individual of S has the property of being a number. When the $\cap$ function applies, the topmost XP, which is of type $\langle e,t \rangle$, becomes a numerical expression of type n as in (30).[13]

12. It should be noted that the silent NUMBER proposed in the present thesis is incompatible with Rothstein's analysis of multiplicands. Rothstein (2013, 2017) proposes that multiplicands are of type $\langle n,\langle e,t \rangle \rangle$. Rothstein's multiplicands cannot combine with the silent NUMBER proposed here.

13. When the XP including the silent NUMBER is modified by the $\cap$ function, it functions as a numerical expression of type n. Therefore, the multiplicative complex cardinal *three hundred* can be used as a multiplier, combining with another multiplicand as in (i).

(30) $[\![{}^{\cap}\text{XP}]\!] = 300$

In order to modify a noun phrase, cardinals of type n need the covert measurement function ε, as in (31a).

(31) a. $[\![\varepsilon]\!]$

$= \lambda P.\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x)=n \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 1 \wedge \forall z \leq_{at} y.[P(z)]]]$

b. $[\![[\ [_{XP}$ *three hundred* NUMBER$]$ $[\ \varepsilon\ [_{NP}$ *students*$]\ ]\ ]\!]$

$= \lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = 300 \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 1 \wedge \forall z \leq_{at} y.[\text{student'}(z)]]]$

Although the denotation in (31b) is different from the one in (27), they denote the same set; a set of students whose cardinality is "three hundred" in total. Importantly, the topmost XP in (28) can be the target of syntactic operations such as LBE, while keeping the main noun intact, as discussed below.

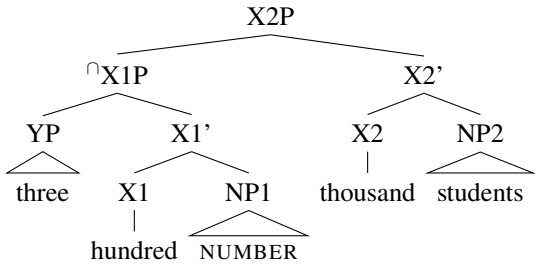
The covert function ε is also used when a noun phrase is modified by a numerical expression in the absence of a multiplicand. For instance, the denotation of *three students* is given in (32b). (See Scontras (2014) (CARD) and Champollion (2017) (MANY) for a similar covert element in the numeral construction.)

(32) a. $[\ [_{YP}$ *three* $]\ [\ \varepsilon\ [_{NP}$ *students* $]\ ]\ ]$

b. $[\![$ *three* ε *students* $]\!]$

$= \lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = 3 \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 1 \wedge \forall z \leq_{at} y.[\text{student'}(z)]]]$

(i) a.



b. $[\![$ *three hundred thousand students* $]\!]$
$= \lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = 300 \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 1000 \wedge \forall z \leq_{at} y.[\text{student'}(z)]]]$

Note also that the covert function ε must be unavailable in obligatory classifier languages where classifiers are generally indispensable in numerical expressions. I speculate that the existence of numeral classifiers blocks the covert function ε in obligatory classifier languages. (See Chierchia (1998) for a similar blocking effect.) The cross-linguistic patterns of cardinal constructions are summarized in (33).

(33)

	Non-classifier languages	Classifier languages
Simplex #	ε	classifiers
Multiplicative #	ε or multiplicands	classifiers or multiplicands

In obligatory classifier languages, numeral classifiers block ε. As will be discussed in Section 2.5, there are several types of classifier languages regarding the co-occurrence of numeral classifiers and multiplicands. In Section 2.5, I will argue that the typological variation can also be captured under the present analysis.

At first glance, the adjunction structure in (28) looks similar to I&M's (2018) adjunction structure given in (3b), because the XP in (28) is an adjunct to the main noun NP. However, the current analysis is different from their adjunction structure in several respects. Firstly, the multiplier occurs in the specifier position of the phrase head by the multiplicand. Secondly, the multiplier and the multiplicand in (28) do not have to be adjectives. Most importantly, the XP in (28) can be the target of syntactic operations such as LBE, while keeping the overt main noun intact, as discussed below.

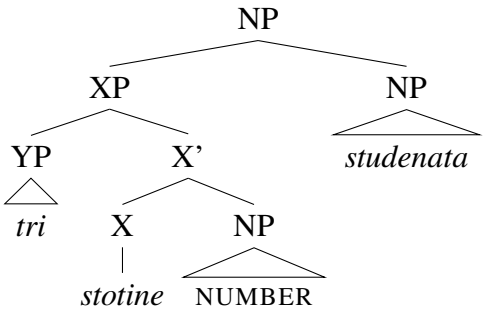
2.4.1 Left-branch extraction

The acceptability of (9b), repeated here as (34), in which the multiplicative complex cardinal undergoes LBE, can be captured under the proposed analysis.

(34) [*Tri stotine*]$_1$ *je Ivan pozvao* [Δ_1 *studenata*]. [Serbo-Croatian]
three hundred.ACC.F is Ivan invited students.GEN.M
'Three hundred students, Ivan invited.' [Aida Talić (p.c.)]

Under the current analysis, the multiplicative complex cardinal in (34) can be analyzed as an adjunct to the main NP, as represented in (35).

(35)



The XP in (35) can undergo LBE, while leaving the overt main noun in situ.[14]

14. The present analysis can also account for the acceptability of (i). Here, the multiplier *tri* alone undergoes LBE.

(i) BCS: Aida Talić, p.c.
?[*Tri*]$_1$ *je Ivan pozvao* [Δ_1 *stotine studenata*].
three is Ivan invited hundred.ACC.F students.GEN.M
'Ivan invited [three]$_F$ hundred students.'

As shown in (35), I propose that multipliers are phrasal. It is then not surprising that *tri* can be the target of LBE, which involves phrasal movement. However, it should be noted that there is some contrast between simplex multipliers and complex multipliers regarding LBE. As shown in (ii-b), it is harder to extract complex multiplier *tri stotine* from a multiplicative complex cardinal. (i-c) shows that it is also harder to extract a multiplier out of a complex multiplier.

(ii) BCS: Aida Talić, p.c.

a. *Ivan je pozvao* [*tri stotine hiljada studenata*].
Ivan is invited three hundred.ACC.F thousand students.GEN.M
'Ivan invited three hundred thousand students.'

b. ??[*Tri stotine*]$_1$ *je Ivan pozvao* [Δ_1 *hiljada studenata*].
three hundred.ACC.F is Ivan invited thousand students.GEN.M
'Ivan invited [three hundred]$_F$ thousand students.'

c. ??[*Tri*]$_1$ *je Ivan pozvao* [Δ_1 *stotine hiljada studenata*].
three is Ivan invited hundred.ACC.F thousand students.GEN.M
'Ivan invited [three]$_F$ hundred thousand students.'

As will be discussed in this section, I assume that complex multipliers have the complementation structure containing the silent NUMBER. Therefore, LBE of complex multipliers should in principle be possible under the current analysis. (Note also that I&M's analysis does not expect the relevant contrast either.) The contrast

2.4.2 Nominal ellipsis

The current analysis can also account for the (im)possible interpretations of elliptical examples. The crucial example is repeated here as (36).

(36) Spanish: Gabriel Martínez Vera, p.c.

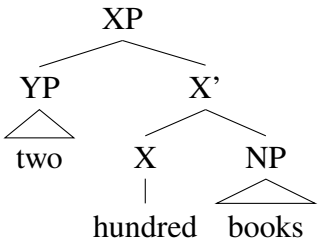
Juan tomó seiscientas fotos, y Maria tomó tres Δ.
Juan took 600 pictures and Maria took three

*'Juan took 600 pictures, and Maria took 300 pictures.'

'Juan took 600 pictures, and Maria took 3 pictures.'

What is important is that the elided part in (36) cannot be interpreted as "three hundred pictures". The current proposal can capture the interpretation of the elliptical example in (36). I assume that multiplicative complex cardinals in Spanish have the adjunction structure as represented in (37) (cf. (28)).

(37)



The elliptical example in (36) cannot be derived from the structure in (37) because there is no phrasal constituent that can undergo ellipsis in (37), to the exclusion of the multiplier "three".[15] The present analysis can thus capture the fact that the elliptical part in (36) cannot mean "three hundred pictures".

may be related to the nature of focus assignment in LBE (LBE affects discourse structure in SC; note that SC is a nuclear stress language - length may be affecting focus-related stress assignment here). However, I leave this issue for future research.

15. I assume that X'-level cannot be a target of ellipsis.

2.4.3 Split topicalization

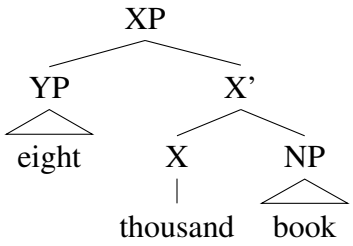
The data about split topicalization in German can also be captured. What is problematic for I&M's analysis is the unacceptability of (14d), repeated here as (38).

(38) German: Sabine Laszakovits, p.c.

*[***Tausend*** *Bücher*]$_1$ *kaufte* *Hans* [***acht*** Δ_1]
thousand books bought Hans eight

The unacceptability of (38) is expected given that the multiplicative complex cardinal in (38) has the structure given in (39) underlyingly.

(39)



The NP *Bücher* can be a target of split topicalization because it is a phrasal constituent. On the other hand, the constituent composed of the multiplicand and the main noun cannot be a target of topicalization because it is not a phrasal projection.

It is worth noting here that numeral classifiers in Mandarin and Vietnamese behave like multiplicands in German regarding leftward movement, as shown in (40) and (41).

(40) Mandarin: Shengyun Gu, p.c.

a. *Qiang mai le* [***wu tiao*** *xianglian*].
Qiang buy ASP five CLS necklace
'Qiang bought five necklaces.'

b. *xianglian*$_1$ *Qiang mai le* [***wu tiao*** Δ_1].
necklace Qiang buy ASP five CLS

c. *[***tiao*** *xianglian*]$_1$ *Qiang mai le* [***wu*** Δ_1].
CLS necklace Qiang buy ASP five

(41) Vietnamese: Thuy Bui, p.c.

a. *Khanh mua* [***năm cuón*** *sách*].
Khanh bought five CLS book
'Khanh bought five books.'

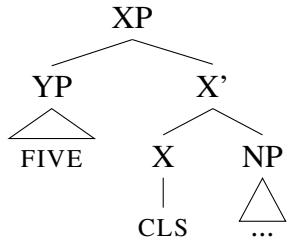
b. *sách*$_1$ *Khanh mua* [***năm cuón*** Δ_1].
book Khanh bought five CLS

c. *[***cuốn*** *sách*]$_1$ *Khanh mua* [***năm*** Δ_1].
CLS book Khanh bought five

As shown in the b-examples of (40) and (41), the main noun can move to the sentence initial position, leaving the cardinal and the numeral classifier in situ. However, it is impossible to move the numeral classifier and the main noun together, as in the c-examples in these classifier languages.

The current analysis can capture the similarity between numeral classifiers and multiplicands in German. Huang and Ochi (2014) propose that Chinese numeral classifiers project their own phrases, taking a noun phrase as the complement. I assume that the classifier phrases in Chinese and Vietnamese have the complementation structure in (42).[16]

(42) [cf. (39)]



16. See however Nguyen (2004) for a different analysis of classifier phrases in Vietnamese. See also Zhang (2013) and references therein for a detailed syntactic analysis of Chinese numeral classifier phrases.

The c-examples in (40) and (41) are unacceptable because the non-maximal projection (i.e. X') cannot be a target of the relevant movement, similarly to split topicalization in German.

One piece of supporting evidence for the structure in (42) comes from the fact that it is impossible to move a cardinal and a numeral classifier while leaving the main noun in situ, as shown in (43a) and (43b).

(43) a. *[***wu tiao***]$_1$ *Qiang mai le* [Δ_1 *xianglian*]. [Mandarin, Shengyun Gu, p.c]
five CLS Qiang buy ASP necklace
'Qiang bought three necklaces.'

b. *[***năm cuón***]$_1$ *Khanh mua* [Δ_1 *sách*]. [Vietnamese, Thuy Bui, p.c.]
five CLS Khanh bought book
'Khanh bought five books.'

The unacceptability of (43a) and (43b) follows from the current analysis. They are unacceptable because there is no constituent composed of the cardinal and the classifier to the exclusion of the main noun, as shown in (42).

Notice also that multiplicative complex cardinal in German cannot undergo split topicalization while leaving the main noun in situ, as in (44).

(44) German: Sabine Laszakovits, p.c.
*[***Acht tausend***]$_1$ *kaufte Hans* [Δ_1 *Bücher*].
eight thousand bought Hans books

Based on the similarity between numeral classifiers in Mandarin/Vietnamese and multiplicands in German, I suggest that multiplicative complex cardinals in German do not appear in the adjunction structure as in (28); multiplicands in German never take the silent NUMBER as the complement.[17]

17. Here, I draw an explicit analogy between multiplicands and numeral classifiers. However, the unacceptability of (44) may also come from other conditions on this leftward movement in German. In light of this, it is worth noting that fractions in German can undergo split topicalization while leaving the main noun in situ,

It should be noted here that it is possible to front a cardinal and a numeral classifier together in some classifier languages such as Ch'ol and Japanese, as in (45b) and (46b).

(45) Ch'ol [Mayan]: Bale et al. (2019: 19)

a. *Ta' jul-i-y-ob* [***ux-tyikil*** *x'ixik*].
PFV arrive-ITV-EP-PL three-CLS woman
'Three women arrived.'

b. [***Ux-tyikil***]$_1$ *ta' jul-i-y-ob* [Δ_1 *x'ixik*].
three-CLS PFV arrive-ITV-EP-PL woman
'[Three]$_{foc}$ women arrived.'

(46) Japanese

a. *kyoositsu-ni* [*zyosei* ***san-nin***]*-ga* *toochaku-sita.*
classroom-LOC woman three-CLS-NOM arrive-DID
'Three women arrived at the classroom.'

b. [***san-nin***]$_1$ *kyoositu-ni* [*zyosei* Δ_1]*-ga* *toochaku-sita.*
three-CLS classroom-LOC woman -NOM arrive-DID
'[Three]$_{foc}$ women arrived at the classroom.'

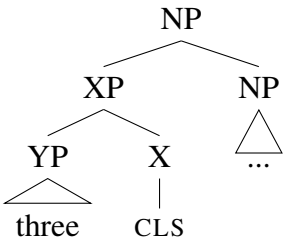
Following Zhang (2013), Huang and Ochi (2014), I assume that there are in principle two structures for numeral classifier phrases; the complementation structure as in (42) and the adjunction structure as in (47).[18]

as in (i). This indicates that at least certain types of numerical expressions can undergo split topicalization in German. I will discuss fractions in German in Chapter 5

(i) German: Sabine Laszakovits, p.c.
Context: Jan has two options regarding his reading assignment in the course; reading two thirds of the book and four fifth of the newspaper, or reading four fifths of the book and two thirds of the newspaper. He can choose one of these options, and the teacher asks the speaker which reading assignment he chose.
OK [*Zwei drittel*] *hat Jan* [Δ *vom Buch*] *gelesen, und vier Fünftel von der Zeitung.*
two three.part have Jan of.the.DAT book read and four five.part of the newspaper
'Jan read two thirds of the book and four fifths of the newspaper.'

18. As will be discussed in Chapter 4, I adopt Kayne's (1994) LCA in this thesis. Under Kayne's LCA, heads generally precede the complement. It is then expected that the classifier head in (47) precedes the numeral. There is, however, a way to circumvent the issue regarding linear order. Watanabe (2006) proposes

(47)



I take the acceptability of (45b) and (46b) as evidence that numeral classifier phrases in these languages make use of the adjunction structure in (47). The XP in (47) can be a target of the relevant movement operation, similarly to LBE in Serbo-Croatian.

2.4.4 *Wh*-questions

The proposed analysis can also capture the contrast between multipliers and multiplicands regarding the (un)availability of wh-questions. The relevant observation is that unlike multiplicands, multipliers can be questioned by a wh-element, while keeping other digits intact. I argue that this contrast is related to their syntactic status; multipliers are phrasal, whereas multiplicands are heads. A similar pattern holds for nominal heads in general. The examples in (49) also demonstrate the same point.

(48) a. *Alex met six **daughters** of Genevieve.* [English]

b. **Bill is wondering who met six* {***what*** | ***whom***} *of Genevieve.*

(49) **Bill is wondering who put six **what** of famous people on the wall.*

ALT = {pictures, lists, etc.} [Jonathan Bobaljik (p.c.)]

These data show that nominal heads alone cannot be replaced by wh-elements. Given this, I suggest that multiplicands cannot be questioned by a wh-element while keeping

that the main noun is base-generated as the complement of the classifier head. The main noun then undergoes snowballing movement, yielding a structure similar to the one in (47). If the classifier phrase in (47) contains the copy of main noun, it may be possible to obtain the numeral-classifier-noun order from (47). However, it is not clear how the covert noun behaves in Kayne's framework. Given this, I put aside the issue regarding linear order in the present chapter, and use the adjunction structure as in (47), for expository purposes.

its multiplier intact because they are cross-linguistically heads in multiplicative complex cardinals.

Unlike multiplicands, multipliers are phrases under the current analysis. It is then not surprising that they can be questioned by using a wh-element as in (16). The present analysis, on which multipliers are phrases whereas multiplicands are heads, can thus capture the cross-linguistic contrast between multipliers and multiplicands regarding wh-replacement.

It should be noted that a similar contrast in wh-replacement possibilities is also observed with English measure words such as *bottle* and *glass*, as shown in (50).

(50) a. *Alex put* [*six* ***glasses*** *of water*] *on the table.* [English]

b. **Bill is wondering who put six* ***what*** *of water on the table.*

c. *Alex added* [*six* ***glasses*** *of water*] *to the soup.*

d. **Bill is wondering who added six* ***what*** *of water to the soup.*

The unacceptability of (50b,d) is expected if measure words are syntactic heads. They cannot be questioned by a wh-element on a par with multiplicands.

Japanese numeral classifiers also behave like multiplicands, with regard to the unavailability of wh-questions. Japanese is an obligatory classifier language, and cardinals must co-occur with an appropriate classifier to modify a noun. In some cases, nouns are compatible with several classifiers. For example, *gakusei* 'student' can co-occur with the classifier *-nin*, *-mei* or *-kumi*, as shown in (51).

(51) a. *Taro-ga* [*san-****nin****-no* *gakusei*]*-o* *home-ta.* [Japanese]
Taro-NOM 3-CLS$_{\text{PERSON}}$-GEN student-ACC praise-PAST
'Taro praised three students.'

b. *Taro-ga* [*san-****mei****-no* *gakusei*]*-o* *home-ta.*
Taro-NOM 3-CLS$_{\text{PERSON.POLITE}}$-GEN student-ACC praise-PAST
'Taro praised three students.'

c. *Taro-ga* [*san-**kumi**-no* *gakusei*]-*o* *home-ta.*
Taro-NOM 3-CLS$_{\text{PAIR}}$-GEN student-ACC praise-PAST
'Taro praised three pairs of students.'

Given these alternatives, it may be expected that the types of classifier can be questioned by a wh-element. However, we cannot question types of classifier by using a wh-element, as shown in (52).

(52) **Taro-ga* [*san-**nani**-no* *gakuse*]-*o* *home-ta* *no.* [Japanese]
Taro-NOM 3-WH-GEN student-ACC praise-PAST Q
Lit. 'Three what of students did Taro praise?'

The impossibility of questioning types of numeral classifier is similar to the impossibility of questioning types of multiplicands and measure words (cf. (18)). This similarity among multiplicands, measure words, and numeral classifiers is understandable from the perspective of the current analysis: they are syntactic heads and hence cannot be replaced by wh-elements.

It is also worth noting that the observation discussed above can be seen as an instance of a more general constraint on syntactic heads given in (53).

(53) Syntactic heads cannot be questioned by using a wh-element.

Although much additional research is needed, we may have here a general property of syntactic heads that is related to the nature of wh-words. (See Cysouw (2004) for a relevant typological survey of wh-words.) I leave a detailed examination of the potential generalization in (53) for future research.[19]

19. One potential issue for the generalization in (53) is *which* in English. *Which* is sometimes assumed to be the head of DP (e.g. Reinhart (1998)). However, it is far from clear that *which* should be analyzed as a head. In some languages like Albanian, "which" co-occurs with the definite article "the", which follows it (see Bošković (2008)), indicating that "which" is in Spec,DP. Furthermore, in languages that allow left-branch extraction, which is a phrasal movement, "which" can undergo it. All this indicates that "which" is not a problem for (53).

2.4.5 Notes on 1-deletion

It should be noted here that the semantic analysis proposed in this thesis implies that multiplicands require a multiplier. Ionin and Matushansky (2018) argue against Rothstein's (2013, 2017) assumption that multiplicands require a type n argument, using French example in (54).

(54) *cent/dix* *personnes* [French]
hundred/ten person.PL
'one hundred/ten people' [I&M (2018: 30)]

However, multiplicands can be used without an overt multiplier only when they are interpreted as including the multiplier "one". Because of this, such data have been analyzed in terms of 1-deletion, which is restricted by independent factors regardless of the semantic type of multiplicands (Hurford 1987, 2003).

Regarding the bare multiplicand construction in French, Zabbal (2005) actually proposed that the low numeral *un* 'a/one' is syntactically present, but not pronounced in examples like (54) Rothstein (2017: 38) also suggested such an analysis for English examples like *the hundred books*. Regarding expressions like *a hundred* in English, Rothstein (2017: 38) argues that the indefinite article *a* is semantically interpreted as the numeral *one* here, hence functions as a multiplier. I follow Rothstein's analysis in this respect.

Notice also that 1-deletion displays quite a bit of crosslinguistic variation. The table in (55) is the summary of 1-deletion in Mandarin Chinese and Japanese.

(55)

	1	10	100	1,000	10,000	1,000,000
Mandarin	*yi*	*shi*	**bai*	**qian*	**wan*	*?bai wan*
Mandarin	*yi*	**yi shi*	*yi bai*	*yi qian*	*yi wan*	*yi bai wan*
Japanese	*ichi*	*zyuu*	*hyaku*	*sen*	*man*	*hyaku man*
Japanese	*ichi*	**iz-zyuu*	**ip-pyaku*	*is-sen*	*ichi-man*	**ip-pyaku man*

This kind of variation suggests that the crosslinguistic variation regarding 1-deletion is orthogonal to the deeper issues regarding the syntax and semantics of multiplicative complex cardinals.

Her et.al. (2015) argues that the silent YI cannot be focused and cannot be a part of a focused numeral classifier phrase.

(56) Mandarin Chinese (Her et.al. 2015: 206)

a. *ta mai-le* [*yi zhang zhuozhi he yi tai diannao*].
he buy-ASP one CLS table and one CLS computer
'He bought one table and one computer.'

b. *ta mai-le* [*zhang zhuozhi he yi tai diannao*].
he buy-ASP CLS table and one CLS computer
'He bought one table and one computer.'

Let us now consider 1-deletion in the coordination construction. As shown in (57), its distribution is different from the silent YI given in (56) and (57).

(57) Mandarin

a. *ta mai-le* [*yi bai zhang zhuozhi he yi bai tai diannao*].
he buy-ASP one hundred CLS table and one hundred CLS computer
'He bought 100 tables and 100 computers.'

b. **ta mai-le* [*bai zhang zhuozhi he yi bai tai diannao*].
he buy-ASP hundred CLS table and one hundred CLS computer

c. **ta mai-le* [*yi bai zhang zhuozhi he bai tai diannao*].
he buy-ASP one hundred CLS table and hundred CLS computer

1-deletion is not allowed in multiplicative complex cardinals including *bai*, *qian* and *wan*. If 1-deletion includes the silent YI, the contrast between (56b) and (57b) is not expected. When the demonstrative *zhe* appears with a classifier, the modified noun phrase is inter-

preted as singular as in (58a). In the absence of a classifier, however, the noun modified by *zhe* is ambiguous between plural and singular interpretations, as in (58b). Wang (2019) assumes that there is the silent YI 'one' in (58a). In other words, the presence of a classifier entails the presence of a numeral.

(58) Mandarin: Wang (2019)

a. *zhe ge xuesheng*
this CLS student
'this student'

b. *zhe xuesheng*
this student
'this student' / 'these students'

What Wang (2019) proposes is that Chinese has a silent YI 'one'. Importantly, the silent YI is not derived by deletion of its overt counterpart *yi* 'one.' There are two lexical items denoting "one" in Mandarin; *yi* and the silent YI. The overt *yi* can functions as an indefinite article or a numeral. On the other hand, the silent YI always functions as a numeral. Since the silent YI is not the deleted counterpart of *yi*, it is expected that they display different behaviors regarding environments in which they occur. To be more precise, the distribution of the silent YI is more restricted than the overt *yi*.

Given these considerations, I believe that I&M's arguments against Rothstein's analysis do not carry over to the analysis proposed in this thesis.

2.4.6 Section summary

In this section, maintaining the spirit of I&M's analysis that multiplicative complex cardinals can in principle have two structures cross-linguistically, I have argued that the complementation structure (25) and the adjunction structure (28) are available for multiplicative complex cardinals. The current analysis differs from I&M's (2018) analysis regarding the treatment of multipliers and multiplicands. The present proposal is that multiplicands are syntactic heads used for measurement, whereas multipliers are phrases appearing in the

specifier position of the phrase headed by a multiplicand. In addition, I have shown that there are both some similarities and differences between multiplicands and numeral classifiers, on the basis of the data involving topicalization and fronting. The cross-linguistic data are summarized in (59).[20]

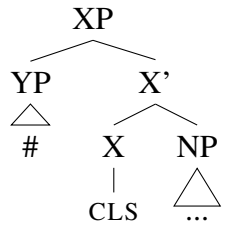
(59)

	Multiplicands	Numeral classifiers
Complementation	German	Mandarin Chinese, Vietnamese
Adjunction	Serbo-Croatian	Ch'ol, Japanese

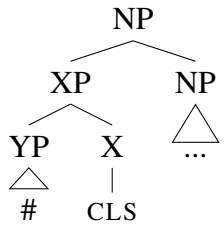
I have proposed that the classification given in (59) arises from the structures represented in (57) and (61).

(60) *Numeral classifier phrases*

a. Complementation

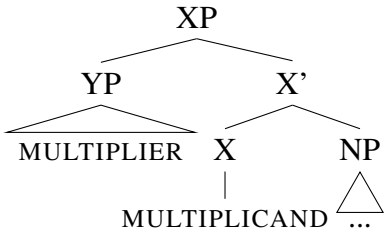


b. Adjunction

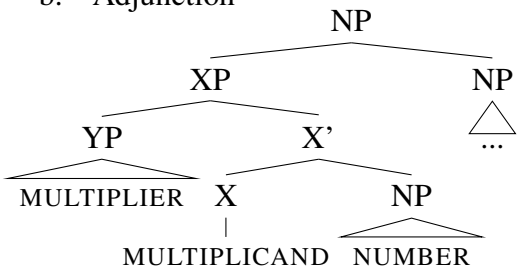


(61) *Multiplicative complex cardinals*

a. Complementation



b. Adjunction



20. I will also discuss the syntactic status of multiplicands in classifier languages in Section 2.5. It will be argued that multiplicands in some languages are associated with a sortal restriction like numeral classifiers. The relevant sortal restriction excludes co-occurence of a multiplicand and a numeral classifier in some classifier languages.

As shown in (57b), the adjunction structure of numeral classifier phrases does not include the silent NUMBER, unlike multiplicands appearing in the adjunction structure as in (61b). In the next section, I will argue that numeral classifiers and multiplicands are different in this respect, because of the sortal restriction of classifier heads. This difference between multiplicands and numeral classifiers makes it possible to account for cross-linguistic distributions of multiplicands and numeral classifiers.

2.5 Multiplicands ≈ classifiers

I showed in Section 2.4.4 that multiplicands, measure words, and numeral classifiers behave alike regarding wh-questions. This similarity is expected because they are syntactic heads used for measurement under the current analysis. In this section, I discuss typological data which show that multiplicands and numeral classifiers have a similar distribution.

In some classifier languages, multiplicands can be used as a classifier. Let us first consider multiplicative complex cardinals in Mokilese [Austronesian]. Mokilese is a classifier language where noncomplex cardinals (1 through 9) are followed by a classifier, as in (62) (Harrison 1976: 99).

(62) a. *amwje pah-men*
mosquito four-CLS
'four mosquitos'

b. *jiloa pah-w*
clam four-CLS
'four clams' [Harrison (1976: 95-96)] [Mokilese]

In contrast to noncomplex cardinals, multiplicative complex cardinals can modify a noun without a numeral classifier, as shown in (63).

(63) Mokilese [Austronesian]: Harrison (1976: 98)

a. *woal ei-jek*
man one-ten
'ten men'

b. *war ei-jek*
canoes one-ten
'ten canoes'

c. *puk ei-jek*
book one-ten
'ten books'

However, when additive complex cardinals such as "fourteen" are used with a noun, a noncomplex cardinal still takes a numeral classifier, as shown in (64).

(64) Mokilese: Harrison (1976: 98)

a.	*woal*	*ei-jek*	*pah-men*	b.	*war*	*ei-jek*	*pah-pas*	c.	*puk*	*ei-jek*	*pah-w*
	man	1-10	4-CLS		canoes	1-10	4-CLS		book	1-10	4-CLS
	'fourteen men'				'fourteen canoes'				'fourteen books'		

The same pattern holds for multiplicative complex cardinals including a higher multiplicand like "hundred", as shown in (65).

(65) Mokilese: Harrison (1976: 99)

a.	*suhkoa*	*pah-pwki*	b.	*suhkoa*	*pah-pwki*	*rah-pas*
	tree	four-hundred		tree	four-hundred	two-CLS
	'four hundred trees'			'four hundred and two trees'		

The presence of the classifier in (64c) and (65b) indicates that the presence/absence of a classifier in Mokilese is independent of the value of a given complex cardinal. Numeral classifiers are not needed in the presence of a multiplicand in Mokilese.

A similar pattern is also observed in Toqabaqita [Austronesian]. As shown in (66a), the noun *(q)alo* 'taro' occurs with the classifier *fa* when it is modified by a noncomplex numeral. However, the classifier is not used in the presence of multiplicands such as "hundred" and "thousand", as in (66b).

(66) Toqabaqita: Lichtenberk (2008: 293)

a.	*ulu*	*fa*	*qalo*	b.	*ulu*	*toqoni*	*alo*
	three	CLS	taro		three	thousand	taro
	'three taro corms'				'three thousand taros (corms or whole plants)'		

The contrast in (66) is related to the presence/absence of the multiplicand, but not to the value of a given cardinal. In additive complex cardinals, for instance, a noncomplex cardinal still occurs with a classifier (i.e. *kwalu fa qalo*), as shown in (67).[21] This example indicates that the absence of the classifier in Toqabaqita is related to the presence of a multiplicand.

(67) [*roo talanga qalo*] [*lima finita qalo*] [*kwalu fa qalo*] [Toqabaqita]
two hundred taro five tensome taro eight CLS taro
'two hundred fifty eight taro corms' [Lichtenberk (2008: 293)]

I propose that multiplicands in Mokilese and Toqabaqita can function as a multiplicative classifier. Multiplicative classifiers and other types of numeral classifiers are used for measurement; the presence of one of them is enough to measure the cardinality of a plural individual. The current proposal expects that a numeral classifier is not needed in Mokilese and Toqabaqita when a multiplicand is present. I will now discuss other classifier languages that provide support for the current analysis, namely Burmese [Sino-Tibetan], Ch'ol [Mayan], Dolakha Newar [Sino-Tibetan] and Nung [Tai-Kadai].

Burmese [Sino-Tibetan] provides a piece of supporting evidence that multiplicands and numeral classifiers can be categorized as a similar type of a syntactic head. In Burmese, an appropriate numeral classifier must be used when a noun is modified by cardinals, except with some cardinals such as "twenty", "hundred", "thousand", etc. (Burling (1965), Soe (1999)). In (68a), the complex cardinal occurs with the numeral classifier *yau'*. However, when an even cardinal that contains a multiplicand (i.e. a lexical power of ten) modifies a noun, the classifier is omitted, as shown in (68b).

21. In Toqabaqita, the main noun appears in each digit of a given additive complex cardinal. This can be seen as supporting I&M's coordination analysis of additive complex cardinals, which I will briefly discuss in Section 6.

(68) a. *tha-hkou: lei: htaun thoun: ya hna-hse kou: yau'* [Burmese]
thief four thousand three hundred two-ten nine CLS
'4329 thieves'

b. *tha-hkou: lei: htaun*
thief four thousand
'4000 thieves' [Soe (1999: 64)]

The acceptability of (68b) can also be explained under the current proposal, on which multiplicands and numeral classifiers are syntactic heads used for measurement. The multiplicand *htaun* 'thousand' in (68b) is a multiplicative classifier and suffices for measurement.

Ch'ol [Mayan] can make use of two types of cardinals; Ch'ol cardinals and Spanish cardinals (Vázquez Álvarez (2011)). Ch'ol cardinals are used only for cardinals from "one" to "six", "ten", "twenty", "forty", "sixty", "eighty", "one hundred", and "four hundred". For other cardinals, cardinals borrowed from Spanish are used. As shown in (69), Ch'ol cardinals obligatorily appear with a classifier, when they modify a noun.

(69) *ux*(-p'ej) tyumuty* [Ch'ol]
three-CLS egg
'three eggs' [Bale and Coon (2014: 701)]

In Ch'ol, a vigesimal system and a decimal system co-exist. The cardinal *k'al* 'twenty' can be used in multiplicative complex cardinals as in (70b). What is important is that when *k'al* 'twenty' is used as a multiplicand, the multiplicative complex cardinal can modify a noun without a numeral classifier, as shown in (70b).

(70) Ch'ol: Bale et al. (2019: 10)

a. *ux-kojty wakax*	b. *ux-k'al wakax*	c. **ux-k'al-kojty wakax*
three-CLS cow	three-twenty cow	three-twenty-CLS cow
'three cows'	'sixty cows'	Int. 'sixty cows'

The acceptability of (70b) is expected if the multiplicand *k'al* 'twenty' is a multiplicative classifier. Moreover, the unacceptability of the (70c) shows that the classifier and the multiplicand are in complementary distribution.

Dolakha Newar is another classifier language which displays a similar pattern as Ch'ol. Most numerals in Dolakha Newar must occur with a classifier to modify a noun (Genetti (2007: 217)). An example is given in (71).

(71) *ŋā-mā dũ wā gwār=ku thi-gur=uri ur-ai* [Dolakha Newar]
five-CLS tiger TOP shelter=LOC one-CLS=IND circle-3.SG.PRES
'Five tigers circled the one shleter.' [Genetti (2007: 100)]

However, multiplicative complex cardinals do not take numeral classifiers, as in (72).

(72) a. *nis-sar mi*
two-hundred people
'two hundred people'

b. **nis-sar mā mi* [Dolakha Newar]
two-hundred CLS person
'two hundred people' [Genetti (2007: 218)]

A similar pattern is also observed in Nung [Tai-Kadai]. In Nung, the presence of a classifier is obligatory when classifiable nouns are modified by a noncomplex cardinal, as in (73a). However, a classifier becomes optional when a multiplicand is present, as shown in (73b).

(73) Nung: Saul and Wilson (1980: 14, 27)

a. *lēo jgà* [*slóng tú má lụhc*].
then kill two CLS dog child
'Then kill two puppies.'

b. *mi* [*slám pảc* (*áhn*) *hơn*].
have three hundred CLS house
'There are three hundred houses.'

The typological data discussed above lead us to the conclusion that there are several types of classifier languages regarding the co-occurrence of numeral classifiers and multiplicands, as summarized in (74). (As for Mokilese, Toqabaqita and Burmese, it is not clear whether they belong to (74b) or (74c), due to the lack of relevant data. Unfortunately, only limited

data are available because the main source of typological data in this section are grammar books and dissertations in typology.)

(74) a. MUL & CLS must co-occur:

E.g. Obligatory classifier languages (e.g. Chinese, Japanese[22])

b. MUL & CLS cannot co-occur:

E.g. Ch'ol, Dolakha Newar

c. MUL & CLS can optionally co-occur:

E.g. Nung

The typological variation in (74) can be captured under the present analysis. I suggest that classifier languages vary with regard to the distribution of the silent NUMBER. In obligatory classifier languages, multiplicands have the sortal restriction in addition to the cardinality restriction as in (75).[23]

(75) ⟦ "hundred" ⟧ [Obligatory classifier languages]

$= \lambda P: \underbrace{\forall u.[P(u) \rightarrow number'(u)]}_{\text{Sortal Restriction}}.\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x)=n$

$\wedge \forall y \in S.[\underbrace{|\{z: z \leq_{at} y\}| = 100}_{\text{Cardinality Restriction}} \wedge \forall z \leq_{at} y.[P(z)]]]$

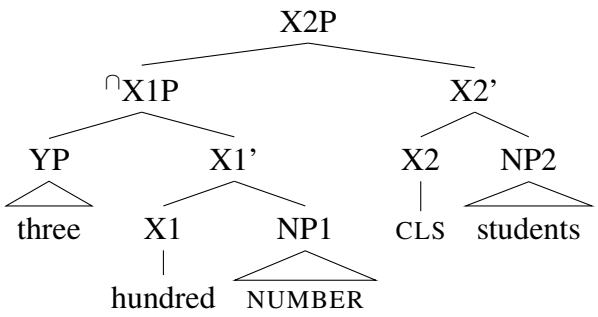
When a multiplicand that has the sortal restriction as in (75) combines with a common noun instead of the silent NUMBER, it leads to semantic incoherence because nothing can be a student and the number concept at the same time. The sortal restriction in (75) thus requires the multiplicand to take the silent NUMBER as the complement. For the main noun to be modified by a multiplicative complex cardinal, a numeral classifier is needed

22. Chinese and Japanese as obligatory classifier languages generally require a numeral classifier in cardinal constructions, regardless of the presence of multiplicands. However, see Sudo (to appear) for several Japanese counting modifiers which cannot co-occur with classifiers.

23. In (75), I treat the sortal restriction as a presupposition following Sudo's (2016) analysis of numeral classifiers. For an alternative analysis of the sortal restriction, see McCready (2009), who argues that the sortal restriction is a conventional implicature. As far as I can tell, nothing hinges on the choice between these options for the purposes of the current thesis.

independently. "Three hundred students" in obligatory classifier languages has the structure in (76).[24]

(76)



Regarding classifier languages in which multiplicands cannot co-occur with a classifier such as Ch'ol and Dolakha Newar, I hypothesize that multiplicands must take the main noun but not the silent NUMBER as the complement, because they include the sortal restriction excluding the silent NUMBER, as shown in (77).

(77) ⟦ "hundred" ⟧ [Ch'ol and Dolakha Newar]

$= \lambda P{:}\underbrace{\forall u.[P(u) \rightarrow \text{non-number'}(u)]}_{\text{Sortal Restriction}}.\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x){=}n$

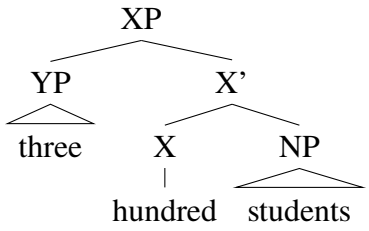
$\wedge\ \forall y{\in}S.[\underbrace{|\{z{:}\ z{\leq_{at}}y\}| = 100}_{\text{Cardinality Restriction}} \wedge \forall z{\leq_{at}}y.[P(z)]]]$

If a multiplicand combines with the silent NUMBER in these languages, the resulting phrase again results in semantic incoherence because an individual cannot be a number and a non-number.[25] This means that Ch'ol and Dolakha Newar cannot have the structure in (76). Multiplicands in Ch'ol and Dolakha Newar should have the complementation structure in (78), and hence a multiplicand and a numeral classifier cannot co-occur.

24. (76) is the complementation structure of classifier phrases, which makes it easy to see the relevant difference between classifier and non-classifier languages. However, the adjunction structure of classifier phrases may also be available, similarly to the adjunction structure for multiplicands (see (28)). For more detailed discussion of the syntax of classifier phrases, see Watanabe (2006, 2010), Zhang (2013), Huang and Ochi (2014), Bale et al. (2019) and references therein.

25. Recall that I assume that the silent NUMBER is interpreted as the property of being a number (i.e. λx[number'(x)]).

(78)



Lastly, I assume that in classifier languages where multiplicands can optionally co-occur with a classifier (e.g. Nung), multiplicands do not have any sortal restrictions like the ones in non-classifier languages (cf. (26b)). Due to the lack of a sortal restriction, multiplicands can optionally take the silent NUMBER or the main noun as the complement in this type of language. In other words, both (76b) and (78) are available in this type of classifier languages.

The current analysis can then accommodate the typological variation in (74), in fact because of the use of the silent NUMBER. The typological variation in question appears to be puzzling under previous analyses of multiplicative complex cardinals like I&M and Rothstein's work.

To recapitulate, this section has shown that multiplicands in some classifier languages such as Mokilese, Toqabaqita, Ch'ol, Burmese, Dolakha Newar and Nung have an effect on the distribution of numeral classifiers. The current analysis can capture this behavior of multiplicands. Multiplicands function as a multiplicative classifier and the presence of a multiplicand is sufficient for measurement in some classifier languages. The typological variation among these classifier languages can be reduced to the semantic content of multiplicands in a given language.[26]

Lastly, I would like to point out that Savosavo [Papuan] has different forms of the multiplicand "ten" depending on the sortal information of a main noun. As shown in (79), *kua* 'ten$_{\text{eggs}}$' is used for the Megapode eggs and *piqu* 'ten$_{\text{coconuts}}$' for ripe coconuts.

26. It should also be noted that numeral classifiers cannot take the silent NUMBER as the complement, because of the sortal restriction that a numeral classifier has. For example, Japanese, an obligatory classifier language, has the numeral classifier for people *nin*. The denotation of the classifier is given in (i).

(79) Savosavo [Papuan]: Wegener (2012: 75)

a. *pa kua kolei*
one ten$_{eggs}$ megapode.egg
'ten Megapode eggs'

b. *pa piqu qazu*
one ten$_{coconuts}$ ripe.coconut
'ten ripe coconuts'

These sortal multiplicands are different from the default multiplicand *atale* 'ten', which appears in a multiplicative complex cardinals (e.g. *poghoro 'atale* 'seven ten = seventy', Wegener (2012: 73)). An example of the default "ten" (*atale*) in Savosavo is given in (80).

(80) Savosavo [Papuan]: Wegener (2012: 178)

Zu Kukui=na ghoi pa atale pise=gha lava
and/but Kukui=NOM also one ten bamboo.seperation=PL PROPR.SG.M

molo=lo te ghoi l-omaqa-(a)le-i.
bamboo=3.SG.M EMPH also 3.SG.M.O-carry-BG.IPFV-FIN
'And Kukui was also carrying a (piece of) bamboo that had ten segments. (If he had met his wife and daughter he would have killed and cooked them in it)'

The multiplicands in (79) show that a sortal restriction and a cardinality restriction can be realized on a multiplicand. This pattern is expected by the current analysis. Like multiplicands in Ch'ol, Dolakha Newar and obligatory classifier languages, *kua* and *piqu* in Savosavo are associated with a sortal restriction in addition to the cardinality restriction. The denotations are given in (81).

(i) $[\![\textit{nin}]\!]$
$= \lambda P: \underbrace{\forall u.[P(u) \rightarrow person'(u)]}_{\text{Sortal Restriction}} .\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = n \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 1 \wedge \forall z \leq_{at} y.[P(z)]]]$

When the numeral classifier *nin* combines with the silent NUMBER, it yields semantic incoherence, similarly to cases in which a multiplicand in obligatory classifier language combines with a noun phrase other than the silent NUMBER (cf. (77)); nothing can have the property of being a number and other properties at the same time. This is another difference between multiplicands and numeral classifiers although they both are syntactic heads used for measurement.

(81) a. $[\![\ kua\ ]\!]$

$= \lambda P: \underbrace{\forall u.[P(u) \rightarrow \text{Megapode-egg'}(u)]}_{\text{Sortal Restriction}}.\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x)=n \wedge \forall y \in S.[\underbrace{|\{z: z \leq_{at} y\}| = 10}_{\text{Cardinality Restriction}} \wedge \forall z \leq_{at} y.[P(z)]]]$

b. $[\![\ piqu\ ]\!]$

$= \lambda P: \underbrace{\forall u.[P(u) \rightarrow \text{coconut'}(u)]}_{\text{Sortal Restriction}}.\lambda n.\lambda x.\exists S.[\mu(x)=n \wedge \Pi(S)(x) \wedge \forall y \in S.[\underbrace{|\{z: z \leq_{at} y\}| = 10}_{\text{Cardinality Restriction}} \wedge \forall z \leq_{at} y.[P(z)]]]$

A similar pattern is also observed in Taba [Austronesian], as in (82). The generic multiplicand for "ten" is *yo*, which co-occurs with the measure classifier *ha* as shown in (82a). In addition to the generic multiplicand, Taba has another multiplicand for "ten"; *beit*. As shown in (82b), *beit* appears in a multiplicative complex cardinal used for counting animals.

(82) Taba: Bowden (1997: 246)

a.	*yo*	*ha-tol*	b.	*beit*	*tol*
	ten	$\text{CLS}_{\text{times}}$-three		$\text{ten}_{\text{animal}}$	three
	'thirty (piece of fruit, etc.)'			'thirty (animals)'	

It is worth noting here that in the language sample discussed here, there is no language in which non-complex cardinals or multipliers display a sortal restriction depending on the main noun. This is another cross-linguistic contrast between multipliers and multiplicands. Any analysis of multiplicative complex cardinals needs to account for this typological pattern.

2.6 Chapter summary

This chapter examined multiplicative complex cardinals in order to determine what kind of hierarchical structure is available cross-linguistically. By using left-branch extraction,

replacement by wh-elements, nominal ellipsis, split topicalization and similar fronting operations as the main tests, I argued that in multiplicative complex cardinals, a multiplicand is a syntactic head used for measurement and a multiplier is a phrase appearing in the specifier position of a phrase headed by a multiplicand. Since multiplicands and numeral classifiers are syntactic heads used for measurement, they behave alike in several respects. With regard to the similarities among these elements, I discussed wh-questions and the distribution of multiplicands and numeral classifiers. Building on the proposed analysis of multiplicative complex cardinals, I will investigate additive complex cardinals in Chapter 3.

Chapter 3

Additive complex cardinals

3.1 Introduction

In this chapter, I investigate additive complex cardinals like (1), building on the analysis of multiplicative complex cardinals proposed in Chapter 2.

(1) a. *Ivan je vidio* [*dvadeset pet*] *devojaka.* [Serbo-Croatian]
Ivan is seen twenty five girls
'Ivan saw twenty five girls.' [Aida Talić & Ivana Jovović, p.c.]

b. *Taro-ga* [*gakusei* ***ni-zyuu go***]*-nin-o mita.* [Japanese]
Taro-NOM student two-ten five-CLS-ACC saw
'Taro saw [twenty five students].'

I will use the term "augend" for a numeral to which another numeral is added. Similarly, the term "addend" is used for a numeral to be added. For examples, in two-member additive complex cardinals such as *twenty eight*, *twenty* is the augend and *eight* is the addend in the sense that *twenty* is the number to which successive numbers are added (e.g. *twenty-one, twenty-two, etc.*). In three-member additive complex cardinals such as *three hundred twenty*

eight, *twenty* is the augend for the addend *eight*. The multiplicative complex cardinal *three hundred* is referred to as the augend for the addend *twenty eight* because *three hundred* is a number to which successive multiplicative complex cardinals are added (e.g. *three hundred twenty-nine, three hundred thirty, etc.*). The relation is summarized in (2).

(2)

	Augend	Addend
	twenty	*eight*
three hundred	Addend	
Augend		

Additive complex cardinals have received little attention in the literature. Ionin and Matushansky (2018) (henceforth I&M) pursue an analysis in which additive complex cardinals have a coordinate structure where two NPs are coordinated. According to their analysis, additive complex cardinals are derived by NP-deletion. One option for NP-deletion is given in (3).[1] (3a) is the underlying structure of the example in (3c). The main noun in the first

1. In Ionin and Matushansky (2006), they suggested that additive complex cardinals can also be derived by right-node raising (RNR), as represented in (i).

(i) RNR: [[$_{NP}$ TWENTY ~~GIRL~~] & [$_{NP}$ TWO ~~GIRL~~]] GIRL ⇒ 'twenty two girls'

However, Ionin and Matushansky (2018) deny the RNR derivation on the basis of the fact that additive complex cardinals in Biblical Welsh (Hurford (1975)) and Scottish Gaelic (Paterson (1989), Hurford (2003)) allow for a lexical noun to precede an overt coordinator in complex cardinals. As shown in (ii), an additive complex cardinal can be interrupted by the modified noun in Welsh and Scottish Gaelic.

(ii) *tri fear dheug 's da fhichead* [Scottish Gaelic]
three man ten plus two twenty
'fifty-three men'

It is difficult to explain the position of the head noun in this kind of additive complex cardinals under the RNR analysis. On the other hand, under the NP-deletion analysis discussed in the text, the head noun in (iii) can be located in the complement of the multiplicand in the first conjunct. Thus, what happens here is that the head noun in the second conjunct is deleted, not the head noun in the final conjunct. Additive complex cardinals in Modern Welsh also exhibit a similar pattern. Modern Welsh has a vigesimal system and the additive numeral "33" is expressed by addition of three numerals; 3 + 10 + 20. The head noun modified by an additive numeral can appear in three positions in Modern Welsh, as in (iv).

(iii) a. [*tair gwlad*] *ar ddeg ar hugain* [Welsh]
three country on ten on twenty
'thirty three countries'

b. *tair ar* [*ddeg gwlad*] *ar hugain* [Welsh]
three on ten country on twenty
'thirty three countries'

conjunct is deleted, as shown in (3b).

(3) Ionin and Matushansky 2018

a. [[$_{NP}$ three [$_{NP}$ hundred [$_{NP}$ girls]] & [$_{NP}$ three [$_{NP}$ girls]]] (NP coordination)

b. [[$_{NP}$ three [$_{NP}$ hundred [$_{NP}$ ~~girls~~]] & [$_{NP}$ three [$_{NP}$ girls]]] (NP-deletion)

c. *three hundred three girls* [English]

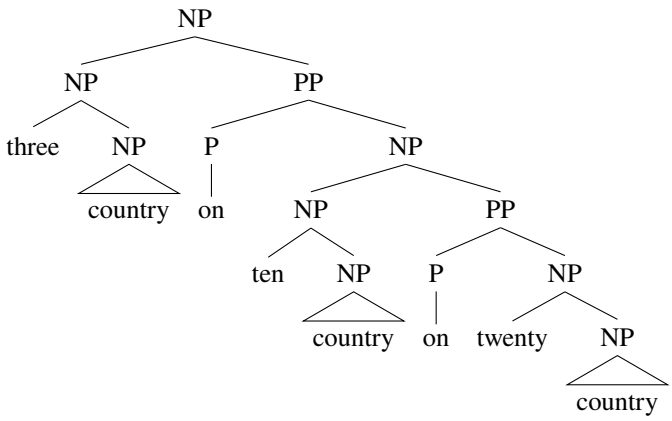
Under Ionin and Matushansky's (2018) analysis, each conjunct is headed by the main noun in the coordinate structure. In what follows, I refer to their analysis as the NP coordination analysis.

Although I follow Ionin and Matushansky (2018) regarding the existence of the coordinate structure of additive complex cardinals, I argue in this chapter that in addition to the NP coordination structure as in (3), a non-coordinate structure is available for additive complex cardinals. Specifically, I propose that a lower-valued cardinal ("three" in "three

c. *tair ar ddeg ar* [*hugain gwlad*] [Welsh]
three on ten on twenty country
'thirty three countries' (David Willis p.c.)

These three variations of additive complex cardinals can be seen as a piece of evidence that additive complex cardinals in Modern Welsh have a coordinate structure of nominals. Ionin and Matushansky (2018) propose that adpositions in an adpositional complex cardinal have the same syntactic structure as other adpositional phrases in a given language. Although Ionin and Matushansky (2018) did not discuss the structure of a three-member complex cardinal as in (iv), the adpositional cardinals in (iv) can have the following underlying structure under their analysis. In (v), each preposition takes NP as its complement, adjoining to another NP. The phrases in (iv) are derived by NP-deletion of one of the head nouns (i.e. country) in (v).

(iv)



hundred three") can directly adjoin to a higher-valued cardinal ("three hundred" in "three hundred three"). The major motivation for the existence of the non-coordinate structure will come from the human classifier *ri* in Japanese, contracted forms of Chinese cardinals, and "21" in Polish.

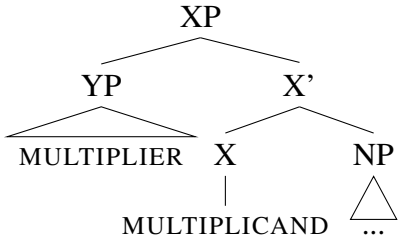
3.2 The NP coordination analysis

In this section, I will show that the analysis of multiplicative complex cardinals proposed in Chapter 2 is compatible with Ionin and Matushansky's (2018) NP coordination analysis of additive complex cardinals.

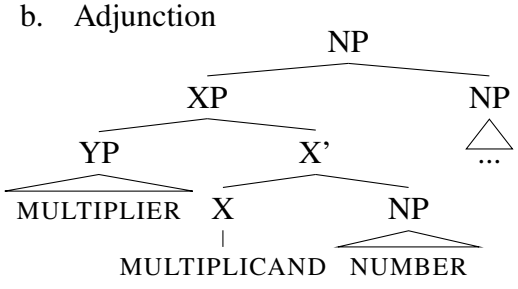
In Chapter 2, I proposed that in multiplicative complex cardinals, a multiplicand is a syntactic head used for measurement and a multiplier is a phrase appearing in the specifier position of a phrase headed by the multiplicand. Moreover, I argued that multiplicative complex cardinals can in principle have two structures cross-linguistically; the complementation structure as in (4a) and the adjunction structure as in (4b). In the adjunction structure, a multiplicative complex cardinal includes the silent NUMBER, which is one of the causes of the different syntactic behavior of multiplicative complex cardinals as discussed in Chapater 2.

(4) *Multiplicative complex cardinals*

a. Complementation



b. Adjunction

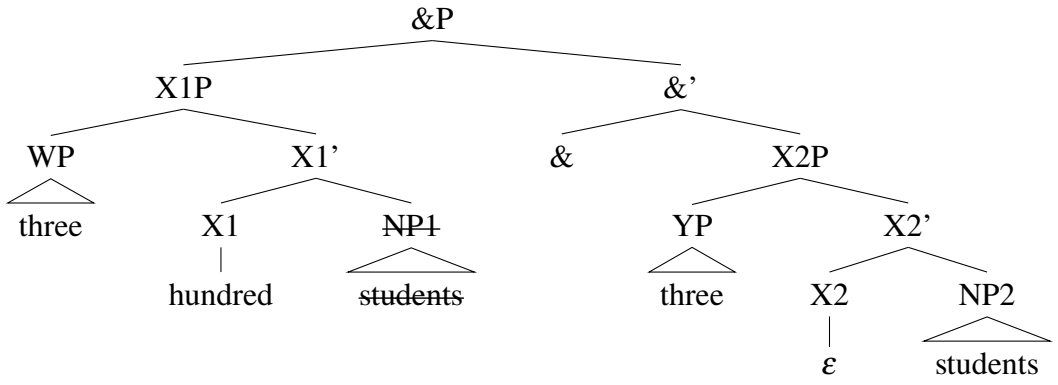


The analysis of multiplicative complex cardinals discussed in Chapter 2 is compatible with

I&M's NP coordination analysis of additive complex cardinals. As noted above, they propose that additive complex cardinals have a coordinate structure of NPs. Each conjunct in the coordinate structure is headed by the main noun, and some of them may undergo NP-deletion.

Adapting I&M's proposal regarding additive complex cardinals to the present analysis of multiplicative complex cardinals, *three hundred three girls* has the coordinate structure given in (5).

(5)



The first conjunct in (5) is headed by the multiplicand *hundred*, and the X1P has the complementation structure of multiplicative complex cardinals. In the second conjunct, the simplex cardinal *three* appears in the specifier of X2P. Recall that the covert function ε is used for simplex cardinals in non-classifier languages, as in (5).

I&M gave data from Biblical Welsh (Hurford (1975)) and Scottish Gaelic (Paterson (1989), Hurford (2003)) as supporting evidence for the NP coordination analysis. I observe that Breton also provides such supporting evidence. In Breton, the main noun precedes an overt coordinator in additive complex cardinals, as shown in (6).

(6) a. *un* ***nadoz*** *ha kant*
one needle and hundred
'101 needles'

b. *dek* ***den*** *ha kant* [Breton]
ten person and hundred
'110 people' [Press (1986: 89)]

In these Celtic languages, the main noun precedes an overt coordinator in additive complex cardinals. Under the NP-deletion analysis, the main noun in (6) can be located in the complement of the multiplicand in the first conjunct. What happens here is that the main noun in the second conjunct is deleted, but not the one in the first conjunct. Given these typological data, I basically follow I&M's NP coordination analysis of additive complex cardinals.

It is also worth noting that in Toqabaqita [Austronesian], the main noun is repeated in each digit of the additive complex cardinal, as shown in (7). Notice also that in Toqabaqita, the constituents of an additive complex cardinal can be optionally coordinated by the conjunction particle *ma* 'and'. This can be seen as additional support for I&M's NP coordination analysis of additive complex cardinals.

(7) Toqabaqita [Austronesian]: Lichtenberk (2008: 296)

teqe toqoni ***imola*** ***ma*** *roo talange-qe* ***imole*** ***ma*** *lima akwale-qe* ***imole***
one thousand person and two hundred-ASC person and five tensome-ASC person
'one thousand two hundred fifty people'

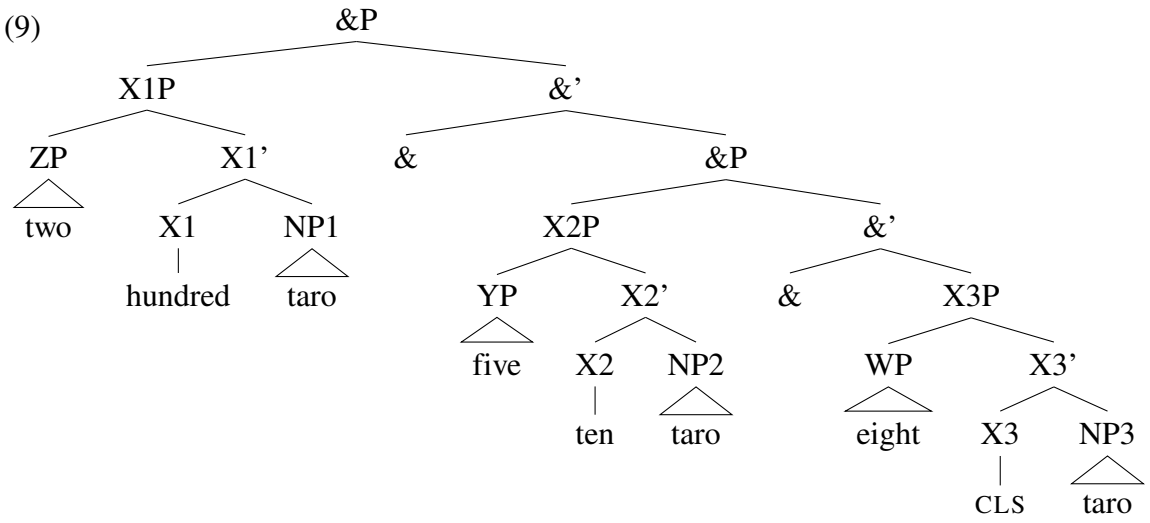
Furthermore, when an addend does not contain an overt multiplicand, the addend needs an overt classifier as in (8). If additive complex cardinals have the coordination structure, it is predicted that each main noun in (8) will appear in the numeral classifier phrase just like the last place of the complex cardinal (i.e. *kwalu fa qalo*).

(8) Toqabaqita [Austronesian]: Lichtenberk (2008: 293)

roo talanga qalo lima finita qalo kwalu fa qalo
two hundred taro five tensome taro eight CLS taro
'two hundred fifty eight taro corms'

The analysis of multiplicative complex cardinals adopted here is also compatible with the three-member additive complex cardinal in (8). The structure is given in (9).

(9)



Recall that I proposed that multiplicands and numeral classifiers are syntactic heads used for measurement. The conjuncts in (9) are thus identical in category.

There are other languages where additive complex cardinals include a classifier in a non-complex addend. As shown in (10) and (11), a numeral classifier appears in the non-complex addend in Kéo [Austronesian] and Hyow [Sino-Tibetan].

(10) Kéo [Austronesian]: Baird (2002: 234)

a. *Ha mbudu 'esa dima.*
one ten CLS five
'fifteen'

b. *Mbudu tedu 'esa wutu.*
ten three CLS four
'thirty four'

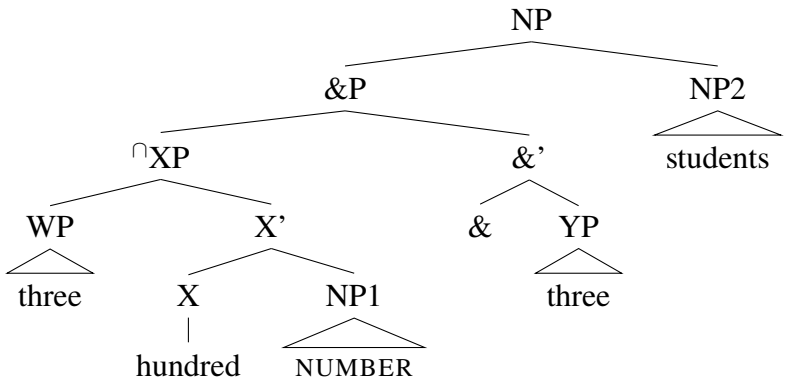
(11) Hyow [Sino-Tibetan]: Zakaria (2017: 152)

a. *èy kúl-gôl-pótsóng-hngɔ́ kí-ní-mêy-hyɔ̂.*
ANAPH.DEM twenty-and-CLS-five 1S-PL-exist-PM
'We were those twenty five learners.'

b. *èydɔ̂ á-lá=tsæ̂ khrá-ák-gól-shɔ́k-gíb-gôl-pây-thûm mítár mêy-hyɔ̂.*
then GRP-land=TOP hundred-one-and-six-ten-and-CLS-three meter_{B} exist-PM
'Then, there were one hundred and sixty three meters of land.'

One crucial difference between the analysis argued for in this chapter and I&M is that as noted in Section 3.1 the former allows for another type of coordination structure as in (12) (cf. (5)).[2]

(12)



In (12), the &P has the coordination structure consisting of two cardinal expressions of type n (∩XP and YP). It is then expected that in the structure in (12), the additive complex cardinal (&P) alone can be the target of syntactic operations. As shown in (13), this expectation is borne out. Additive complex cardinals in Serbo-Croatian can indeed be the target of LBE.[3]

2. Ionin and Matushansky (2018: 137-138) briefly discussed the possibility of an NP adjunction structure similar to (12). However, they did not pursue this type of structure for additive complex cardinals.

3. It is impossible to extract a part of the additive complex cardinal, as shown in (i). This pattern holds regardless of whether the lower numeral exhibits agreement or not as in (ii).

(i) a. *[*dvadeset*]$_1$ *je Ivan vidio* [Δ_1 (*i*) *pet*] *studenata.*
twenty is Ivan seen and five students.GEN.PL.M

b. *[*pet*]$_1$ *je Ivan vidio* [*dvadeset* (*i*) Δ_1] *studenata.*
five is Ivan seen twenty and students.GEN.PL.M

(ii) a. *[*dvadeset*]$_1$ *je Ivan vidio* [Δ_1 (*i*) *jednu*] *djevojku.*
twenty is Ivan seen and one.F.ACC girl.ACC.SG.F

b. *[*jednu*]$_1$ *je Ivan vidio* [*dvadeset* (*i*) Δ_1] *djevojku.*
one.F.ACC is Ivan seen twenty and girl.ACC.SG.F

Under the current analysis, this might be seen as a violation of the Coordinate Structure Constraint (Ross (1967)). Given that additive complex cardinals involve coordination of two numerals as in (12), it may be expected that conjuncts cannot be extracted from the coordination phrase following the Coordinate Structure Constraint. However, in a number of contexts, the Coordinate Structure Constraint can be violated in Serbo-Croatian with first conjunction extraction but not with second, as discussed by Bošković (2018, 2019, 2020), Stjepanović (2014). (See also Oda (2017) for further cross-linguistic exceptions regarding the Coordinate Structure Constraint.) The unacceptability in (i) and (ii) may not be completely clear in light of this (note also that the a=examples are better than the b-examples in (i-ii).). I will have to leave this issue for future research.

(13) Serbo-Croatian: Aida Talić and Ivana Jovović, p.c.

a. *Ivan je vidio* [*dvadeset i pet*] *studenata.*
Ivan is seen twenty and five students.GEN.PL.M
'Ivan saw twenty five girls.'

b. [*dvadeset i pet*]$_1$ *je Ivan vidio* Δ_1 *studenata.*
twenty and five is Ivan seen students.GEN.PL.M

Serbo-Croatian is a language where the main noun never appears inside of an additive complex cardinal. Therefore, it is in principle not clear whether additive complex cardinals in the language have the NP coordination structure as in (5) or the adjunction structure as in (12). However, the acceptability of (13) shows that the adjunction structure is possible in Serbo-Croatian. The data in (13) is problematic for I&M's NP coordination analysis. Under their analysis, each conjunct contains the main noun, as in (14). There is no single syntactic constituent that directly corresponds to an additive complex cardinal to the exclusion of the overt main noun (cf. the arguments against scattered deletion and remnant fronting of LBE in Serbo-Coratian discussed in Chapter 2).

(14) *I&M's NP coordination*

[$_{\&P}$ [$_{NP}$ twenty [$_{NP}$ student]] & [$_{NP}$ five [$_{NP}$ student]]]

To recapitulate, I have argued in this section that there are two types of coordination structure for additive complex cardinals. One is the coordination phrase where each conjunct is a noun phrase headed by the main noun. The other is the coordination phrase where each conjunct is a numerical phrase of type n, as in (12).

3.3 Additive complex cardinals without coordination

We have seen in the previous section that there are two types of coordination structure for additive complex cardinals. I argue in this section that additive complex cardinals can also have a non-coordinate structure which does not include the coordination head. Specifically, I propose that in the non-coordinate structure, a lower-valued cardinal ("three" in "three hundred three") can directly adjoin to a higher-valued cardinal ("three hundred" in "three hundred three"). The major motivation for the existence of the non-coordinate structure comes from the human classifier *ri* in Japanese, contracted forms of Chinese cardinals, and "21" in Polish.

3.3.1 The human classifier *ri* in Japanese

In this section, I consider human numeral classifiers in Japanese. I will show that a contextual restriction of the human classifier *ri* in Japanese provides support for the existence of non-coordinate additive complex cardinals. Japanese is an obligatory classifier language, and numerals must co-occur with an appropriate classifier to modify a noun phrase. Japanese has two classifiers for common nouns referring to human beings; *nin* and *ri*. Crucially, the classifier *ri* has a contextual restriction regarding the type of a cardinal it combines with. It co-occurs with the native Yamato cardinals *hito* 'one' and *huta* 'two' as in (15a), but not with the Sino-Japanese cardinals *ichi* 'one' and *ni* 'two', as shown in (15).

(15) Japanese

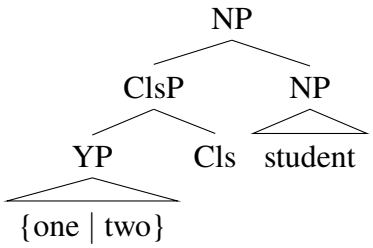
a. {*hito* | *huta*}-*ri*-*no* *gakusei*
one two-CLS-GEN student
'{one | two} student(s)'

b. {**ichi* | **ni*}-*ri*-*no* *gakusei*
one two-CLS-GEN student
'{one | two} student(s)'

Regarding Japanese numeral classifiers, I assume that they are functional heads for mea-

surement. The noun phrase in (15a) thus has the following structure. (See Saito and Murasugi (1990) and Huang and Ochi (2014) for the adjunct status of pre-nominal numeral classifier phrases in Japanese.)

(16) (= 15a)



In Japanese, when a nominal modifier precedes a noun phrase, the genitive linker *no* occurs between the pre-nominal modifier and the noun phrase (e.g. *gengogaku-no gakusei* linguistics-GEN student 'students of linguistics'). Following Kitagawa and Ross (1982), and Watanabe (2006), I assume that the genitive linker *no* is morphologically inserted.

I propose that the classifier *ri* is selected as an exponent of the classifier head when *hito* and *huta* are a sister of the classifier head dedicated to human beings. In (16), the simplex cardinal (YP) is a sister of the classifier phrase (ClsP), and the relevant contextual restriction holds between them.

Crucially, the contextual restriction is violated when a cardinal occurs in an additive complex cardinal, as in (17a). In this environment, the classifier *nin*, which is the elsewhere exponent of the classifier head dedicated to human beings (Watanabe (2010, 2014)), must be used together with the Sino-Japanese cardinals, as shown in (17b).

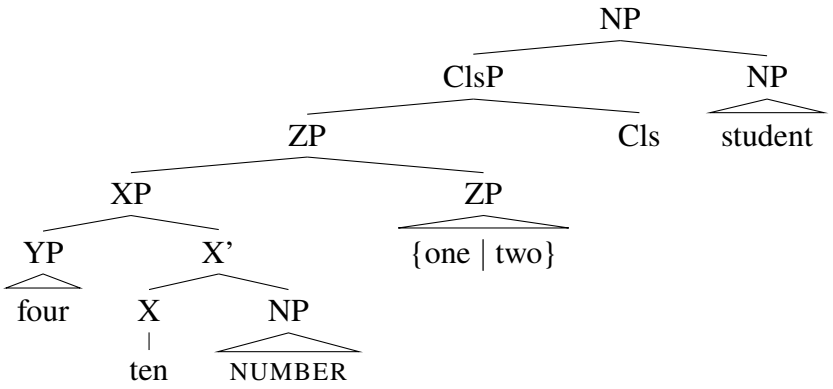
(17) a. [*yon-zyuu* {**hito* | **huta*}]-*ri-no* *gakusei* [Japanese]
four-ten one two -CLS-GEN student
'forty {one | two} students'

b. [*yon-zyuu* {*ichi* | *ni*}]-*nin-no* *gakusei* [Japanese]
four-ten one two -CLS-GEN student
'forty {one | two} students'

Under the NP-coordination analysis, additive complex cardinals involve coordination of noun phrases headed by the main noun. This means that the additive complex cardinals in (17) contain the structure in (16) as one of the conjuncts. The NP-coordination analysis then predicts that the numeral "one" and "two" in (17) behave exactly like the numerals in (15), contrary to the fact. The NP-coordination analysis thus does not expect the contrast between (15) and (17).

However, if a non-coordinate structure is available for Japanese additive complex cardinals, the contrast in question can be accounted for. Specifically, (17a) can be captured by assuming that it has the non-coordinate structure as in (18).

(18) Non-coordinate additive complex cardinal



In (18), the higher-valued cardinal (i.e. XP) is an adjunct of the lower-valued cardinal (i.e. ZP). Since the lower-valued cardinal is not a sister of the classifier head in (18), the relevant contextual restriction between them is violated. This problem does not arise when *hito* or *huta* are used as simplex cardinals because they are sisters of the classifier head dedicated to human beings, as shown in (16). The contrast between (15a) and (17a) can thus be seen as a piece of evidence for the existence of a non-coordinate structure of additive complex cardinals.

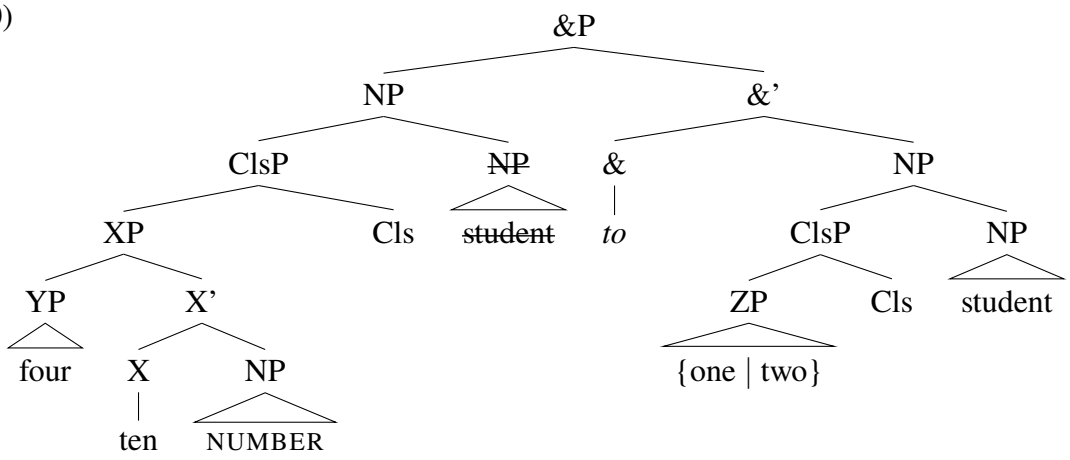
It should be noted here that it seems that Japanese additive complex cardinals can have the coordinate structure in some cases. As shown in (19), Japanese additive complex

cardinals can contain the overt coordinator *to* 'and' (Hiraiwa (2016b)). What is important is that the contextual restriction of the classifier *ri* is respected in the presence of *to*.

(19) [*yon zyuu to* {*hito* | *huta*}]-*ri-no* *gakusei* [Japanese]
four ten and one two -CLS-GEN student
'forty and {one | two} students'

I assume that when an additive complex cardinal contains the overt coordinator, it has the coordinate structure as in (20).

(20)



The noun in (19) can be treated as a case of NP-coordination. In (20), the lower-valued cardinal (YP) is a sister of the classifier head in the second conjunct. The contextual restriction is therefore satisfied in (20). (The Japanese conjunctive particle *to* appears between two nominal conjuncts. (e.g. *Yuta to Hiro* 'Yuta and Hiro'))

Ionin and Matushansky (2018) propose that additive complex cardinals generally involve coordinate structures. In some languages, a coordinator can be overtly realized in additive complex cardinals. However, the absence of an overt coordinator does not reflect the syntactic absence or presence of the coordinator under their analysis. In fact, the presence/absence of an overt coordinator seems to be superficial in some languages such as Serbo-Croatian, as discussed in Section 5. However, I showed in this section that

Japanese additive complex cardinals have different syntactic structures, depending on the presence/absence of an overt coordinator, which makes a significant difference regarding morphosyntactic behaviors.

3.3.2 Contracted forms in Mandarin Chinese

Contracted forms of Chinese cardinals also offer supporting evidence for the existence of non-coordinate additive complex cardinals. Chinese is an obligatory classifier language, and a cardinal must appear with an appropriate classifier when it modifies a noun, as shown in (21).

(21) *san* *(*tiao*) *xianglian* [Mandarin]
three CLS necklace
'three necklaces'

Mandarin Chinese has a contracted form consisting of *san* 'three' and the general classifier *ge*, as shown in (22b).[4]

(22) a. *san-ge xuesheng*
three-CLS student
'three students'

b. *sa xuesheng* [Mandarin]
three.CLS student
'three students'

However, as observed by He (2015), the contracted form cannot appear in additive complex cardinals, as in (23).

(23) a. [*sishi san*]-*ge xuesheng*
forty three-CLS student
'forty three students'

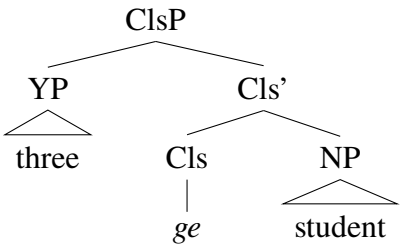
b. *[*sishi sa*] *xuesheng* [Mandarin]
forty three.CLS student
'forty three students'

I propose that Chinese additive complex cardinals have the non-coordinate structure. First,

4. *liang* 'two' also has a contracted form; *lia*. Since *lia* behaves like *sa*, I use examples with *sa* in this chapter.

let us consider the simplex cardinal in (22). I assume that the noun in (22a) has the structure represented in (24).[5] Here, the numeral "three" appears in the specifier position of the phrase headed by the numeral classifier *ge*.

(24)



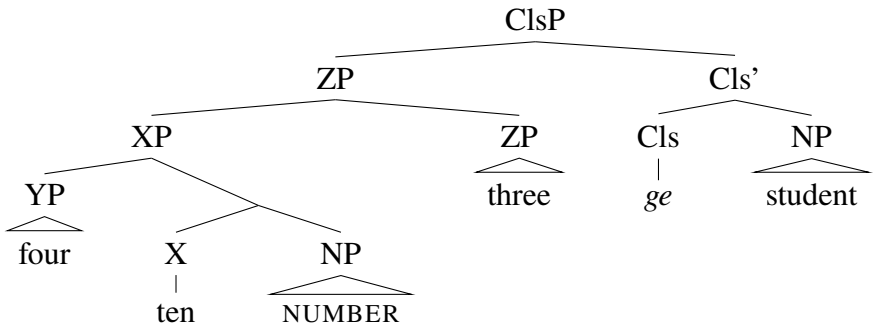
I propose that *san* 'three' and the classifier *ge* can be fused only when they are in a Spec-Head relation as stated in (25).[6]

(25) A numeral and the classifier *ge* can be fused only when they are in a Spec-Head relation.

In (24), the cardinal (YP) and the classifier head (Cls) can undergo morphological fusion without any problems because they are in the Spec-Head relation.

On the other hand, when *san* 'three' appears inside an additive complex cardinal, *sishi* 'forty' and *san* 'three' form a constituent, resulting in the non-coordinate structure in (26).[7]

(26)



5. For a detailed syntactic analysis of Chinese classifier phrases, see Zhang (2013) and references therein.
6. Mandarin Chinese also has the contract form for the numeral *liang*; *liang-ge* 'two-CLS' ⇒ *lia*. This contract form is also subject to (25).
7. This is the approach taken by He (2015) although the details are different.

In (26), the multiplicative complex cardinal "forty" adjoins to ZP, and morphological fusion cannot take place because the phrase headed by *san* 'three' and *ge* are not in a Spec-Head relation. The unavailability of a contracted form can thus be captured by assuming that additive complex cardinals have the non-coordinate structure in Chinese.

Support for the current analysis of the contracted form in Mandarin given in (25) comes from approximative numerals. As shown in (27), the contraction of a numeral and the classifier *ge* is blocked when the numeral is used as a part of an approximative number construction.

(27) *Approximative numbers in Mandarin*: Shuyan Wang, Ting Xu, Muyi Yang, p.c.

a. *liang san-ge xuesheng*
two three-CLS student
'two or three students'

b. **liang sa xuesheng*
two three.CLS student
'two or three students'

Regarding the syntax of the approximative construction like (27a), I propose that it contains the sequence of classifier phrases. Recall that Mandarin Chinese has two forms of the numeral "two"; *liang* and *er*. *Liang* functions as a cardinal appearing in a classifier phrase. However, it cannot perform other functions such as an addend in additive complex cardinals, counting numbers and ordinals. The relevant examples are repeated below.

(28) *Classifier phrases in Mandarin*

a. **er-ge xuesheng*
two-CLS student
'two students'

b. *liang-ge xuesheng*
two-CLS student
'two students'

(29) *Additive complex cardinals in Mandarin*

a. *si shi er-ge xuesheng*
four ten two-CLS student
'forty two students'

b. **si shi liang-ge xuesheng*
four ten two-CLS student
'forty two students'

(30) *Ordinals in Mandarin*

a. *di er-ge xuesheng*
ORD two-CLS student
'the second student'

b. **di liang-ge xuesheng*
ORD two-CLS student
'the second student'

In this respect, the fact that *liang* can appear in the approximative construction as in (27) is notable. As shown in (31), *er* cannot be used in the approximative construction.

(31) *Approximative numbers in Mandarin*: Shuyan Wang, Ting Xu, Muyi Yang, p.c.

**er san-ge xuesheng*
two three-CLS student
'two or three students'

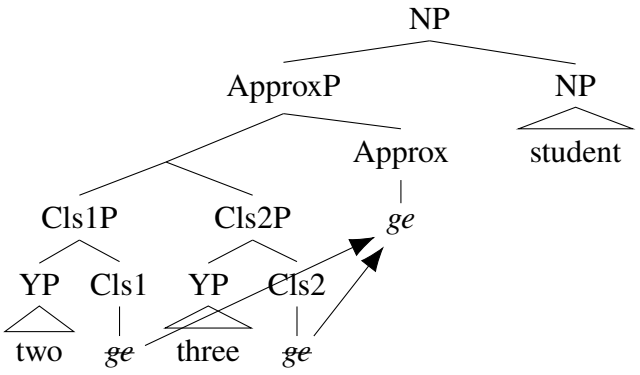
The contrasts between *liang* and *er* are summarized in (32).[8]

(32)

	Numeral	Addend	Cardinal	Ordinal	Approximative
liang	*	*	✓	*	✓
er	✓	✓	*	✓	*

Based on the contrast in (32), I assume that *liang* in the approximative construction in (27) functions as a cardinal. To be more precise, I propose that the approximative construction contains sequential classifier phrases as shown in (33).

(33)



8. I will discuss the syntax of ordinals in Chapter 4.

In (33), the Approximative head (Approx) is located above two classifier phrases. The numeral classifiers then undergo Right Node Raising to the Approx head.[9] One piece of supporting evidence for (33) comes from insertion of the linking element *de*. Li and Rothstein (2012) take the presence of the particle *de* as a hallmark of the left branching structure of classifier phrases. As shown in (33), under the present analysis, a classifier phrase appearing in the approximative construction has a left-branching structure, and hence should allow insertion of *de*. This predication is borne out as in (34a). Typical classifier phrases, which have the complementation structure under the current analysis, disallow *de* as in (34b).

(34) *Insertion of de in Mandarin*: Shuyan Wang, Muyi Yang, p.c.

a. *liang san-ge de xuesheng*
two three-CLS DE student
'two or three students'

b. **san-ge de xuesheng*
three-CLS DE student
'three students'

Furthermore, the relevant approximative construction overtly contains classifier phrases in some other classifier languages. In Kadu, each sequential number appears with a numeral classifier as shown in (35).

(35) Kadu [Sino-Tibetan]: Sangdong (2012: 239)

a. *hanīng =ká sóm-hú shì-kaú-tóng =lamà.*
2.PL =TOP three-CLS.person four-CLS.person-big =MIR
'You are three or four people.'

b. *hú-à kalìng-hú sóm-hú nāng =mā -ták.*
CLS.person-one two-CLS.person three-CLS.person go =RLS =HS
'A few people went there.'
Lit. 'one person, two persons, and three persons went there.'

9. See Kornfilt (2012) for an independent analysis where suspended affixation in Turkish involves Right Node Raising.

In Lisu and Burmese, the presence of a numeral classifier for the first cardinal is optional, as shown in (36) and (37).

(36) Lisu [Sino-Tibetan]: Roop (1970: 57)

a. *nyì-zū sà-zū*
two-CLS.person three-CLS.person
'two or three people'

b. *nyì-sà-zū*
two-three-CLS.person
'two or three individuals'

(37) Burmese [Sino-Tibetan]: Soe (1999: 64)

a. *htamin: lei: lou' nga: lou'*
rice four CLS.mouth five CLS.mouth
'four or five mouthfuls of rice'

b. *htamin: lei: nga: lou'*
rice four five CLS.mouth
'four or five mouthfuls of rice'

In Taba [Austronesian], each sequential number must co-occur with a numeral classifier as in (38).

(38) Taba [Austronesian]: Bowden (1997: 250-251)

a. **kapaya p-tol pa hot*
pawpaw CLS-three or four
'three or four pawpaws'

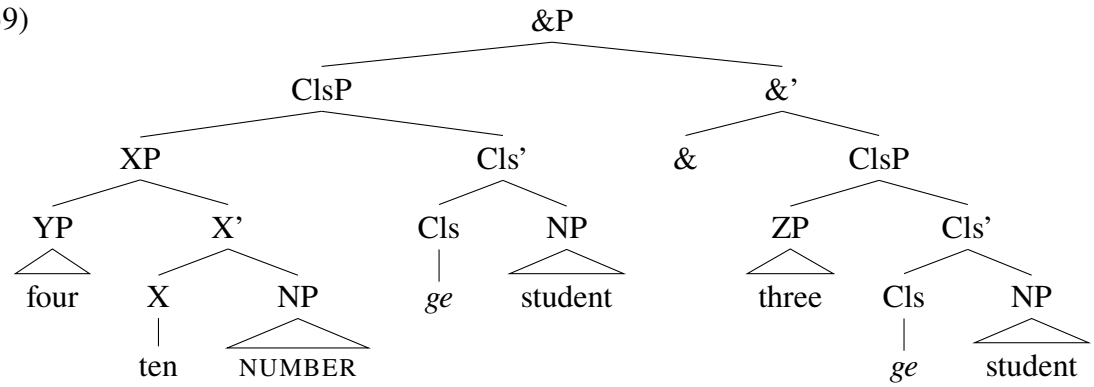
b. *kapaya p-tol pa p-hot*
pawpaw CLS-three or CLS-four
'three or four pawpaws'

These typological data can be seen as support for the current analysis of the approximative construction given in (33). The difference among languages above rests on whether Right Node Raising (i.e. suspended affixation, see footnote 8) takes place in the approximative construction. In Lisu and Burmese, it is optional but it is obligatory in Mandarin Chinese. On the other hand, Right Node Raising of numeral classifiers is unavailable in Taba.

Crucially, as shown in (33), Right Node Raising breaks the Spec-Head relation between the cardinal "three" (YP) and the classifier head *ge*. The morphological contraction is thus blocked in this structure, giving rise to the unacceptability of (27)[10], because of the violation of the Spec-Head requirement given in (25).

It should be noted here that the coordinate structure of additive complex cardinals should be unavailable in Chinese. If the coordinate structure as in (39) were available in Chinese additive complex cardinals, it would be expected that the numeral "three" and the general classifier *ge* should be able to undergo morphological fusion, contrary to the fact. This is because the cardinal "three" and the numeral classifier are in a Spec-Head relation in the second conjunct of the NP-coordination structure in (39).

(39)



Note also that Chinese additive complex cardinals do not allow the presence of an overt coordinator, as in (40), in contrast to Japanese additive complex cardinals.

(40) **sishi he san-ge xuesheng* [Mandarin]
forty and three-CLS student
'forty three students'

The unacceptability of (40) then confirms that the coordinate structure of additive complex cardinals is unavailable in Chinese.

10. Kornfilt (2012) also discusses some syntactic effects in suspended affixation, arguing for the Righnt Node Raising analysis of suspended affixation.

3.3.3 "21" in Polish

Support for the non-coordinate structure also comes from a non-classifier language; Polish. In Polish, the cardinal "one" is normally adjectival, and shows agreement with a noun in number, case and gender, as shown in (41a). However, when the cardinal "one" appears in an additive numeral, the agreement is blocked, as shown in (41b).

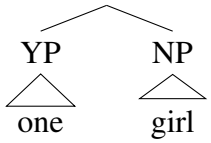
(41) a. *Jan zobaczył* {**jeden* | *jedną* } *dziewczynę.* [Polish]
Jan saw one.NOM.M one.ACC.F girl.ACC.SG.F
'Jan saw one girl.'

b. *Jan zobaczył dwadzieścia* { *jeden* | **jedną* } *dziewcząt.*
Jan saw twenty.NV.ACC one.NOM.M one.ACC.F girl.GEN.PL
'Jan saw twenty-one girls.' (Asia Pietraszko, p.c.)

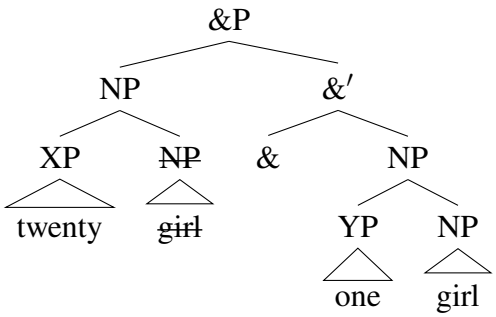
Ionin and Matushansky (2018) assume that cardinals are phrasal adjuncts (similar to adjectives) when they agree with the head noun. Following their analysis, I assume the object noun in (41a) has the structure in (42a). The cardinal "one" in (41a) agrees with the noun, and it is analyzed as an adjunct of the head NP.

The cardinal "one" in (41b) cannot be analyzed in the same way. If the object noun in (41b) could have a coordinate structure, it would have the structure in (42b).

(42) a.



b.



In the second conjunct of (42b), the cardinal "one" and the noun phrase form a constituent.

Since the second conjunct in (42b) is identical to (42a), it is expected that the cardinal "one" in (42b) should behave like the cardinal "one" in (42a) regarding agreement, contrary to the fact. Therefore, we need another analysis for the additive complex cardinal in (41b).

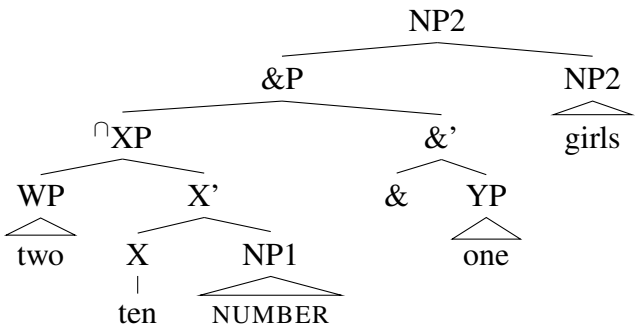
It should be noted that the coordination of numerical phrases as in (12) also does not expect the unacceptability of the agreeing form of "one" in (41b). I proposed that additive complex cardinals in Serbo-Croatian have the coordination phrase in which each conjunct is a numerical phrase, based on the fact that additive complex cardinals in Serbo-Croatian can undergo LBE while leaving the main noun in situ. In this respect, Polish also allows for fronting of an additive complex cardinal, as shown in (43).

(43) Polish: Paulina Lyskawa, p.c.

[*Dwadzieścia jeden*]$_1$ *Jan zobaczył* Δ_1 *dziewcząt.*
twenty.NV.ACC one.NOM.M Jan saw girl.GEN.PL
'Jan saw twenty-one girls.'

I take the acceptability of (43) as evidence that additive complex cardinals in Polish have the coordinate structure of numerical expressions, similarly to Serbo-Croatian, as represented in (44). Here, the coordination phrase can be the target of LBE.

(44)



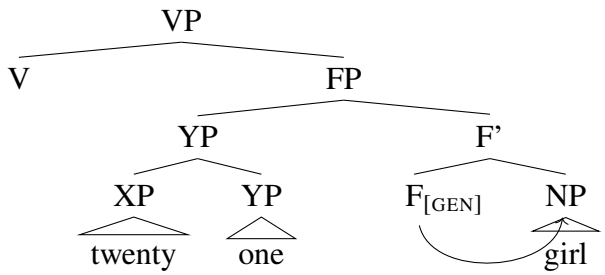
Importantly, the cardinal "one" in Serbo-Croatian agrees with the main noun, even when it appears in an additive complex cardinal, as shown in (45).

(45) *Peter je vidio dvadest* (*i*) *jednu djevojku.* [Serbo-Croatian]
Peter is seen twenty and one.F.ACC girl.F.ACC.SG
'Peter saw twenty one girls.'

Since the extraction test indicates that additive complex cardinals in Polish and Serbo-Croatian have the coordinate structure of numerical expressions as in (44), it is expected that additive complex cardinals in Polish will also behave like Serbo-Croatian regarding agreement. Given this, the unavailability of the agreeing form of "one" in Polish (i.e. (41b)) cannot be attributed to the coordinate structure in (44).

In order to account for the agreement pattern in (41b), I propose that the object noun in (41b) has the non-coordinate structure, as represented in (46).

(46)



In (46), the higher-valued cardinal (i.e. XP) adjoins to the lower-valued cardinal "one", without involving coordination. In (46), the cardinal "one" is not a modifier of the main noun "girl", and does not receive the relevant feature specifications via agreement from "girl". As a result, the non-agreeing form *jeden* must be used in (46).

It should be noted here that the head noun "girl" in (41b) receives the so-called genitive of quantification (GQ). With regard to case marking, I assume that genitive of quantification in Polish is an inherent case assigned by a functional head, which I refer to as F for expository purposes. Slavic languages differ as to whether they treat genitive of quantification as structural or inherent case (see Franks (1994, 1995), Bošković (2006, 2013) for detailed discussion). Although the status of Polish in this respect is controversial (Franks

(1995)), I assume, following Franks (1995), that genitive of quantification in Polish is an inherent case assigned by a functional head.

In (46), the main noun receives genitive case from F and accusative case from the verb. When a single noun bears a structural case and an inherent case, the conflict is resolved by realizing the inherent case. (This essentially follows Franks (1994); Bošković (2006)). In (46), NP2 therefore exhibits genitive of quantification. Recall that when the cardinal "one" alone is used as a simplex cardinal, it has the adjunction structure given in (42a). In (42a), the cardinal "one" is an adjunct of the NP. Similarly to adjectives, it exhibits agreement with the NP.[11]

To recapitulate, I proposed in this section that the agreement pattern in Polish (41) can be explained by assuming the non-coordinate structure of additive complex cardinals, as in (46).

3.3.4 More on additive complex cardinals in Slavic languages

Before concluding the chapter, I will discuss briefly complex cardinals in other Slavic languages. This is because the agreement pattern of "21" in Polish is somewhat peculiar. It is important to note that I am not claiming that all additive complex cardinals in Polish have the non-coordinate structure as in (46). The opacity of the lower-valued cardinal is observed only when the cardinal "one" is used in Polish. For instance, the paucal cardinal "two" agrees with the overt head noun, even when it occurs in an additive complex cardinal as in (47b).

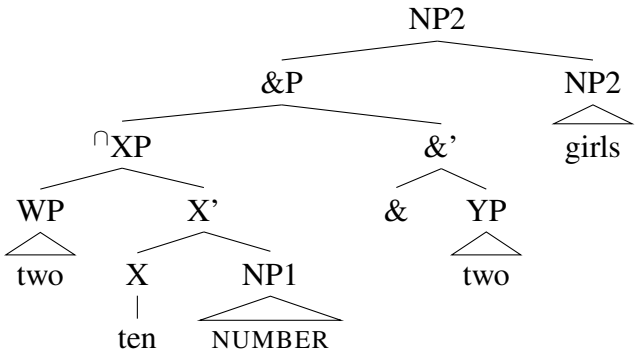
(47) a. *Jan zobaczył dwie dziewczyny.* [Polish]
Jan saw two.ACC.F girl.ACC.PL.F
'Jan saw two girls.'

11. I assume that when there is no genitive of quantification, F is not present in the structure.

b. *Jan zobaczył dwadzieścia dwie dziewczyny.* [Polish]
Jan saw twenty.NV.ACC two.ACC.F girl.ACC.PL.F
'Jan saw twenty-two girls.'

The agreement pattern in (47b) can be captured under the current analysis. The object noun phrase in (47b) has the coordinate structure represented in (48).

(48)



Recall that I do not deny the existence of the coordinate structure. In (48), the lower-valued cardinal "two" form a coordination phrase together with the multiplicative complex cardinal. I assume that what is peculiar about the cardinal "one" in Polish is that it cannot occur in the coordinate structure as in (48).

A question immediately arises as to why only the cardinal "one" in Polish exhibits the peculiar behavior. Let me mention one potentially relevant factor. The presence of an overt coordinator is optional in Serbo-Croatian, as shown in (45). On the other hand, the cardinal "one" in Polish disallows the presence of an overt coordinator when it occurs in an additive complex cardinal. A relevant example is given below.

(49) **Jan zobaczył dwadzieścia i jeden dziewcząt.* [Polish]
Jan saw twenty.NV.ACC and one.NOM.M girl.GEN.PL.F
Int. 'Jan saw twenty-one girls.'

When "one" is used as an addend in an additive complex cardinal, the overt coordinator *i*

'and' cannot intervene between the two cardinals in Polish. Under my analysis, the unacceptability of (49) can be taken to indicate that the cardinal "one" cannot occur in the coordination structure in Polish, unlike "one" in Serbo-Croatian. (Note also that the numeral "one" does not exhibit the peculiar behavior regarding agreement in other Slavic languages such as Russian.) In light of this, I suggest here that "21" in Polish exhibits the peculiar behavior because the cardinal "one" in Polish is incompatible with the coordination structure of numerals. The typological variation of additive complex cardinals may thus be related to the nature of coordinators in a given language, but I leave further examination of the variation for future research.[12]

3.3.5 More typological support for the non-coordinate structure of additive complex cardinals

So far, I have shown that the two types of structure are available for additive complex cardinals cross-linguistically. Mandarin Chinese allows only for the non-coordinate structure. In Polish, the cardinal "one", but not other cardinals, is compatible only with the non-coordinate structure. Japanese additive complex cardinals have either the coordinate structure or the non-coordinate structure depending on the presence of an overt coordinator.

There are other languages which allows the two types of structures of additive complex cardinals like Japanese. For instance, Kikuyu/Gĩkũyũ [Niger-Congo] has two types of additive complex cardinals as in (50).

(50) Kikuyu/Gĩkũyũ [Niger-Congo]: Li (2015: 46-47)

12. It is worth noting that additive complex cardinals containing the coordinator *i* 'and' become slightly better when the lower-valued numeral is higher than "one", as in (i).

(i) ?**Jan zobaczył dwadzieścia i dwie dziewcząt.* [Polish]
Jan saw twenty.NV.ACC and two.ACC.F girl.GEN.PL.F
'Jan saw twenty two girls.' [Paulina Lyskawa, p.c.]

a. *tũ-gui* *i-gana* *na* *mĩ-rongo* *ĩ-ĩrĩ.*
NC_{13}-dog NC_5-hundred and NC_4-set.of.ten AC_4-two
'a hundred twenty puppies'

b. *tũ-gui* *i-gana* *rĩ-a* *mĩ-rongo* *ĩ-ĩrĩ.*
NC_{13}-dog NC_5-hundred AC_5-ASSOC NC_4-set.of.ten AC_4-two
'a hundred twenty puppies'

In (50), NC stands for noun class markers. As shown in (50a), the overt coordinator *na* 'and' can appear in the additive complex cardinal. In this case, the augend "hundred" and the addend "twenty" have their own noun classes, independently of the noun class of the main noun. Another type of additive complex cardinals in Kikuyu/Gĩkũyũ is given in (50b). Here, instead of the coordinator *na*, the associative marker *a* is used. The associative marker appears with the agreement class marker (AC) of the augend, which agrees with the multiplicand *i-gana* '$_5$-hundred', but not with the main noun *tũ-gui* 'NC_{13}-dog'.

The associative construction in Kikuyu/Gĩkũyũ is used to combine two nominal elements, especially when the second noun functions as some sort of a modifier of the first noun. Li (2015: 49) reports that "the associative construction can be used in Gĩkũyũ to 1) indicate possession, 2) indicate location, 3) form non-adjectival expressions of attribution, and 4) form ordinal numerals." Some examples are given below.

(51) Kikuyu/Gĩkũyũ [Niger-Congo]: Li (2015: 50-51)

a. *mũ-arĩ* *ũ-a* *maitũ* [Possession]
NC_1-daughter AC_1-ASSOC NC_{1a}.mother
'my sister' (Lit. 'daughter of my mother')

b. *i-rigũ* *rĩ-a* *cukari* [Attributive]
NC_5-banana AC_5-ASSOC NC_{14}.sugar
'a sweet banana' (Lit. 'banana of sugar')

What is important is that the agreement class marker to which the associative *a* attaches agrees with the modified noun in the attributive constructions. Recall that in (50b), the agreement class marker combined with the associative stem agrees with the multiplicand "hundred", not with the main noun. I take this pattern of agreement as evidence that the addend in (50b) is a modifier of the augend, in parallel with the attributive construction given in (51), as represented in (52).

(52) a. [hundred *rĩ-a* twenty] 'one hundred twenty'

b. [banana *rĩ-a* sugar] 'sweet banana/banana of sugar'

The current analysis of additive complex cardinals, in which the two types of structures are available for additive complex cardinals, can capture additive complex cardinals in Kikuyu/Gĩkũyũ. In particular, the additive complex cardinal in (50b) is analyzed as involving modification of the augend by the addend without resorting to coordination (hence the coordinator is not present). On the other hand, the additive complex cardinal in (50a) has the coordinate structure with the coordination particle *na* 'and'. Thus, Kikuyu/Gĩkũyũ allows two types of additive complex cardinals like Japanese.

The contrast between the coordinate and the non-coordinate complex cardinals can also be observed in German. Stolz (2002) reports that in German, the cardinal *ein* 'one' requires the main noun to be singular even when it is used as an addend of an additive complex cardinal as in (53a). However, the main noun can be plural when the the cardinal *ein* 'one' appears in a compound additive complex cardinal without the overt coordinator.

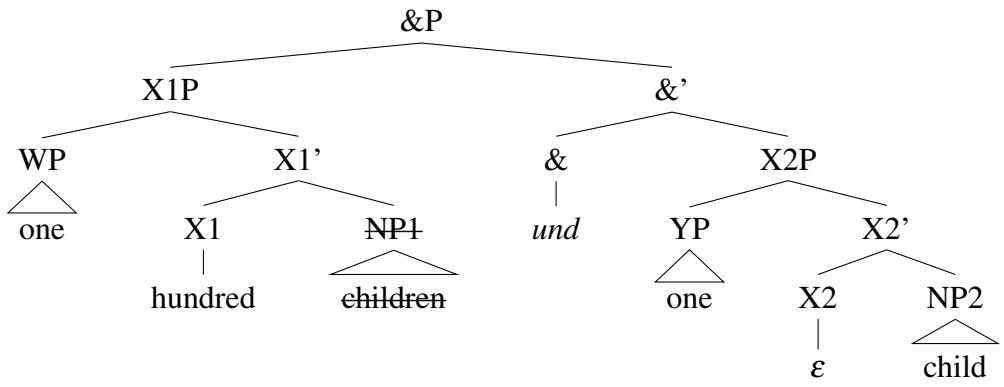
(53) German: Stolz (2002: 357)

a. *ein-hundert und ein* {*Kind* | **Kinder*} *saßen im Palast*
one-hundred and one child children sit in palace
'One hundred and one children were sitting in the palace.'

b. *ein-hundert-ein Kinder saßen im Palast*
one-hundred-one children sit in palace
'One hundred and one children were sitting in the palace.'

The contrast in (53) can be accounted for under the present analysis. Recall that in Chapter 2, I argued that multiplicative complex cardinals in German have the complementation structure and disallow the adjunction structure, on the basis of data regarding split topicalization. The additive complex cardinal in (53a) thus has the coordinate structure in (54).

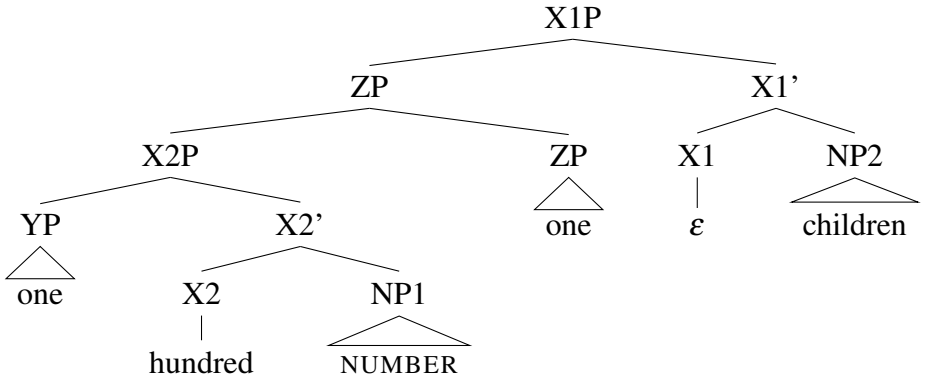
(54)



In the second conjunct of the coordinate structure in (54), the main noun and the cardinal *ein* 'one' exhibit singular agreement, which rules out the plural form of the main noun.

The present analysis also allows for the non-coordinate structure for the additive complex cardinal in (53b). The non-coordinate structure is given in (55).

(55)



In (55), the main noun shows agreement with the whole additive complex cardinal (i.e. the higher ZP), which results in the plural form. The phrase headed by the numeral "one" (the lower ZP) and the main noun are dissociated, unlike the numeral "one" in (54). On the present account, the presence of the coordinator *und* is thus seen as a hallmark of the coordinate structure.

3.4 Chapter summary

In this chapter, I first argued that there are two types of coordination structure for additive complex cardinals, building on I&M's analysis of additive complex cardinals. One is the coordination phrase where each conjunct is a noun phrase headed by the main noun. The other is the coordination phrase where each conjunct is a numerical phrase of type n. I have also argued that in addition to these coordinate structures, additive complex cardinals can also have a non-coordinate structure, which does not include the coordination head. Ionin and Matushansky (2018) argue that additive complex cardinals in general involve a coordinate structure. However, I have shown in this chapter that additive complex cardinals in some languages behave differently depending on the presence/absence of an overt coordinator. This pattern is not expected under Ionin and Matushansky's analysis. The contracted form in Chinese also posits a problem for their analysis. Support for the existence of the non-coordinate structure also comes from a non-classifier language, Polish. I also provided typological data which indicate the possibility of the availability of the coordinate and the non-coordinate structures in a single language. In particular, I discussed additive complex cardinals in Japanese, Kikuyu/Gĩkũyũ and German. All the data discussed in this chapter can be accounted for by assuming the non-coordinate structure of additive complex cardinals, in addition to the coordinate structure.

Chapter 4

Ordinal numbers

4.1 Introduction

This chapter investigates derivational patterns of ordinal numbers (henceforth ordinals) on the basis of results of a broad crosslinguistic survey. Recall that I distinguish the following types of numerical expressions in this thesis.

(1) a. **Numbers**: mathematical/arithmetic concepts.
(E.g. 3 + 4 = **7**)

b. **Numerals**: linguistic expressions corresponding to numbers.
(E.g. *Three plus four is **seven***. or counting numbers *one, two, three, four, ...*)

c. **Cardinals**: numerals used to express the cardinality of sets.
(E.g. ***seven** books*)

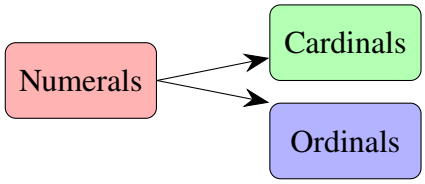
d. **Ordinals**: numerals used to express an ordering property.
(E.g. *the **seventh** book*)

I represent numbers using double quotes, distinguishing it from numerals represented in italics. For instance, "three" is a number, but *three* is a numeral in English. I use double

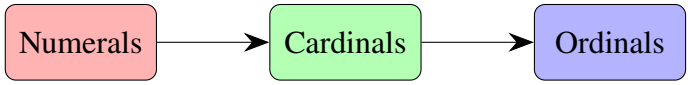
quotes for numbers because Arabic figures (e.g. 1, 2, 3, etc.) are used for numbering of chapters, sections, examples and footnotes.

Given the classification in (2), a question arises regarding derivational patterns. In this chapter, I will investigate the derivational patterns given in (2).

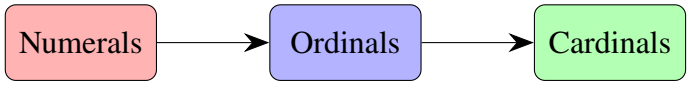
(2) a.



b.



c.



I take it for granted that bare numerals are the most fundamental linguistic expression for numbers following (1). Cardinals and ordinals may then be expected to be derived from numerals. This is in fact represented in (2). In (2b), cardinals are derived from numerals, and then becomes ordinals. (2c) is the opposite pattern of (2b). Ordinals are derived from numerals and then cardinals are formed based on the derived ordinals. In (2as), cardinals and ordinals are independently derived from numerals, and hence there is no direct derivational relationship between cardinals and ordinals.

Not many languages in fact morphophonologically distinguish numerals and cardinals. In this thesis, I refer to numerical expressions used in counting numbers and arithmetic statements as numerals. Cardinals are typically used with a lexical noun to express the cardinality of the set denoted by the lexical noun. If a given language uses a different numerical expression in these contexts, the language distinguishes numerals from cardinals. English does not distinguish numerals and cardinals as shown in (3). Mandarin Chinese, on the other hand, distinguishes numerals and cardinals in the number "two". The numeral

er is used in counting numbers as in (4a), but not in the cardinal context.[1] In contrast, the cardinal *liang* must be used in the cardinal context as in (4b).

(3) English

a. ***one, two, three*** *..., etc.* [Numeral context]

b. ***one*** *book,* ***two*** *books,* ***three*** *books ..., etc.* [Cardinal context]

(4) Mandarin

a. ***yi***, {***er*** | ****liang***}, ***san***, *..., etc.* [Numeral context]

b. [***yi*** *ben shu*], [{****er*** | ***liang***} *ben shu*], [***san*** *ben shu*], *..., etc.*
one CLS book two two CLS book three CLS book [Cardinal context]

Regarding derivational patterns of ordinals, it has been argued that ordinals are derived from cardinals (Stampe 1976, Veselinova 1998, Stolz & Veselinova 2013). However, previous studies are based mainly on data from non-classifier languages (e.g. English) where the distinction between numerals and cardinals in the sense defined in (2) is not completely clear in most cases.[2]

Within this context, this chapter will examine derivational patterns of ordinals in natural languages based on results of a crosslinguistic investigation. I first divide my language sample into two types: classifier languages and non-classifier languages. By classifier languages, I mean languages in which numerals can/must co-occur with a classifier to modify a noun (i.e. the sample includes both optional and obligatory classifier languages). The typological distinction between classifier and non-classifier languages has received a lot of attention in the literature (Krifka (1995), Chierchia (1998), Borer (2005), Bale and Coon (2014), Sudo (2016), a.o.). What is important for the purposes of the present chapter is

1. Note however that *er* can appear in a cardinal context when it is a part of a complex cardinal; *er-shi ben shu* 'two-ten CLS book = twenty books' and *si shi er ben shu* 'four ten two CLS book = forty two books'. The numeral *er* in these contexts is discussed in Chapter 2 and Chapter 3, respectively.
2. The distinction between numerals and cardinals are observed in some cases; e.g. *eins* and *ein*(*e*) in German (Huford 1987, 2001)

that numeral classifiers appear when numerical expressions are used in the cardinal context (i.e. (1c)) in classifier languages. In other words, the distinction between numerals and cardinals has overt manifestation by the presence of numeral classifiers in classifier languages. Classifier languages thus provide an important clue to the derivational patterns of numerical expressions, as discussed in Section 4.3.

In many languages, ordinals appear with certain markers. For instance, the suffix *-th* is used as an ordinal marker in English. However, the definition of an ordinal marker is not clear in some cases, which becomes an issue when carrying out a broad cross-linguistic survey. This is because elements used for ordinal numbers are multi-functional in some languages. For example, English makes use of *-th* as an ordinal marker for numerals higher than *three*. However, English ordinals also require the definite article *the* in most cases. It seems reasonable to identify the suffix *-th* as an ordinal marker. However, one may still consider whether it is possible and desirable to count the definite article *the* as (part of) an ordinal marker in English because it also co-occurs with ordinals. Given this, I adopt the following guideline to identify ordinal markers in a given language when relevant data are available.

(5) *Identifying ordinal markers*

a. Is the target element used exclusively for ordinal numbers?

   YES ⇒ The element is an ordinal marker.

   NO ⇒ (5b)

b. Can the target element be omitted while keeping the meaning of ordinal numbers?

   YES ⇒ The element is not an ordinal marker.

   NO ⇒ The element is an ordinal marker.

According to (5), the suffix *-th* is identified as an ordinal marker. However, the definite article *the* is not analyzed as an ordinal marker because it can be omitted in some environ-

ments while keeping the meaning of ordinals (i.e. specifying the rank of a given item in a certain order). For example, English ordinals can appear without *the* in the adverbial use (e.g. *Second, ... Third, ... Fourth, ...*), some idiomatic expressions (e.g, *First of all*, *second to none*), and dates (e.g. *January ninth*).

This chapter is organized as follows; Section 4.2 discusses the results of my cross-linguistic investigation of ordinals in non-classifier languages. It will be shown that ordinals behave like nominals cross-linguistically. I also argue that ordinal markers occur in the same position as numeral classifiers. Section 4.3 investigates the derivational patterns of ordinals in classifier languages. Although cardinals in classifier languages include numeral classifiers, ordinals in classifier languages still show a similar pattern as the ones in non-classifier languages; ordinals behave as nominalized numerical expressions. Section 4.3 is the summary of this chapter.

4.2 Ordinals in non-classifier languages

In this section, I address a puzzle regarding (im)possible constituent orders of nominals, numerals and ordinal markers, which is similar to Greenberg's (1972) observation about constituent orders of nominals, quantifiers and classifiers. I propose that the observation discussed in the following section as well as Greenberg's (1972) observation can be captured by assuming that ordinal markers occur in the same positions as numeral classifiers.

4.2.1 Strategies of expressing ordinals in non-classifier languages

In this section, I investigate ways of expressing ordinals in non-classifier languages in which a systematic use of numeral classifiers is not observed.[3] The results of my survey is given

3. I put aside classifiers which appear in non-cardinal contexts. For example, Mam [Mayan] has a set of noun classifiers which occurs when a third person noun phrase is omitted (England (1983: 158)). However, Mam is still categorized as a non-classifier language in this thesis because classifiers in Mam are not numeral

in (6).[4,5]

(6) *Ordinal markers in non-classifier languages*

a. Particular affixes/particles:

(i) Post-numeral (# ≺ ORD, 27 languages, 19 genera (cf. Dryer (1989))):

Basque [Basque], Bilua [Papuan], Breton [Celtic], Dutch [Germanic], English [Germanic], Estonian [Uralic], German [Geman], Greek [Greek], Hunzib [Nakh-Daghestanian], Hindi [Indic], Italian [Romance], Kashmiri [Indic], Kazakh [Turkic], Khanty (Earstern) [Uralic], Kisi [Niger-Congo], Koromfe [Niger-Congo], Kurmanji [Iranian], Lezgian [Nakh-Daghestanian], Luwo [Nilotic], Mam [Mayan], Maninka [Bantu], Oko [Niger-Congo], Russian [Slavic], Serbian [Slavic], Spanish [Romance], Sumerian [Sumerian], Welsh [Celtic]

(ii) Pre-numeral (ORD ≺ #, 10 languages, 5 genera):

Àhàn [Niger-Congo], Choctaw [Muskogean], Crow [Siouan], Kokota [Austronesian], Kula [Alor-Pantar], Pangasinan [Austronesian], Rapa nui [Austronesian], Sawila [Alor-Pantar], Seediq [Austronesian], Tagalog [Austronesian]

(iii) Circumfixal (ORD # ORD, 6 language, 5 genera):

Garifuna [Arawak], Georgian [Kartvelian], Kanuri [Saharan], Macushi [Carib], Chamula [Mayan], Tojobal [Mayan]

b. Relative clauses (6 languages, 5 genera):

Akan [Niger-Congo], Biak [Austronesian], Gaahmg [Nilo-Saharan], Leti [Austronesian], Tamil[6] [Dravidian], Turkana [Sudanic]

classifiers.

4. The names of language families used in this thesis are based mainly on The World Atlas of Language Structure Online (WALS).

5. In (6), I take into consideration the samples from Veselinova (1997), Stump (2010) and Slotz & Veselinova (2013), in addition to my own.

6. Veselinova (1997) mentions Tamil as a language which uses a postposition to form ordinals. However, I could not find examples of ordinals appearing with postpositions. Rather, ordinals in Tamil are formed by the suffix *-aavatu* or *-aam*. Notice also that the ordinal markers (i.e. *-aavatu* and *-aam*) are participial

c. Postposition (3 languages, 3 genera):
Cahuilla [Uto-Aztekan], Navajo [Athapaskan] ('in, inside'), Yup'ik [Eskimo-Aleut]

d. Attributive/Associative construction (3 languages, 2 genera):
Meithei [Sino-Tibetan], Kikuyu/Gĩkũyũ [Niger-Congo], Swahili [Niger-Congo]

e. Overt "number": English [Germanic], and many other languages

f. Definiteness (1 language, 1 genus): Maltese [Semitic]

The results summarized in (6) largely matches with Veselinova's (1997) observations about derivational strategies for ordinals. However, the overt "number" strategy and the attributive construction are not discussed in Veselinova (1997).[7] I will illustrate all these strategies below.

Particular affixes/particles

Regarding the particular affixes/particles strategy, as shown in (6), post-numeral ordinal markers are common cross-linguistically. Pre-numeral ordinal markers and cicumfixal ordinal markers are relatively rare in my sample. Some examples of the particular affixes/particles type of ordinals with the three subclasses are given below.

(7) Basque [Basque]: Trask (2003: 129)
hogei.ta-bost-garren
20.and-5-ORD
'twenty fifth' [Post-numeral (# $\prec$ ORD)]

forms derived from the verb *aaku* 'become' (Lehmann (1993: 116)). Given this, I classify Tamil as having relativized ordinals.

7. Veselinova (1997) also mentions a compounding strategy, but without giving actual examples. It is not clear what this strategy means and I could not find this type of ordinals. Given this, I put aside this potential strategy in the thesis.

(8) Kashimiri [Indic]: Wali and Koul (1997: 263)

trey-im-i *ko:r-i* *li:ch* *cith'.*
three-ORD-ERG girl-ERG wrote letter
'The third girl wrote the letter.' [Post-numeral (# ≺ ORD)]

(9) Àhàn [Niger-Congo]: Ogunmodimu (2015: 69)

ól-íro *ashí*
ORD-eight dog
'the eighth dog' [Pre-numeral (ORD ≺ #)]

(10) Georgian [Kartvelian]: Hewitt (1995: 56)

me-ekvs-e
ORD-six-ORD
'sixth' [Circumfixal]

In my sample, most languages in fact use particular affixes/particles as ordinal markers. However, ordinal markers in these languages might be related to other strategies of expressing ordinals, diachronically or synchronically.[8] I will not investigate this issue in the thesis due to the limits of the available data.

Relative clauses

Turning to the relative clause strategy, in Lezgian [Nakh-Daghestanian], ordinals are formed by attaching the element *lahaj* to a numeral. The ordinal marker *lahaj* is the Aorist participle of *luhun* 'say'. Given this, Haspelmath suggests that the literal translation of *q'ud lahaj nük* 'four ORD bird = the fourth bird' may be something like 'the bird about which four

8. Georgian uses the circumfix *me- -e* to form ordinals. Crucially, Hewitt (1995: 103) reports that the same circumfix can also be used as a nominalizer (e.g. *bag-i* 'garden', *me-bag-e* 'gardner'). This is another indication that ordinals are nominalized numerical expressions, as discussed later in this section.

was said' Haspelmath (1993: 233). Another example of this strategy comes from Biak [Austronesian].

(11) Biak [Austronesian]: Steinhauer (2005: 802)

rum *ve-ve-suru*
house REL-QUA-two
'second home'

Telugu is not included in (6) because it has a set of classifiers. However, Telugu uses the suffix *ō* to form ordinals (e.g. *mūḍ-ō* 'three-ORD = third'). Krishnamurti (2003: 266) observes that the suffix *ō* stems from *agu/awu* 'to become' in Old Telugu (i.e. *-ō* < *-awa-,* < *awu*). Given this diachronic change, it is possible that ordinals in Old Telugu were formed by the relative clause strategy involving a verbal predicate 'to become'.

Postpositions

Veselinova (1997) reports that Cahuilla [Uto-Aztekan], Navajo [Athapaskan] and Yup'ik [Eskimo-Aleut] make use a postposition to express ordinals. (12) is an example from Navajo.

(12) Navajo [Athapaskan]: Young and Morgan (1980: 37)

naaki *góne'*
two inside
'second'

Attributive/associative constructions

Consider now the Attributive/associative construction strategy. In Meithei [Sino-Tibetan], ordinals are formed by the attributive prefix *ə-* and the nominalizer *-pə* in combination

with *-su* 'also'. Ordinals occur either before or after the main noun as in (13). The same attributive construction is also used for other adjectives specifying size, as shown in (14). One similarity between ordinals and attributive modifiers is that an attributive phrase can also appear before or after the main noun.

(13) Meithei: Chelliah (1997: 73)

a. *ə-ni-su-pə mə-čá nu-pi-tu*
ATT-two-also-NM N-small person-FEM-DDET
'the second daughter' [N = noun marker]

b. *mə-čá nu-pi ə-ni-su-pə-tu*
N-small person-FEM ATT-two-also-NM-DDET
'the second daughter' [DDET = distal determinar]

(14) Meithei: Chelliah (1997: 73)

a. *ə-čaw-pə učék-tu phéǰe-í*
ATT-big-NM bird-DDET beauty-NHYP
'That big bird is beautiful'

b. *učék ə-čaw-pə-tu phéǰe-í*
bird ATT-big-NM-DDET beauty-NHYP
'That big bird is beautiful' [NM = nominalizer, NHYP = nonhypothetical]

In Meithei, cardinals appear to the left of the main noun. Unlike ordinals, it is impossible for cardinals to appear to the right of the main noun.

(15) Meithei: Chelliah (1997: 75)

phi təra-si
cloth ten-PDET
'these ten (pieces of) cloth'

The associative construction in Kikuyu/Gĩkũyũ is used to combine two nominal elements, especially when the second noun functions as a modifier of the first noun. An example of the attributive construction in Kikuyu/Gĩkũyũ is given in (16).

(16) Kikuyu/Gĩkũyũ [Niger-Congo]: Li (2015: 51)

i-rigũ *rĩ-a* *cukari*

NC_5-banana AC_5-ASSOC NC_{14}.sugar

'a sweet banana' (Lit. 'banana of sugar')

In Kikuyu/Gĩkũyũ, ordinals appear in the associative construction, as in (17).

(17) Kikuyu/Gĩkũyũ [Niger-Congo]: Li (2015: 48)

ũtukũ *ũ-a* *mĩ-rongo* *ĩ-ĩrĩ*

NC_{14}.night AC_{14}-ASSOC NC_4-set.of.ten AC_4-two

'the twentieth night'

(18) The cross-linguistic pattern of the attributive/associative strategy:

In the attributive/associative strategy, ordinals function as nominal modifiers.

Veselinova (1997) claims that Sawahili uses the possessive strategy to form ordinals. However, what Veselinova refers to as a possessive particle seems to be a connective particle (Polomé (1967)), as shown in (19a). In Swahili, ordinals appear in the same attributive/associative construction as in (19b).

(19) Swahili [Niger-Congo] : Polomé (1967: 132,133)

a. *kabati la mti*

cupboard LINK wood

'a wooden cupboard'

b. *kitabu cha tatu*

book LINK three

'the third book'

Given this, I categorized Swahili as an attributive/associative strategy language.

Possessive constructions

Some languages also make use of possessive constructions to express ordinals. Ordinals in Kula [Alor-Pantar] appear in the possessive construction, as shown in (20a).

(20) Kula [Alor-Pantar]: Klamer et al. (2014: 343), attributed to Nick Williams, p.c.

a. *wanta gi-we-araasiku*
day 3.POSS-APPL-four
'the fourth day'

b. *Maria gi-skola*
Maria 3.POSS-school
'Maria's school'

Nonetheless, I classify Kula as a pre-numeral affix language. First of all, it should be noted that ordinals in Kula appear with the applicative verbal prefix *we*. This applicative prefix is not observed in the possessive construction in (20b). Moreover, Klamer et al. (2014) compare (20a) with ordinals in Sawila [Alor-Pantar], which is typologically related to Kula. As shown in (21), ordinals in Sawila are also marked by the applicative prefix *wii-*. However, ordinals in Sawila do not appear in the possessive construction.

(21) Sawila [Alor-Pantar]: Klamer et al. (2014: 343)

a. *imyalara wii-tua*
man APPL-three
'the third man'

b. *imyalara gi-araasing*
man 3.POSS-house
'the man's house'

Although there are no data that show whether ordinals in Kula obligatorily appear in the possessive construction, I hypothesize that the applicative prefix but not the possessive one functions as an ordinal marker in Kula and Sawila on the basis of their typological similarities.

However, it should be noted that in (20a), the ordinal appears in the same position as the possessed phrase in (20b). A similar pattern is also attested in Mam [Mayan]. In Mam, ordinals are followed by the suffix *-an*. The ordinal in (22a) appears in the same position as

the possessed nominal phrase in (22b). Given this, England (1983) states that "this suffix [=AN] forms noun stems" (p.121).

(22) Mam [Mayan]: England (1983: 143,148)

a. *t-kab'-an tx'yaan jawan*
3.SG-two-ORD dog fierce
'the second fierce dog'

b. *t-jaa-ta xu7j*
3.SG-house-EMPH woman
'the woman's house'

As discussed in Section 4.3, possessive ordinals are also attested in classifier languages. Some examples of possessive ordinals in classifier languages are given below. I will return to these patterns in Section 4.3.

(23) Abui (Kratochvíl 2007: 119, 139)

a. *moku he-sua*
kid 3.II.AL$_{ORD}$-three
'third child'

b. *maama he-sepeda*
father 3.II.AL-bike
'father's bike'

(24) Ch'ol [Mayan]

a. *Tsa' chäm-i* [*i-cha'-kojty-lel wakax*].
PFV die-IV A3-two-CLS-NML cow
'The second cow died.' [Bale et.al. 2019: 18]

b. *i-pisl-el aj-Rosa*
A3-cloth-EL NC-Rosa
'Rosa's clothing' (e.g. that she wears on her body)' [Coon 2010: 86]

(25) Kove [Austronesian]: Sato (2013: 197-198)

a. *moe* *hua* *ai-a*
sleeping.mattress two 3SG.POSS-A.POSS
'the second sheet of sleeping mattress'

b.?* *hua* *ai-a* *moe*
two 3SG.POSS-A.POSS sleeping.mattress
Int. 'the second sheet of sleeping mattress'

What is important is that there is a cross-linguistic pattern of the possessive strategy, as stated in (26).

(26) *The cross-linguistic pattern of possessive ordinals*:

In the possessive strategy of expressing ordinals, a numeral behaves as a possessed phrase.

Overt "number"

In my languages sample, I found ordinals that include an overt noun meaning 'number'. This overt "number" strategy is common cross-linguistically. An example from English is given in (27).[9]

9. There are interesting issues to work out concerning the nature of the overt "number" strategy. This strategy can be used in the context where the relevant ranking/ordering is not semantically entailed. For instance, *applicant number seven* in (i) can refer to the third applicant whose piece of paper has "seven" on it (Jonathan David Bobaljik, p.c.).

(i) Context: applicants are assigned a random number when they come in the interview room.
We will now meet applicant number seven.

Moreover, there is a construction similar to the "number" strategy. (iia) can refer to an alphabetically ordered question. However, it does not necessarily entail an ordering. Thus, (ii) can be used in a context where there is only one question. (iib) also does not have to entail an ordering.

(ii) a. *the question B*
b. *day seven* (cf. *seven days*)

In this respect, the "number" strategy and related constructions may be an instance of naming constructions, and the flavor of ordering might arise from a real-world convention which maps numbers (and alphabets) to an order. In many cases, the number "five" element could be the fifth one in some order. This issue may also be related to the possessive strategy and the relative clause strategy of expressing ordinals which are discussed in the text. In these strategies, ordinals can be paraphrased as "X which has number *n*" (the

(27) English [Germanic]

the question number five

The overt "number" strategy is also attested in classifier languages like Bislama [Creole in Vanuatu]. I will discuss the overt "number" strategy in section 4.2.3

(28) Bislama [Creole in Vanuatu]: Crowley (2004: 55)

Namba-tri haos hem i blong mi.
number-three house 3SG I of I
'the third house is mine.'

Definiteness

The last strategy of forming ordinals is to use a definiteness marker. In Maltese [Semitic], ordinals are marked by the definite prefix, as in (29).

(29) Maltese [Semitic]: Borg (1974: 303)

it-tilet-yuwm
DEF-three-day
'the third day'

A common property of the strategies of expressing ordinals

At first glance, the derivational strategies summarized in (6) vary across languages quite widely - it in fact seems impossible to make a generalization/generalizations regarding this variation. However, we can identify one important property that the strategies summarized

possessive strategy) and "X which is number *n*" (the relative clause strategy), including the number strategy. Although these strategies may be different from other strategies of expressing ordinals in certain ways, I would like to include these strategies in the current survey, leaving exploration of potential deeper questions regarding the linguistic manifestation of ordinals hinted at in this footnote for future research.

in (6) all have in common, by putting aside the nature of the particular affixes/particle in the first two parts of (6).

What the strategies in (6) have in common is that ordinals are expressed by nominal constructions. Schematic representations of the strategies in (6) are given below.

(30) *The relative clause strategy*

a. [[$_{\text{RelP}}$ ... N_{pred} ...] N_{main}] (e.g. *an expression* [*that is* ***a numeral***])

b. [[$_{\text{RelP}}$ ... # ...] N_{main}] [Order irrelevant]

(31) *The postpositional strategy*

a. [$_{\text{PP}}$ N P]

b. [$_{\text{PP}}$ # P] [Order irrelevant]

(32) *The attributive/associative strategy*

a. [N_{main} (ASSOC) N_{mod}] (e.g. *a student with* ***a mask***)

b. [N_{main} (ASSOC) #] [Order irrelevant]

(33) *The possessive strategy*

a. [$N_{\text{possessor}}$ POSS $N_{\text{possessee}}$] (e.g. *Yuta's* ***thesis***)

b. [$N_{\text{possessor}}$ POSS #] [Order irrelevant]

(34) *The overt "number" strategy*

[$_{\text{N}}$ NUMBER #] (e.g. *the question* ***number four***) [Order irrelevant]

(35) *The definiteness strategy*

a. [DEF N]

b. [DEF #] [Order irrelevant]

In the relative clause strategy, ordinals can be analyzed as the nominal predicate in a relative clause. In the postpositional strategy, numerals are nominal in the sense that they combine with a postposition. In the attributive/associative strategy, ordinals also behave like nominal modifiers. The possessive relation typically holds between two referents denoted by nouns. In the possessive strategy, ordinals appear in the same position as a possessed phrase, as discussed above (cf. (26)). This indicates that ordinals in this strategy are also nominal. The overt "number" strategy includes an overt nominal element meaning 'number'. The overt "number" itself can be the source of noun-hood of ordinals. Lastly, the definiteness strategy also quite clearly shows the nominal nature of ordinals. The definiteness marker typically appears with a nominal expression.

Given the derivational strategies in (6), this chapter will pursue an analysis in which ordinals are numerical nouns. The main observation is given in (36).

(36) *Observation*

Ordinals function as nominal expressions cross-linguistically.

The observation in (36) is drawn from the cross-linguistic survey of non-classifier languages. However, it will be broadened later to include classifier languages as well, as will be discussed in Section 4.3.

The question to address regarding (36) concerns the nature of the nominal property of ordinal numbers. I propose that ordinals display nominal behavior because ordinal markers are syntactic heads that occur in the same position as numeral classifiers in the extended nominal projection. In the next section, I will provide details of the present analysis in relation to (im)possible constituent orders of nominals (N), numerals (#) and ordinal markers (ORD).

4.2.2 (Im)possible constituent orders in non-classifier languages

My typological observation regarding constituent orders of nominals (N), numerals (#) and ordinal markers (ORD) in non-classifier languages is summarized in (37). The table in (37) does not include languages where ordinals are formed by circumfixes (i.e. Garifuna [Arawak], Georgian [Kartvelian], Kanuri [Saharan], Macushi [Carib], Chamula [Mayan], and Tojobal [Mayan] are not included in (37, cf. (6)).

I also did not count suppletive ordinals like *first* in making the table in (37). This is because of the possibility of analyzing suppletive ordinals as superlative adjective (meaning 'earliest' or 'foremost'). Furthermore, suppletive ordinals are not helpful for the current purposes because we cannot see the word order between # and ORD in suppletive forms.

(37)

	Order	Langauges
✓	#-ORD-N	Basque, Bilua, Breton, Dutch, English, German, Greek, Hindi, Italian, Kashmiri, Khanty (Earstern), Lezgian, Mam, Meithei, Russian, Serbian, Spanish, Welsh
✓	N-#-ORD	Sumerian, Koromfe, Kurmanji, Luwo
✓	N-ORD-#	Biak, Crow, Kikuyu/Gĩkũyũ, Sawila
✓	ORD-#-N	Àhàn, Maltese
*	#-N-ORD	None
*	ORD-N-#	None

There are six mathematically possible combinations of N, #, and Ord (factorial 3 = 3 × 2 × 1 = 6). However, the last two combinations in (37) are not attested in my sample. We need an explanation for the two unattested constituent orders. In this chapter, I will argue that #-N-ORD and ORD-N-# are unattested cross-linguistically because of certain syntactic constraints.

Importantly, the two unattested combinations in (37) correspond to Greenberg's (1972) unattested constituent orders of N, #, and Cls, namely *#-N-Cls and *Cls-N-#. Based on

this observation, I put forth an analysis in which ordinal markers appear in the same position as classifiers. Syntactically, they will be analyzed as the same type of functional head and shown to behave alike, regarding constituent orders. Examples of each constituent order are given below.

#-ORD-N

In many non-classifier languages, ordinal markers attach directly to a numeral. (38) is an example of ordinals in Italian. Here, the ordinal suffix (*-esimo*/*-esima*) follows the numeral *vent* and the ordinal precedes the main noun.

(38) Italian [Romance]: Pietro Cerrone, p.c.

per favore apri la [*vent-esima porta*].
please open the 20-ORD door.SG
'Please open the twentieth door.'

In Breton, ordinals are formed by attaching the suffix *-vet* to a numeral. Ordinals in Breton precede the modified noun, as shown in (39).

(39) Breton [Celtic]: Press (1986: 91)

ar peder-vet gwech
the four-ORD time
'the fourth time'

N-#-ORD

The constituent order N-#-Ord is also attested in my sample. Examples of this type of languages are given below.

(40) Sumerian [Sumerian]: Jagersma (2010: 259)

dumu min-kamma=ane
son two-ORD=his
'his second son'

(41) Koromfe [Niger-Congo]: Rennison (1997: 309)

a kɛ̃ɔ̃ tãã-ndɔ hoŋ wileti də wũn dããnɛ
ART woman three.HUM-ORD DET.HUM.SG turn.round PRON.3.SG.HUM return home(ADV.)
'The third wife turned round and went back home.'

(42) Luwo [Nilotic]: Storch (2014: 273)

dhyɛ̀ pàày-gɛ́n
cow.SG ten-ORD
'the tenth cow'

N-ORD-#

This constituent order is relatively rare in my sample. However, this order is observed in Crow, Kikuyu/Gĩkũyũ and Sawila.

(43) Crow [Siouan]: Graczyk (2007: 170)

baapé ii-shoopé kan baapaalée-m kalakoón
day ORD-four then dawn-SIMULT then

sapée-o-lak iláa-(a)-watt-uu-m iikukkú-k
someone-PL-DET talk-CONT-continue-PL-COMP hear-DECL

'on the fourth day at dawn he heard some people talking'

(44) Kikuyu/Gĩkũyũ [Niger-Congo]: Li (2015: 48)

ũtukũ *ũ-a* *mĩ-rongo* *ĩ-ĩrĩ*

NC_{14}.night AC_{14}-ASSOC NC_4-set.of.ten AC_4-two

'the twentieth night'

(45) Sawila [Alor-Pantar]: Klamer et al. (2014: 343)

imyalara *wii-tua*

man APPL-three

'the third man'

ORD-#-N

In my sample, I found two non-classifier languages which display the ORD-#-N order; Àhàn and Maltese.

(46) Áhán [Niger-Congo]: Ogunmodimu (2015: 69)

ól-íro *ashí*

ORD-eight dog

'the eighth dog'

(47) Maltese [Semitic]: Borg (1974: 303)

it-tilet-yuwm

DEF-three-day

'the third day'

As will be discussed in Section 4.3, the order Ord-#-N is also observed in Belep [Austronesian], which has numeral classifiers. Ordinal numerals in Belep are formed by attaching the derivational proclitic *ba=* to a numeral, as shown in (48).

(48) Belep (McCracken 2012: 293)

ô *ta-me-li* *ba* *pwadu* *gawaar,*
REAL go.UH-CTP-GEN ORD two day
'The second day came,'

*#-N-ORD and *ORD-N-#

The last two combinations in (37) (i.e. *#-N-ORD and *ORD-N-#) are not attested in my sample. There are six mathematically possible combinations of N, #, and Ord (factorial 3 = 3 × 2 × 1 = 6). The lack of these two combinations needs to be accounted for. In the next section, I will argue that these unattested combinations are impossible because of certain syntactic constraints, building on Cinque's (2005) analysis of Greenberg's (1963) Universal 20. Specifically, I propose that ordinal markers appear in the same position as numeral classifiers. It is then expected that they are the same type of head and behave alike in some respects.

4.2.3 Analysis: Similarities between ORD and CLS

It is important to note that the unattested combinations in (37) correspond to Greenberg's (1972) unattested constituent orders of nominals (N), quantifiers (#), and classifiers (CLS). Greenberg (1972) reports that only four combinations of noun (N), quantifier (#), and classifier (CLS) are attested in his sample. The two unattested combinations in Greenberg's sample are #-N-CLS and CLS-N-#. His observation is summarized in (49). Here, I also added several languages from my sample. (See also Jones (1970), Aikhenvald (2003).)[10]

10. Bangla allows for post-nominal numeral classifier constructions (i.e. N-#-CLS). However, it seems that post-nominal numeral classifiers are derived by NP-movement (Bhattacharya (1999)). Japanese also has pre-nominal and post-nominal numeral classifiers. I classified Japanese numeral classifier phrases as N-#-CLS because in the pre-nominal position, a numeral classifier phrase must be followed by the genitive linker *no* (e.g. *hon san-satsu* 'book three-CLS = three books' vs. *san-satsu-no hon* 'three-CLS-GEN book = three books').

(49)

#-CLS-N	frequent	Bangla [Indic], Chinese [Sino-Tibetan], Vietnamese [Austro-Asiatic], Hmong [Hmong-Mien], Uzbek [Turkic], Hungarian [Uralic]
N-#-CLS	frequent	Burmese [Sino-Tibetan], Japanese [Japanese], Khmer [Austro-Asiatic], Lahu [Sino-Tibetan], Mal [Austro-Asiatic], Thai [Tai-Kadai]
CLS-#-N	rare	Ibibio [Niger-Congo]
N-CLS-#	rare	Abun [Papuan], Bodo [Sino-Tibetan]
#-N-CLS	*	unattested
CLS-N-#	*	unattested

Greenberg (1972) included Hungarian in his sample because it has a numeral series used only with persons. Moreover, Greenberg's (1972) observation was made based on data containing the numerical interrogative "how many" and indefinite quantifiers such as "few", "many".[11] In this chapter, I basically follow his criteria.

Her (2017) investigates whether Greenberg's observation summarized in (49) can be captured by previous approaches to another cross-linguistic pattern of constituent orders; namely Greenberg's (1963) Universal 20, given in (50).

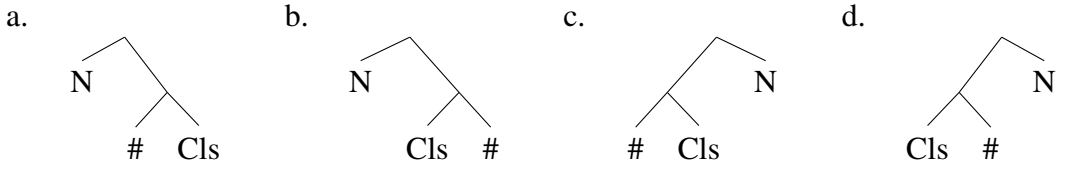
(50) *Greenberg's Universal 20*: Greenberg (1963: 87)

When any or all of the items (demonstrative, numeral, and descriptive adjective) precede the noun, they are always found in that order. If they follow, the order is either the same or its exact opposite.

Her (2017) argues that the (im)possible constituent orders in (49) can be accounted for by assuming the structures in (51).

11. Quantifiers can co-occur with classifiers in Chinese, Thai and Vietnamese, but not in Japanese. As Greenberg (1972) discussed, classifiers are not homogeneous in this respect.

(51)



Crucially, Her (2017) assumes that a classifier and a numeral form a constituent to the exclusion of the main noun. The structures in (51) will result in the attested combinations in (49). Moreover, it is impossible for a noun to intervene between the numeral and the classifier because of the assumption that classifiers and numerals form a constituent excluding the head noun in the extended nominal projection. Therefore, there is no way to obtain the unattested combinations (i.e. *#-N-CLS and *CLS-N-#).

Her's (2017) analysis hinges on the assumption that classifiers (CLS) and numerals (#) form a constituent before combining with the main noun. However, this assumption faces a problem with some data from classifier languages. For example, Nguyen (2004) reports that classifiers in Vietnamese can be elided together with the head noun, while leaving a numeral as the remnant. In (1b,c), the elliptical phrase is interpreted as 'three books'.

(52) Vietnamese [Austro-Asiatic]: Thuy Bui, p.c.

Nguyên mua năm cuón sách và ...
Nguyen bought five CLS book and
'Nguyen bought five books and ...'

a. *Khanh mua [ba cuón sách].*
Khanh bought three CLS book
'Khanh bought three books.'

b. *Khanh mua [ba cuón* Δ].
Khanh bought three CLS
'Khanh bought three books.'

c. *Khanh mua* [*ba* Δ].
Khanh bought three
'Khanh bought three books.'

What is important here is that the acceptability of (1c) is not expected if we assume that numerals and classifiers must be combined directly with each other, as schematically represented in (51). In (51), there is no constituent which can undergo ellipsis excluding a numeral. Nguyen (2004) in fact proposes that a classifier takes the main noun as its complement in Vietnamese.

One may consider that (1c) may be analyzed as involving nominal ellipsis with a null classifier, as illustrated in (53).

(53) [[three [$_{\text{Cls}}$ ∅]] ~~[$_{\text{NP}}$ book]~~]

Some common nouns in Vietnamese can be modified by a numeral without a classifier as in (63a). However, *sách* 'book' is an obligatory-classifier noun, and the presence of an overt classifier is required, as shown in (63b).

(54) Vietnamese [Austro-Asiatic]: Simpson and Ngo (2018: 213-214)

a. *bốn* (*cuón*) *phòng*
four CLS room
'four rooms'

b. *bốn* *(*cuón*) *sách*
four CLS book
'four book'

One may still claim that when the main noun is a covert pronoun *pro*, the null classifier can be null. However, the acceptability of (1c) cannot be related to the availability of *pro*. Mandarin Chinese and Japanese, which also allow for *pro*, do not have an elliptical construction like (1c). In these classifier languages, a numeral classifier is required to license the elliptical construction, as shown in (55).

(55) a. Mandarin [Sino-Tibetan]: Shuyan Wang, p.c.

Zhangsan mai-le wu ben shu. Lisi mai-le {*san ben* Δ | **san* Δ}
Zhangsan buy-ASP five CLS book Lisi buy-ASP three CLS three

'Zhangsan bought five books. Lisi bought three books.'

b. Japanese [Japanese]

Daiki-wa [*hon go-satsu*]-*o katta.*
Daiki-TOP book five-CLS-ACC bought

Erika-wa {*san-satsu* Δ | **san* Δ}-*o katta.*
Eriko-TOP three-CLS three -ACC bought

'Daiki bought five books. Erika bought three books.'

If the elided part in (1c) contains *pro* and a null numeral classifier, it is not clear why Mandarin Chinese and Japanese do not allow for the same type of elliptical construction. Given these considerations, I do not adopt Her's (2017) analysis in the thesis.[12]

It is important to note that following Abels and Neeleman (2012), Her (2017) abandons the specifier-head-complement hypothesis, which follows from Kayne's (1994) Linear Correspondence Axiom (LCA). According to the specifier-head-complement hypothesis, the hierarchical structure in (56) always yields the linear order Y-X-Z.

12. It is worth noting that Vietnamese is not the only language which shows the ellipsis pattern in (1c). Thai behaves like Vietnamese regarding nominal ellipsis, as shown in (i). I refer the reader to Jenks (2011) for a detailed analysis of numeral classifiers in Thai.

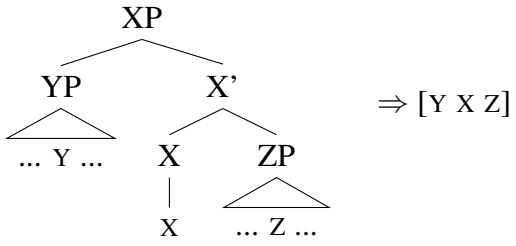
(i) Thai [Tai-Kadai]: Panat Taranat, p.c
Nat sɯ́ɯ náŋsɯ̌ɯ hâa lêm, lɛ? ...
Nat buy book five CLS and
'Nat bought five books, and ...'

a. *Somsak sɯ́ɯ náŋsɯ̌ɯ sǎam lêm.*
Somsak bought book three CLS
'Somsak bought three books.'

b. *Somsak sɯ́ɯ sǎam lêm.*
Somsak bought three CLS
'Somsak bought three books.'

c. *Somsak sɯ́ɯ sǎam.*
Somsak bought three
'Somsak bought three books.'

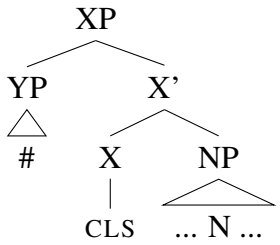
(56) The specifier-head-complement hypothesis



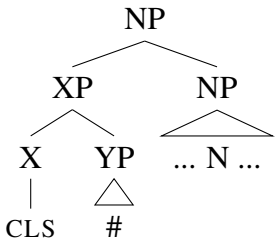
Instead of the specifier-head-complement hypothesis, Her (2017) opts for the head parameter, yielding the options given in (51). The advantage of the head parameter in this context, however, does not seem to be well-motivated, especially given the data on nominal ellipsis in Vietnamese. Recall also that in Chapter 2, I proposed that numeral classifier phrases have either the complementation structure as in (59a) or the adjunction structure as in (59b), building on the wide typological data of multiplicative complex cardinals and numeral classifier phrases.

(57) *Numeral classifier phrases*

a. Complementation



b. Adjunction



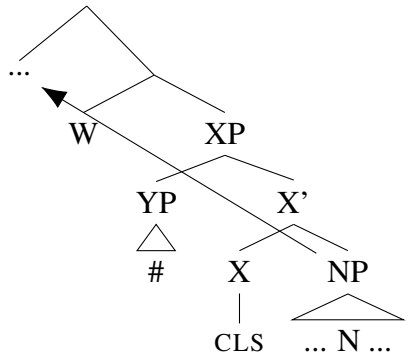
If we allow for the head parameter options, the complement structure could produce the unattested order (*#-N-CLS). Given this, the present thesis adopts the specifier-head-complement hypothesis, also maintaining the assumption that there are in principle two types of structure for numeral classifier phrases.[13] This means that the complementation structure in (59a) yields only the order #-CLS-N. On the other hand, the adjunction struc-

13. It should be noted that in contrast to Kayne (1994), I distinguish specifiers and adjuncts in this thesis. (the distinction is not incompatible with the LCA, see in this respect Chomsky (1995))

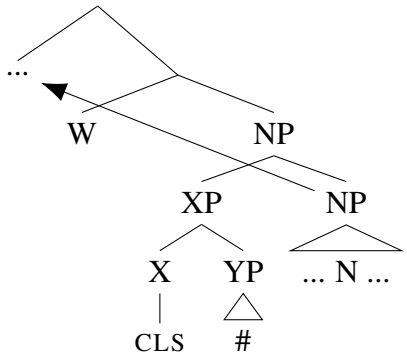
ture produces the CLS-#-N order, following Kayne's LCA. This is a desirable result because these combinations #-CLS-N and CLS-#-N are attested typologically.[14]

The present analysis can also yield the other attested orders (i.e. N-#-CLS and N-CLS-#). These orders will be derived by movement of the main noun phrase to a higher position in the extended nominal projection, as in (58).

(58) a. N-#-CLS



b. N-CLS-#



Crucially, the unattested orders (*#-N-CLS and *CLS-N-#) are not derived from either the complementation structure or the adjunction structure, given in (57).

All in all, Greenberg's observation about the (im)possible constituent orders of N, # and CLS summarized in (49) can be accounted for under the present analysis in combination with the specifier-head-complement hypothesis. Let us now consider my observation regarding the (im)possible constituent orders of N, # and ORD.

14. Sheehan et al. (2017) point out that the Final-Over-Final condition proposed in Biberauer et al. (2014) as in (i) is incompatible with Abels & Neeleman's (2012) analysis of Greenberg's Universal 20, which Her's (2017) analysis rests on.

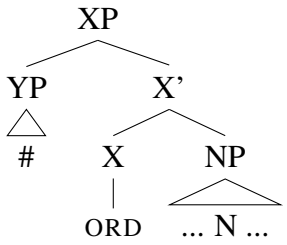
(i) *The Final-over-Final Constraint*: Biberauer et al. (2014: 171)
A head-final phrase αP cannot dominate a head-initial phrase βP, where α and β are heads in the same extended projection.

On the other hand, Cinque's (2005) analysis of Greenberg's Universal 20, which Abels and Neeleman (2012) argue against, is compatible with the Final-Over-Final condition. Since the Final-Over-Final condition is deduced form a wide range of typological data, an analysis compatible with it should be favoured. It should also be noted that Abels & Neeleman's (2012) analysis and Cinque's analysis cover the same range of data regarding Greenberg's (1963) Universal 20. One crucial difference between Cinque (2005) and Abels and Neeleman (2012) is that the former but not the latter assumes the specifier-head-complement hypothesis. In this respect, the current analysis follows Cinque's (2005) analysis of Greenberg Universal 20.

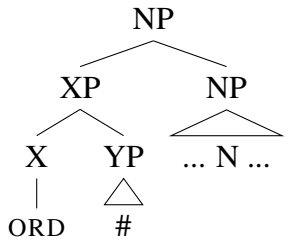
The fact that ordinal markers behave like classifiers with respect to the (im)possible constituent orders can be accounted for if we assume that ordinal markers appear in the same position as numeral classifiers. According to the current analysis, ordinal numbers can then in principle have the structures in (59).

(59) *Ordinals*

a. Complementation



b. Adjunction



The structures in (59) yield all and only the attested combinations of N, # and ORD (i.e. N-#-ORD, #-ORD-N, N-ORD-#, and ORD-#-N).

The denotation of an ordinal marker appearing in the complementation structure in (59a) is given in (60a). Remember that in Chapter 2, I proposed that that the denotation of numeral classifiers includes the measurement function μ. Building on the similarities between numeral classifiers and ordinal markers, I propose that ordinal markers are also syntactic heads used for measurement in ranking. In (60), μ_{rank_C} stands for the ranking function that takes an individual and returns its contextually determined rank in number. The denotation of *the fourth student* is given in (60b).

(60) a. $[\![\text{ORD}]\!]^c = \lambda P.\lambda n.\lambda x.[\mu_{\text{rank}_C}(x) = n \wedge P(x)]$

b. $[\![\text{the fourth student}]\!]^c = \iota x.[\mu_{\text{rank}_C}(x) = 4 \wedge \text{student'}(x)]$

The ordinal marker in the adjunction structure given in (59b) also has a similar denotation. As for the ordinal marker in (59b), I use the type shifter γ to combine a numeral with a classifier first.

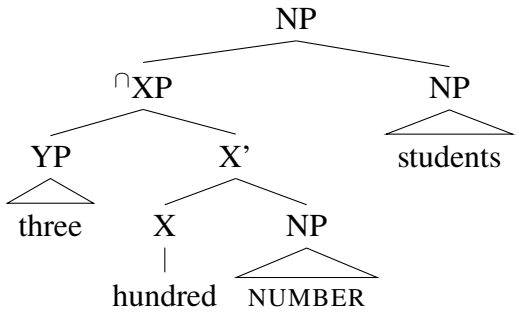
(61) a. $[\![\gamma]\!]^c = \lambda Q.\lambda n.\lambda P.\lambda x.[Q(n)(P)(x)]$

b. $[\![\gamma\text{-ORD}]\!]^c = \lambda n.\lambda P.\lambda x.[\mu_{\text{rank}_C}(x) = n \wedge P(x)]$

The difference between the original denotation of an ordinal marker in (60) and its derived version in combination with γ is that the former takes a number as its second argument, but the latter takes a number as its first argument. This type shifter is independently needed under the present analysis which allows for both the complementation structure and the adjunction structure.

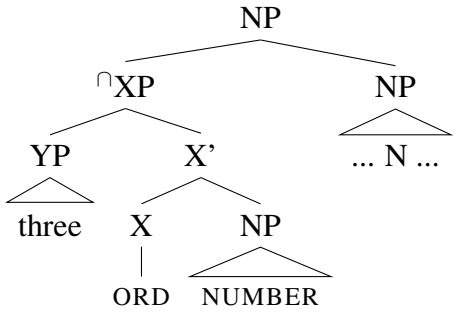
Recall also that in Chapter 2, I proposed that multiplicands can take the silent numerical noun NUMBER as the complement. The adjunction structure with the silent NUMBER is repeated here as (62).

(62) *The adjunction structure of multiplicative complex cardinals*



In Chapter 2, I showed that multiplicands and numeral classifiers are syntactic heads used for measurement, and they in fact behave alike in several respects. Building on the analysis from Chapter 2, I propose that ordinal markers can take the silent NUMBER, as represented in (63).

(63) *Ordinals with the silent* NUMBER



In Chapter 2, I proposed that numeral classifiers cannot take the silent NUMBER as the complement, because of a sortal restriction associated with a given numeral classifier. For example, Japanese, an obligatory classifier language, has the numeral classifier for people *nin*. This classifier has the denotation in (64) under the present analysis.

(64) $[\![\ nin\ ]\!]$

$= \lambda P\text{: } \underbrace{\forall u.[P(u) \rightarrow person'(u)]}_{\text{Sortal Restriction}} .\lambda n.\lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = n$
$\wedge \forall y \in S.[|\{z\text{: } z \leq_{at} y\}| = 1 \wedge \forall z \leq_{at} y.[P(z)]]]$

I assume that the silent NUMBER is interpreted as a property of being a number (i.e. λx[number'(x)]). When the numeral classifier *nin* combines with the silent NUMBER, it yields semantic incoherence. The problem here is that no individual can be a person and a number at the same time (i.e. $\forall u.[number'(u) \rightarrow person'(u)]$ will give rise to a presupposition failure).

However, we can avoid a presupposition failure if there is a classifier-like element which does not have a sortal restriction. I proposed that multiplicands are such syntactic heads in Chapter 2. In the current Chapter, I propose that ordinal markers also lack a sortal restriction, as shown in (60a) above. When an ordinal like 'fourth' has the adjunction structure with the silent NUMBER, it has the denotation in (65).

(65) $[\![\ [\text{four ORD NUMBER}]\ ]\!]^c = \lambda x.[\mu_{\text{rank}_C}(x) = 4 \wedge number'(x)]$

Building on Rothstein (2013, 2017), I assume that an element of type ⟨e,t⟩ can be converted into a singular term of type n by the $\cap$ function (Chierchia (1985)) if it denotes a property of being a number. In (65), each atomic individual of S has the property of being a number. The adjunct XP in (63) becomes a numerical expression of type n as in (66) when the $\cap$ function applies.[15]

(66) $[\![\cap$[four ORD NUMBER] $]\!] = 4$ (in rank)

The adjunction structure with the silent NUMBER can also account for the observation developed in Section 4.2.1, where ordinals are numerical nouns cross-linguistically. This property can be explained under the current analysis. In particular, I assume that the nominal property of ordinals stems from the silent NUMBER in (63), rather than ordinals themselves.

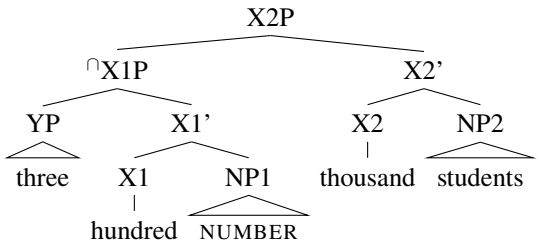
The proposed analysis can also account for an interesting correlation between ordinals and genitive of quantification in Serbo-Croatian. As shown in (67), unlike some higher cardinals, ordinals generally do not assign genitive of quantification to the main noun.

(67) Serbo-Croatian

a. *Ivan je pročitao pet knjiga.*
Ivan CL read five books.GEN
'Ivan read five books.'

15. Recall that in Chapter 2, I argued that the multiplicative complex cardinal *three hundred* can be used as a multiplier, combining with another multiplicand as in (i).

(i)



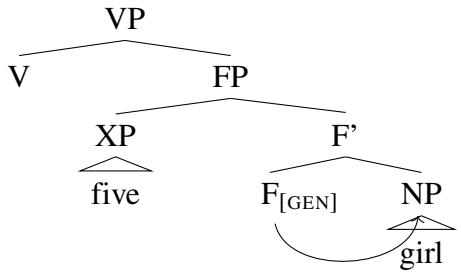
In (i), the $\cap$ function yields an element of type n (i.e. the multiplier). The same process takes place in ordinals as in (66).

b. *Ivan je pročitao petu knjigu.*
Ivan CL read five.ACC book.ACC
'Ivan read the fifth book.'

c. **Ivan je pročitao petu knjiga.*
Ivan CL read five.ACC book.GEN

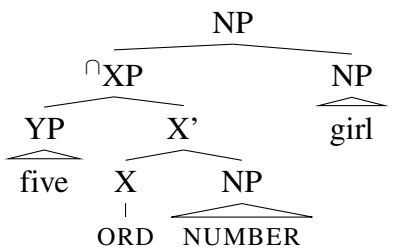
In Chapter 3, I proposed that genitive of quantification is assigned by the functional head F. The relevant structure for (67) is given in (68).

(68)

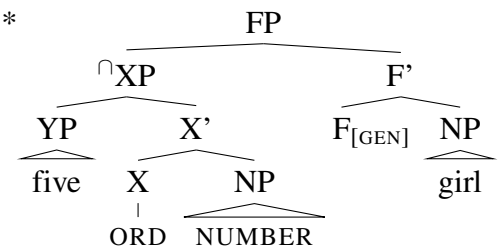


I assume that when there is no genitive of quantification, F is not present in the structure. Based on this assumption, I propose that genitive of quantification is not available in the ordinal construction because ordinals block the function head F. Following Bošković (2013), I assume that the F head is a preposition-like element. Ordinals in Serbo-Croatian are adjectival showing agreement with the main noun. I assume that they adjoin to the main NP, as shown in (69a). (Recall that I proposed in Chapter 2 & 3 that lower numerals which agree with the main noun also adjoin to the main NP, similarly to the ordinal in (69a).) When the F head intervenes between them, the resulting structure results in ungrammaticality as in (69b). This is because ordinals as adjectival elements cannot appear above the preposition-like F element.

(69) a.



b. *



Notice also that ordinals can undergo LBE, as shown in (70). This is consistent with ordinals in Serbo-Croatian having the adjunction structure in (63)/(69a). $\cap$XP can be the target of LBE in these structures.

(70) Serbo-Croatian: Ivana Jovović, p.c.

Petu$_1$ *je Ivan pročitao* [Δ_1 *knjigu*].
five.ACC CL Ivan read book.ACC
'Ivan read the fifth book.'

Moreover, the structure in (69a) can account for the LBE pattern of complex ordinals in Serbo-Croatian. As shown in (71), complex ordinals can undergo LBE. Notice also that the complex ordinal can optionally include the coordinator in Serbo-Croatian.

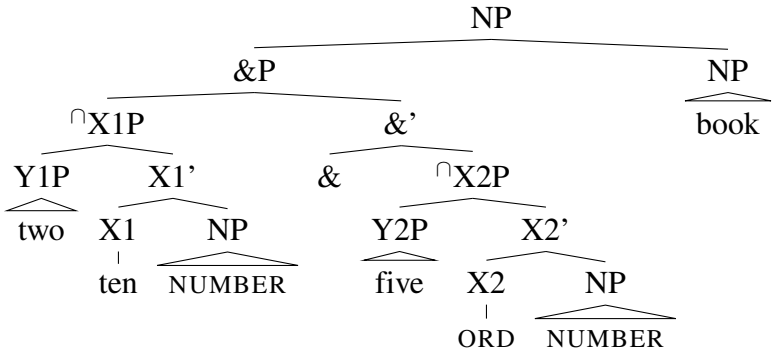
(71) Serbo-Croatian: Ivana Jovović, p.c.

a. *Ivan je pročitao* [*dvadest* (*i*) *petu knjigu*].
Ivan CL read twenty and five.ACC book.ACC
'Ivan read the twenty fifth book.'

b. [*Dvadest* (*i*) *petu*]$_1$ *je Ivan pročitao* [Δ_1 *knjigu*].
twenty and five.ACC Ivan CL read book.ACC

Recall that in Chapter 3, I proposed that additive complex cardinals can have the coordination phrase of numerical expressions. Under the current analysis, the complex ordinal in (71) can be analyzed straightforwardly as having the coordinate structure given in (72).

(72)

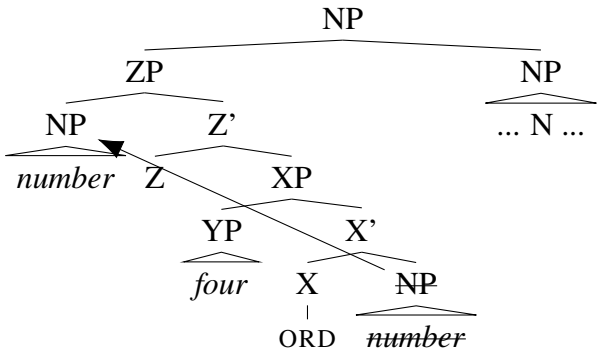


In (72), the higher numeral (*dvadest*) and the ordinal (*petu*) appear with the silent NUMBER. X1P and X2P here are converted into numerical expressions of type n due to the $\cap$ function. Hence, (72) invloves coordination of two numerical expressions of the same type. Furthermore, the coordination phrase in (72) can be the target of LBE.

The existence of the silent NUMBER in ordinals can be supported by the overt "number" strategy of expressing ordinals. We can treat the nominal element meaning 'number' in the overt "number" strategy as an overt realization of the silent NUMBER. Regarding the 'overt' number strategy in English, I hypothesize that the overt *number* moves to a higher position as shown in (73).[16]

(73) a. *the question number four*

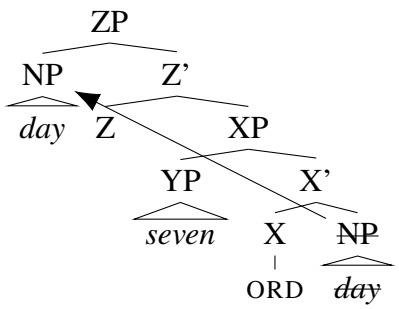
b.



A similar inversion process of the complement of the covert ORD may be involved in other examples (e.g. *day seven*), as in (74).

(74) a. *day seven*

b.



16. Regarding semantics, I assume that a moved element is reconstructed into the base-generated position.

Importantly, the structures I proposed in this section generate all and only the attested constituent orders of N, # and ORD, in combination with the specifier-head-complement hypothesis. The unattested combinations (i.e. *ORD-N-# and #-N-ORD) do not arise under the present analysis. Since numeral classifiers and ordinal markers occur in the same syntactic position, they behave alike regarding (im)possible constituent orders.

4.3 Ordinals in classifier languages

In the previous section, I focused on ordinals in non-classifier languages. I proposed that numeral classifiers and ordinal markers occur in the same syntactic position, and hence behave alike regarding (im)possible constituent orders. Building on the proposed analysis, this section investigates derivational strategies of ordinals in classifier languages.

Recall that I distinguish the following types of numerical expressions in this thesis.

(75) a. **Numerals**: linguistic expressions corresponding to numbers.
(*Three plus four is **seven***.)

b. **Cardinals**: numerals used to express the cardinality of sets.
(***seven** books*)

c. **Ordinals**: numerals used to express an ordering property.
(*the **seventh** book*)

In the literature, it has been argued that ordinals are derived from cardinals (Stampe (1976), Veselinova (1997), Stolz and Veselinova (2005)). However, previous studies are based on data from non-classifier languages where the distinction between numerals and cardinals is not completely clear in most cases. Given this, derivational patterns of ordinals in classifier languages would be beneficial to examine.

The typological distinction between classifier and non-classifier languages has re-

ceived a lot of attention in the literature (Krifka (1995), Chierchia (1998), Borer (2005), Bale and Coon (2014), Sudo (2016), a.o.). In Chapter 2, I proposed that non-complex cardinals are of type n. In non-classifier languages, the covert measurement function ε, which corresponds to numerical classifiers in classifier languages, is used to combine a cardinal of type n and the main noun. For instance, the denotation of *three students* is given in (76). (See Scontras (2014) for a similar analysis of numeral constructions.)

(76) a. [[$_{\text{YP}}$ *three*] [ε [$_{\text{NP}}$ *students*]]]

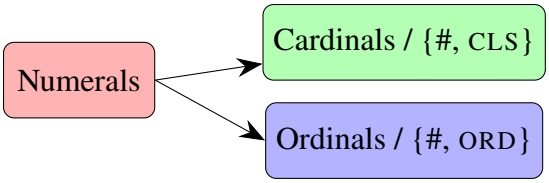
b. $[\![$ *three* ε *students* $]\!]$

$= \lambda x.\exists S.[\Pi(S)(x) \wedge \mu(x) = 3 \wedge \forall y \in S.[|\{z: z \leq_{at} y\}| = 1 \wedge \forall z \leq_{at} y.[\text{student'}(z)]]]$

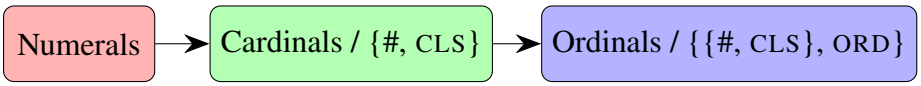
Note also that the covert function ε must be unavailable in obligatory classifier languages where classifiers are generally indispensable in numerical expressions. I speculate in this thesis that the existence of numeral classifiers blocks the covert function ε in obligatory classifier languages. (See Chierchia (1998) for a similar blocking effect, where the existence of an overt element performing a particular semantic function blocks the covert counterpart of the same element.)

I proposed in Chapter 2 that non-complex numerals need the covert measurement function to modify a noun phrase. Since ε is a covert element, the distinction between bare numerals and the cardinal usage of numerals does not have to be overtly realized in non-classifier languages, with few exceptions (e.g. *eins* and *ein*(*e*) in German, Hurford (1987, 2001)). On the other hand, the distinction between numerals and cardinals is overtly manifested by the presence of numeral classifiers in classifier languages. What is important is that numeral classifiers appear when numerical expressions are used in the cardinal context (i.e. (2b)) in classifier languages. Classifier languages thus provide an important clue as to the derivational patterns of numerical expressions. Logical possibilities of derivational patterns of ordinals are summarized in (77).

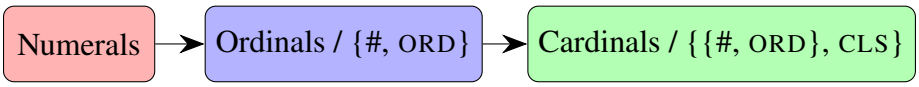
(77) a.



b.



c.



I take it for granted that bare numerals are the fundamental expression for number concepts. In (77b), cardinals are derived from numerals, and then becomes ordinals. (77c) is the opposite pattern of (77b). Ordinals are derived from numerals and then cardinals are formed based on the derived ordinals. In (77a), cardinals and ordinals are independently derived from numerals, and hence there is no direct derivational relationship between cardinals and ordinals. In what follows, I will examine derivational patterns of ordinals in classifier languages.

4.3.1 Strategies of expressing ordinals in classifier languages

In this section, I give strategies of forming ordinals observed in my sample of classifier languages. I refer to both optional and obligatory classifier languages as classifier languages in this thesis when systematic use of numeral classifiers is observed. The results of my cross-linguistic survey is summarized in (78).

(78) Ordinal markers in optional/obligatory classifier languages

a. Particular affixes/particles:

(i) Post-numeral (# $\prec$ ORD, 8 languages, 8 genera):

Atong [Tibeto-Burman], Boko [Mande], Hungarian [Uralic], Japanese [Japanese], Korean [Korean], Lai/Chin [Sino-Tibetan], Toqabaqita [Austronesian], Turkish [Turkic]

(ii) Pre-numeral (ORD $\prec$ #, 14 languages, 8 genera):

Anong [Sino-Tibetan], Bih [Austronesian], Hakha Lai [Sino-Tibetan], Helong [Austronesian], Indonesian [Austronesian], Japanese [Japanese], Kana [Niger-Congo], Lamjung Yolmo [Tibeto-Burman], Mandarin Chinese [Sino-Tibetan], Mokilese [Austronesian], Metting Belait [Austronesian], Nung [Tai-Kadai], Telugu [Dravidian], Xong [Hmong–Mien]

(iii) Circumfixal 2 languages, 1 genus):

Batak (Karo) [Austronesian], Batak (Toba) [Austronesian],

b. Relative clauses (4 languages, 4 genera):

Abun [Papuan], Kiribati/Kiribatese [Austronesian], Thai [Tai-Kadai], Vietnamese [Austro-Asiatic]

c. Preposition (1 language, 1 genus):

Achenese [Austronesian] (preposition 'to'),

d. Possessives (4 languages, 3 genera):

Abui [Alor-Pantar], Chontal Maya [Mayan], Itzaj [Mayan], Kove [Austronesian]

e. Overt "number" (2 languages, 2 genera):

Bislama [Creole in Vanuatu], Japanese [Japanese]

f. Definiteness (2 language, 2 genera): Nuosu [Sino-Tibetan], Samoan [Austronesian]

Particular affixes/particles

As with non-classifier languages, there are a number of classifier languages which use particular affixes/articles to express ordinals. In Xong, ordinals are formed by attaching the ordinal prefix *dib-* to Sinitic numerals. Numeral classifiers follow the numeral and the main noun is optional (Sposato 2015 :289). Sposato (2015) suggested that the prefix *dib-*

was borrowed from Standard Mandarin on the bases of its phonetic form, meaning, and the position where it occurs.

(79) Xong: Sposato (2015: 290, attributed to Shinxiang Wu's fieldnotes),

Pre-numeral (ORD ≺ #)

Boub bioud nins dib-sank-donb.

1.PL home COP ORD-three-$\text{CLS}_{\text{building}}$

'Our home is (in) the third building (on the left there).'

(80) Mandarin Chinese: Xuetong Yuan, p.c., Pre-numeral (ORD ≺ #)

Zhangsan du le [***di san***] *ben shu.* [Mandarin Chinese]

Zhangsan read ASP ORD three CLS book

'Zhangsan read the third book.'

(81) Kana [Niger-Congo]: Ikoro (1996: 87), Pre-numeral (ORD ≺ #)

èrêè-nìà sɔ́

ORD-four time

'the fourth time'

(82) Boko [Mande]: Jones (1998: 126), Post-numeral (# ≺ ORD)

a. *i a pɔ́ sɔ́o-de dia-ɛ̀*

2.PL.SUBS 3.POSS.INAN thing five-ORD add-B

'And then you will add a fifth to it.'

b. *mɔ sɛ̃́íá* [*gɔɔ gɛ̃̀o-mɛ̀n̰-do-sài-de*] *zɪ́*

month first day fifteen-CLS-one-ABES-ORD time

'on the fourteenth day of the first month'

In Karo-Batak [Autronesian], ordinals are formed by the circumfix *pe-* ... *-ken*, similarly to Toba-Batak in which the circumfix *pa-* ... *-h0n* is used to form ordinals.

(83) Batak (Karo) [Autronesian]: Woollams (1997: 130), Circumfixal

*Sibarkenna ibas lubang **pe**-lima-**ken** nari ku teruh.*
(PASS).measure.he at hole ORD-five-ORD from to bottom
'He measured from the fifth hole down to the end (of the flute)'

(84) Batak (Toba) [Autronesian]: Nababan (1981: 72), Circumfixal

a. *dúa*
two
'two'

b. *pa-dúa-h0n*
ORD-two-ORD
'second'

Relative clauses

The relative clause strategy is also attested in classifier languages. In Thai [Tai-Kadai], *thîi* is homonymous to a relative pronoun (Warotmasikkhadit 1972: 56). (See also Kullavanijaya (2008) for a historical study of this element in Thai and Jenks (2014) for a syntactic analysis of relative clauses in Thai.)

(85) Thai [Tai-Kadai]: Warotmasikkhadit 1972: 48

a. *măa tua nán thîi khun hĕn kàt dèk*
dog CLS that THII you see bite child
'That do which you saw bit a boy.'

b. *Khun hĕn măa tua nán thîi kàt dèk.*
you see dog CLS that THII bite child
'You saw the dog that bit a boy.'

The same particle is used to express ordinals in Thai.

(86) Thai [Tao-Kadai]: Panat Taranat, p.c.

chán hây kháw [*náŋsŭu mày lêm thîi săam*].
I give him book new CLS THII three
'I gave him the third new book.'

In Lao, ordinals are formed by using the relativizer *thii1*.

(87) Lao [Tai-Kadai]: Enfield (2007: 113, 136, 157)

a. *hùan2 thii1 sòòng3*
house ORD two
'the second house' [Arabic figures stand for pitch contours]

b. *hùan2 lang3 thii2 sòòng3*
house CLS ORD two
'the second house'

In Abun, ordinals are formed by attaching the prefix *do* 'the one which', as shown in (138).

(88) Abun [Papuan]: Berry&Berry (1999: 93)

a. *An git weu (bo) do-at.*
3SG eat banana CLS the.one.which-four
'He is eating the fourth banana.'

b. *nu gwes kok kwat do-gri.*
house leg high platform the.one.which-three
'the house on stilts' third level'

It should be noted that the relativization strategy is not restricted to languages where numerals are verbal. For examples, cardinals in Thai do not show any verbal behavior and occurs in the attributive position in the nominal domain.

Prepositions

Remember that there are three non-classifier languages which use a postposition to form ordinals (Cahuilla [Uto-Aztekan], Navajo [Athapaskan], Yup'ik [Eskimo-Aleut]). In classifier languages, I found one language which uses a preposition to express ordinals. Durie (1985) reports that ordinals in Achenese is formally PPs, consisting of the preposition *keu* 'to' and a cardinal. Durie (1985: 138) also mentions that "Ordinals are used without classifiers, most commonly occurring in a relative clause with *nyang*, the relative marker", giving the example in (89).

(89) Achenese [Austronesian]: Durie (1985: 138)

'oh trôh bak-langet nyang-keu-phôn ...
when arrive at-heaven REL-to-first
'When (he) arrived at the first layer of the heavens ...'

Ordinals in Achenese could be analyzed as involving the relative clause strategy. However, it is not clear whether Achenese ordinals must alwasy occur in relative clauses. Given this, I categorized Achenese as a language which has the preposition strategy.

Possessives

Recall that in Section 4.2, I observed that in the possessive system, ordinals behave as a possessed phrase in non-classifier languages. Importantly, the same holds for the possessive strategy in classifier languages. Some examples are given below.

(90) Abui (Kratochvíl 2007: 119, 139)

a. *moku he-sua*
kid 3.II.AL$_{ORD}$-three
'third child'

b. *maama he-sepeda*
father 3.II.AL-bike
'father's bike'

(91) Ch'ol [Mayan]

a. *Tsa' chäm-i* [*i-cha'-kojty-lel wakax*].
PFV die-IV A3-two-CLS-NML cow
'The second cow died.' [Bale et.al. 2019: 18]

b. *i-pisl-el aj-Rosa*
A3-cloth-EL NC-Rosa
'Rosa's clothing' (e.g. that she wears on her body)' [Coon 2010: 86]

(92) Kove: Sato (2013: 197-198)

moe hua ai-a
sleeping.mattress two 3SG.POSS-A.POSS
'the second sheet of sleeping mattress'

These data support the cross-linguistic pattern summarized in (93).

(93) *The cross-linguistic pattern of possessive ordinals*:
In the possessive strategy of expressing ordinals, a numeral behaves as a possessed phrase.

Overt "number"

As briefly discussed in Section 4.2, Bislama uses an overt element meaning 'number' to express ordinals.

(94) Bislama [Creole in Vanuatu]: Crowley (2004: 55)

Namba-tri haos hem i blong mi.
number-three house 3SG I of I
'the third house is mine.'

Definiteness

'o is an element associated with definiteness, and the following element like *le* seems to bear number and/or other agreement features. Note that *'o* also appear in pronouns and demonstratives; *'o lenei* 'this', *'o a'u* 'I' (Neffgen 1918).

(95) Samoan [Austronesian]: Neffgan (1918: 5)

a. *'o le māile*
the.SG dog
'the dog'

b. *'o la māile*
the.DU dog
'the two dogs' / 'both the dog'

Crucially, the singular definite marker functions as an ordinal marker in Samoan, as in (96).

(96) Samoan [Austronesian]: Neffgan (1918: 38)

a. *'o le lua*
the.SG two
'second'

b. *'o le tolu*
the.SG three
'third'

A common property of the strategies of expressing ordinals

Like the strategies in non-classifier languages discussed in Section 4.2, the strategies I found in the above sample of classifier languages show that ordinals behave as nominal expressions. Prepositions typically combine with a noun. In the prepositional strategy, numerals are thus nominal. The possessive relation typically holds between two referents denoted by nouns. In the possessive strategy, ordinals appear in the same position as the possessed phrase. This indicates that ordinals in this strategy are also nominal. In the relative clause strategy, ordinals can be analyzed as the nominal predicate in a relative clause. The overt "number" strategy includes an overt nominal element meaning 'number'. The overt "number" itself can be the source of the nounhood of ordinals. Lastly, the definiteness strategy also shows the nominal nature of ordinals. The definiteness marker typically

appears with a nominal expression. All in all, the data discussed in this section and Section 4.2 provide us with the cross-linguistic pattern given in (97).

(97) *Observation*

Ordinals function as nominal expressions cross-linguistically.

Importantly, (97) is exactly the same as the cross-linguistic observation about ordinals in non-classifier languages given in (36) in Section 4.2. In other words, the observation in (97) holds quite generally for ordinals in both classifier languages and non-classifier languages. In the next section, I will consider whether the observation in (97) can be accounted for under the present analysis, investigating (im)possible constituent orders of nouns (N), numerals (#), ordinal markers (ORD) and numeral classifiers (CLS).

4.3.2 (Im)possible constituent orders in classifier languages

The (im)possible constituent orders observed in my survey are summarized in (98) (# = numerals, CLS = classifiers, ORD = ordinal markers).

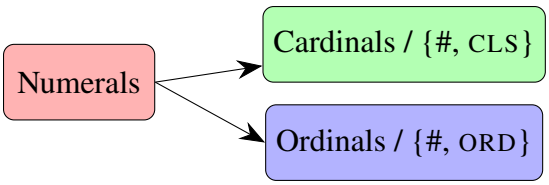
(98)

Order	Langauges
ORD-#	Armenian, Begak-Ida'an, Achenese, Belait, Indonesian, Javanese, Kana, Kosraean, Makassar, Padoe/Mori, Samoan, Sawu, Turkish, Puyuma, Sedang
#-ORD	Boko, Gilaki, Hungarian, Nivkh (East Sakhalin), Persian, Romani, Toqabaqita, Anong, Chontal Maya, Deuri/Chutiya, Hakha Lai, Lamjung Yolmo,
ORD-#-CLS	Mandarin, Cantonese, Mokilese, Itzaj, Xong, Mien/Yao, Chuukese/Trukese, Kiribati/Kiribatese, Ulithian
ORD-CLS-#	Not observed
#-ORD-CLS	Not observed
#-CLS-ORD	Japanese, Korean, Burmese, Chontal Maya, Kwaza
CLS-ORD-#	Abun, Lao, Nung, Thai
CLS-#-ORD	Atong, Mussau, Kilivila

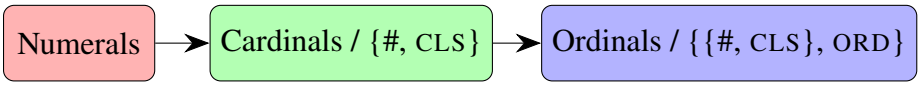
The survey includes 182 classifier languages. I first checked the database of The World Atlas of Language Structure Online (WALS), in which 62 optional classifier languages and 78 obligatory classifier languages are included. The data on ordinals were attested in 39 languages (39/140). I also checked additional 42 languages chosen on a quasi-random basis, in which systematic use of numeral classifiers is observed (both optionally and obligatorily).

Recall that there are several logical possibilities for derivational patterns of ordinals are summarized in (99).

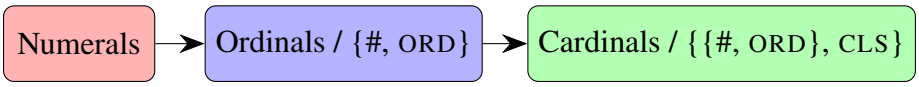
(99) a.



b.



c.



The results of our survey summarized in (98) show that in many classifier languages, ordinals do not include classifiers (#-ORD and ORD-#). These patterns are not expected under the analysis in (99b), where ordinals are derived from cardinals (= numeral classifier phrases). (99a) and (99c) are consistent with the patterns in question. However, an independent problem for the analysis in (99c) is that there is no classifier languages in which cardinals/classifier phrases are expressed by ordinals or ordinal markers. In light of all of this, the fact that the majority of the languages in our sample shows NUM-ORD or ORD-NUM can be seen as support for the pattern in (99a).

Ordinals, superlatives and the containment hypothesis

It has been observed that ordinals behave like superlatives in several respects (Bhatt (2006), Barbiers (2007), Sharvit (2010)). Given this, one may expect that ordinal markers would be similar to superlative morphemes and hence exhibit an effect similar to the Containment Hypothesis given in (100).

(100) The Containment Hypothesis: Bobaljik (2012)
The representation of the superlative properly contains that of the comparative (in all languages that have a morphological superlative).

The containment hypothesis requires that the representation of superlatives properly contains the representation of comparatives. Therefore, the complex unit given in (101a) is available for superlatives in all languages, but the one in (101b), where the superlative does not properly contain the representation of comparatives, is cross-linguistically disallowed. One example of the transparent containment pattern is given in (101c) from Persian.

(101) a. [[[ADJECTIVE] COMPARATIVE] SUPERLATIVE]

b. *[[ADJECTIVE] SUPERLATIVE]

c. Persian: Bobaljik (2012: 31)
kam, *kam-tar*, *kam-tar-in*
'little, little-CMPR, little-CMPR-SPRL'

However, as shown in (98), ordinal markers can combine directly with numerals in many classifier languages. The present survey indicates that (102a) is available when it comes to ordinals. This also means that (102b) should not be a general condition on the representation of ordinals. If (102b) were a general condition, the fact that ordinals do not include classifiers in many classifier languages would not be expected. Also, as discussed above, the representation in (102c) must be abandoned because there is no classifier language in

which cardinals/classifier phrases are expressed by ordinals or ordinal markers.[17]

(102) a. [[NUMERAL] ORDINAL-MARKER]

b. [[NUMERAL] CARD/CLASSIFIER] ORDINAL-MARKER]

c. [[NUMERAL] ORDINAL-MARKER] CARD/CLASSIFIER]

Notice also that the Containment Hypothesis holds only for relative superlatives, which essentially mean 'more ADJ than all alternatives' (Bobaljik (2012)). (So-called absolute superlatives (also sometimes called elatives) are excluded from the scope of the Containment Hypothesis.) Relative superlatives semantically involve comparison (and hence some sort of ranking or ordering). The Containment Hypothesis is thus consistent with the semantics of relative superlatives; relative superlatives semantically and morphosyntactically contain comparatives. In this respect, one might expect that ordinals would morphosyntactically contain a layer which would bear the meaning of comparison, because ordinals also semantically require a certain ranking or ordering. The representation in (102b) actually illustrates this type of analysis.

However, that (102b) is not imposed is also not surprising when we consider the mathematic nature of numerals. Mathematically speaking, numerals are inherently associated with certain ranking/ordering. Let us first consider von Neumann's (1923) definition of natural numbers. As shown in (103), von Neumann proposes that natural numbers can be represented in the set theory.

(103) *von Neumann's definition of natural numbers*

a. $0 = \varnothing$

b. $1 = \varnothing \cup \{\varnothing\} = \{\varnothing\} = \{0\}$

c. $2 = \{\varnothing\} \cup \{\{\varnothing\}\} = \{\varnothing, \{\varnothing\}\} = \{0, 1\}$

17. I will also argue that the impossibility of (102c) can be a part of a broad constraint on the representation of cardinals and ordinals, in connection with the Containment Hypothesis in (100).

d. $3 = \{\varnothing, \{\varnothing\}\} \cup \{\{\varnothing, \{\varnothing\}\}\} = \{\varnothing, \{\varnothing\}, \{\varnothing, \{\varnothing\}\}\} = \{0, 1, 2\}$

e. $n = \{0, 1, \ldots, n-1\}$

Here, "zero" is defined as an empty set ($\varnothing$). "One" is equivalent to a set containing the empty set ($\{\varnothing\}$). Similarly, "two" is equivalent to a set containing the set already constructed (i.e. $\varnothing$ and $\{\varnothing\}$). In other words, every natural number is composed of the smaller natural numbers.

Now, Chomsky (2008) points out a connection between the syntactic operation Merge and von Neumann's mathematical definition of the natural numbers, as shown in (104).

(104) Chomsky (2008: 139)

> Suppose that a language has the simplest possible lexicon: just one LI, call it "one." Application of Merge to the LI yields { one }, call it "two". Application of Merge to { one } yields { one, { one }}, call it "three." And so on. In effect, Merge applied in this manner yields the successor function. It is straightforward to define addition in terms of Merge(X, Y), and in familiar ways, the rest of arithmetic.

More recently, Watanabe (2017) proposes a connection between natural numbers and objects produced in the syntax given in (105), based on Chomsky's suggestion.

(105) a. $0 =_{\text{def}} i$

b. $1 =_{\text{def}} \{ i \}$

c. $2 =_{\text{def}} \{ i, \{ i \} \}$

d. $3 =_{\text{def}} \{ i, \{ i, \{ i \} \} \}$

Watanabe uses variable *i*, which can be any arbitrary lexical item. If we replace the variable *i* with the lexical item denoting the number concept "zero", the natural number series starts from "zero". In this way, von Neumann's definition of natural numbers in (103) can be implemented linguistically.

Importantly, von Neumann's definition of natural numbers can derive the five Dedekind-Peano axioms given in (106) as theorems (Partee et al. (1990), Landman (1991), Dasgupta (2014)).

(106) *The Dedekind-Peano Axioms*

a. "Zero" is a natural number.

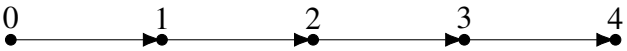
b. Every natural number n has a unique successor S(n) which also is a natural number.

c. "Zero" is not the successor of any natural number.
($\forall x[\neg(S(x) = 0)]$)

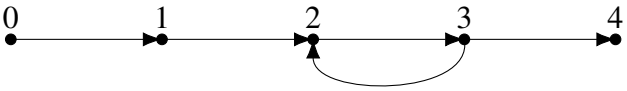
d. No two distinct natural numbers have the same successor.
($\forall m,n \in N\ .\ [S(m) = S(n) \rightarrow m = n]$)

e. If P is a property of natural numbers such that
(i) "zero" has the property P, and
(ii) whenever a natural number has the property P so does its successor,
then all natural numbers have the property P.

The Dedekind-Peano axioms in (106) generate the ranking/ordering relation among natural numbers represented in (107).

(107) 

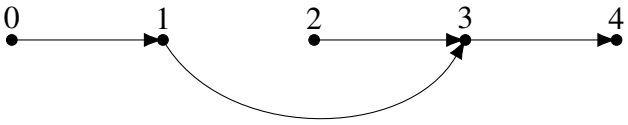
Other orders do not satisfy the Dedekind-Peano axioms. For example, the orders below are not allowed.

(108) 

[Violation of (106b)]

(109) 

[Violation of (106c)]

(110) 

[Violation of (106d)]

(108) violates (106b) because "3" has two successor functions (S(3) = 2 and S(3) = 4). (109) violates (106c) because "zero" here is a successor of X (i.e. S(X)). Lastly, (110) is not allowed because "one" and "two" have the same successor (S(1) = S(2) = 3). The set of natural numbers thus forms only the order in (107), which is transitive, irreflexive and total.

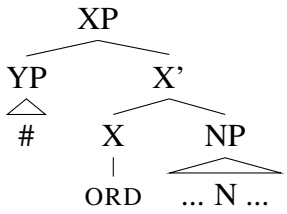
Simply put, natural numbers can be inherently mapped onto the ordering relationship without any additional operations. In other words, there is no obvious semantic motivation for an intervening element between numerals and ordinal markers in the representation of ordinals. The representation in (102b) is thus semantically/mathematically unmotivated.

(Im)possible constituent orders of #, CLS and ORD

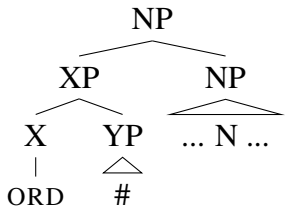
Let us now consider (im)possible constituent orders of #, CLS and ORD observed in my language sample, summarized in (98). In Section 4.2, I proposed that ordinal markers occur in the same position as numeral classifiers based on the typological data regarding the (im)possible constituent orders. The proposed structures are given below.

(111)

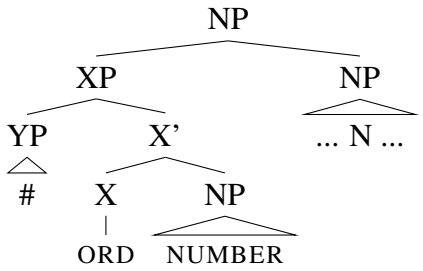
a. Complementation



b. Adjunction



(112) Ordinals with the silent NUMBER



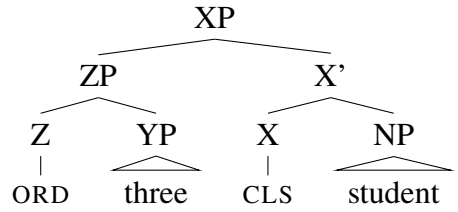
Recall that as discussed in Section 4.2, I assume the specifier-head-complement hypothesis following Kayne (1994) and Cinque (2005). Two attested combinations (#-ORD and ORD-#) in (98) can be derived from the complementation structure and the adjunction structure, respectively. The structure in (112) also yields the #-ORD sequence.

ORD-#-CLS

The present analysis also allows for the ORD-#-CLS order. Thus, regarding ordinals in Mandarin, I propose that they have the structure in (113b). (113b) is a combination of the complementation structure in (111a) and the adjunction structure in (111b).

(113) a. *di* *san-ge* *xuesheng*
ORD three-CLS student
'the third student'

b.



The ordinal marker *di* combines with the numeral *san*, projecting its own projection. The numeral classifier, on the other hand, occurs in the complementation structure taking the main noun as the complement. The ordinal phrase (OrdP) appears in the specifier of the ClsP headed by the numeral classifier. Due to the specifier-head-complement hypothesis,

the ordinal marker precedes the numeral, and they precede the numeral classifier yielding the ORD-#-CLS order.[18]

18. In (113b), the classifier *ge* takes an ordinal, not a numeral as its specifier. This should be ruled out for Japanese ordinals because Japanese does not allow for the the ORD-#-CLS order as in (i). When the ordinal prefix is used in Japanese, a numeral classifier must be omitted.

(i) Japanese

a. *san nin no koohosya*
three CLS GEN candidate
'three candidates'

b. *dai san no koohosya*
ORD three GEN candidate
'the third candidate'

c.* *dai san nin no koohosya*
ORD three CLS GEN candidate
Int. 'the third candidate'

One crucial difference between Mandarin Chinese and Japanese is that classifiers in Mandarin can co-occur with non-numerical expressions. It has been reported that numeral classifiers in Bih, Mandarin, Thai and Vietnamese can co-occur with quantifiers like "every".

(ii) a. Thai [Tai-Kadai]: Jenks (2011: 82)
thúrian thúk lûuk
durian every CLS
'every durian'

b. Mandarin Chinese: Shuyan Wang and Kangzheng Gao, p.c.
mei ben shu
every CLS book
'every book'

c. Vietnamese [Austro-Asiatic]: Tran (2013: 91)
mỗi con chó
every CLS dog
'every dog'

d. Bih [Austronesian]: Nguyen (2013: 125)
Grăp čô mnuih manei kĭn di ñu ačô.
every CLS people wash DAT PL 3 REFL
'Everyone washed himself.'

However, Japanese numeral classifiers cannot co-occur with any quantifiers, as in (iii).

(iii) Japanese
*{*subete* | *hotondo* | *sukosi*} *satsu-no hon*
all most few CLS-GEN book
'all/most/few books'

Although I leave the detailed semantic analysis of Mandarin classifiers for future research, in light of this, it seems reasonable to assume that Mandarin allows for non-numeral expressions like ordinals in the specifier position of a phrase headed by a classifier.

It is worth noting here that the present analysis can account for the ban on contraction of the numeral *san* and the classifier *ge* in Mandarin ordinals. As discussed in Chapter 3, Mandarin Chinese has the contracted form of the numeral *san* 'three' and the default classifier *ge*; *sa* (*san-ge* 'three-CLS' ⇒ *sa*). When a cardinal is used as an addend of an additive complex cardinal, the contraction is blocked, as in (114b).

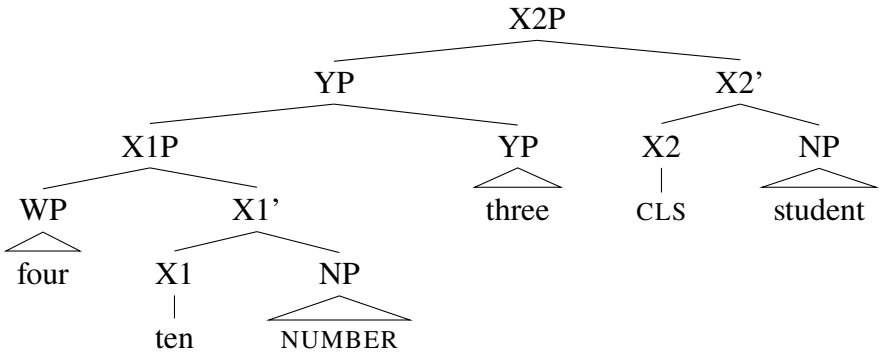
(114) Mandarin Chinese: Shuyan Wang (p.c.)

a. *si-shi san-ge xuesheng*
four-ten three-CLS student
'forty three student'

b. **si-shi sa xuesheng*
four-ten three.CLS student
'forty three student'

In Chapter 3, I proposed that when *san* 'three' appears inside an additive complex cardinal, *sishi* 'forty' and *san* 'three' form a constituent in (115).

(115)



In (115), X1P adjoins to *san* 'three', and morphological fusion cannot take place because the phrase headed by *san* and *ge* are not in a Spec-Head relation. The unavailability of a contracted form thus can be captured by assuming that additive complex cardinals have a non-coordinate structure in Chinese. The assumption I adopted in the thesis regarding the classifier contraction in Mandarin Chinese is summarized in (116).[19]

19. Mandarin Chinese also has the contracted form for the numeral *liang*; *liang-ge* 'two-CLS' ⇒ *lia*. This contracted form is also subject to (116).

(116) A numeral and the classifier *ge* can be fused only when they are in a direct Spec-Head relation.

As discussed in Chapter 3, support for the current analysis in (116) comes from approximative numerals. As shown in (117), the contraction of a numeral and the classifier *ge* is blocked when the numeral is used as a part of an approximative number construction.

(117) Mandarin Chinese [Sino-Tibetan]: Shuyan Wang, Ting Xu, Muyi Yang

a. [*liang san*]-*ge* *xuesheng*
two three-CLS student
'two or three students'

b. **liang sa* *xuesheng*
two three.CLS student
'two or three students'

The contrast in (117) naturally follows from the current analysis, given in (116). In the approximative number construction, the sequential numbers form a unit and the numeral *san* 'three' and the classifier *ge* cannot be in the required Spec-Head relation. (See Section 3.3.2 of Chapter 3 for the detailed analysis of the approximative number construction in Mandarin.)

Crucially, the contraction in question is also banned in the ordinal construction as in (118b).

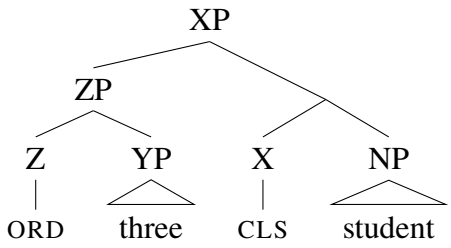
(118) Mandarin: Shengyun Gu, Shuyan Wang, Ting Xu, Muyi Yang

a. *di* *san-ge* *xuesheng*
ORD three-CLS student
'the third student'

b. **di* *sa* *xuesheng*
ORD three.CLS student
'the third student'

The current analysis of the ORD-#-CLS order in Mandarin Chinese can account for the fact that the ordinal prefix *di* does not allow for the contracted form. The structure of the ordinal construction is given in (119).

(119)



The OrdP in (119) appears in the complementation structure of the numeral classifier phrase headed by the classifier *ge*. In (119), the numeral (YP) and the classifier head are not in a Spec-Head relation. Therefore, the contraction is blocked.

There is another piece of evidence for the structure in (119). Recall that Mandarin Chinese has two forms of the numeral "two"; *liang* and *er*. *Liang* functions as a cardinal and cannot be used in the ordinal construction, as in (120). The general distribution of *liang* and *er* is summarized in (121).

(120)

a. *di* *er-ge* *xuesheng*
ORD two-CLS student
'the second student'

b. **di* *liang-ge* *xuesheng*
ORD two-CLS student
'the second student' [Mandarin]

(121)

	Numeral	Addend	Cardinal	Ordinal	Approximative
liang	*	*	✓	*	✓
er	✓	✓	*	✓	*

Given the distribution in (121), I assume that *liang* can be used only when it appears in the specifier of the phrase headed by a classifier head (i.e. in the cardinal context), whereas *er* is an exponent of the numeral "two" appearing elsewhere. As shown in (119), numerals appear in the complement of the ordinal head (Ord) in the ordinal construction under the current analysis. It is then expected that *er* but not *liang* must be used in the ordinal construction, as shown in (120).

CLS-#-ORD

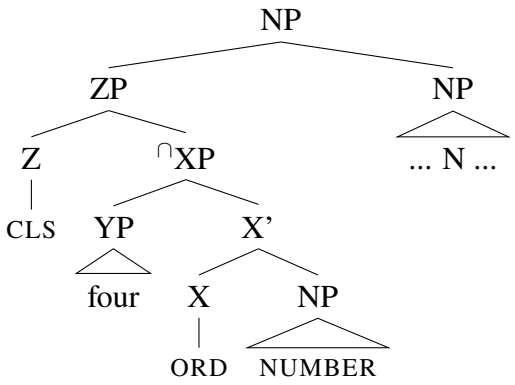
Turning now to the CLS-#-ORD order, this order is observed in Nung, as shown in (122).

(122) Nung [Tai-Kadai]: Saul & Wilson (1980: 34)

mu'hn pay áu tú tại chéht tê
he go take CLS ORD seven that
'He went and married the seventh girl.'

The present analysis can also capture the CLS-#-ORD order. This order can be derived from the structure in (123).

(123) CLS-#-ORD



In (123), the XP contains the silent NUMBER and can be converted into a numerical expression of type n via the ∩ function. The denotation of the converted ordinal number is given in (124) (Chierchia (1985), Rothstein (2013, 2017)).

(124) ⟦ ∩[four ORD NUMBER] ⟧ = 4 (in rank)

The classifier head in (123) takes the converted ordinal number as its complement, just like the one in the adjunction structure in (59b). Following the specifier-head-complement hypothesis, the structure in (123) generates the CLS-#-ORD.

[NUM-CLS-ORD] and [CLS-ORD-NUM] vs. *[ORD-CLS-NUM] and *[NUM-ORD-CLS]

So far, we have seen that the ORD-#-CLS and the CLS-#-ORD orders can be derived under the analysis proposed in the thesis. In addition to these attested orders, I also found other two patterns in my sample; [CLS-ORD-NUM] and [NUM-CLS-ORD]. It should be noted that what these two orders have in common is the CLS-ORD sequence. Similarly, there are two constituent orders unattested in my language sample; *[ORD-CLS-NUM] and *[NUM-ORD-CLS]. These orders contain the ORD-CLS sequence. These typological observations can thus be summarized in (125).

(125) a. (NUM) CLS-ORD (NUM)

b. *(NUM) ORD-CLS (NUM)

I assume that in languages that exhibit [NUM-CLS-ORD] or [CLS-ORD-NUM], the numeral classifier forms a complex head combining with the ordinal marker, as represented in (126a). In (126a), the classifier head adjoins to the ordinal marker forming the complex ordinal head. (I will give detailed structures derived from (126a) in the next section.)

(126) a. (NUM) $[_{\text{ORD}}$ [CLS] ORD] (NUM)

b. *(NUM) $[_{\text{CLS}}$ [ORD] CLS] (NUM)

Recall that I adopt Kayne's LCA. Under Kayne's LCA, adjuncts generally precede the target constituent. Therefore, The structure in (126a) will yield either [NUM-CLS-ORD] or [CLS-ORD-NUM], depending on the position of the numeral.

To account for the lack of (125b), I propose that the containment relation given in (126b) is disallowed cross-linguistically. In (126b), the ordinal head adjoins to the classifier head, forming a complex classifier head.

The ban on the structure in (126b) is in line with the observation discussed in the beginning of this section; there is no classifier language in which cardinals/classifiers are

expressed by using ordinals/ordinal markers. In other words, the schematic representation in (127) is not possible crosslinguistically.

(127) [[NUMERAL] ORDINAL-MARKER] CARD/CLASSIFIER] [= (102c)]

Importantly, in both (126b) and (127), the ordinal marker (ORD) contains the classifier (CLS). In light of the Containment Hypothesis in (100), what we have here can then be treated as a general ban on the containment relationship between cardinals and ordinals, as summarized in (128).

(128) *The containment constraint on cardinals and ordinals*

In languages where numerals and cardinals are distinguished morphosyntactically, the representation of cardinals cannot contain that of ordinals.

I leave further investigation of the nature of the constraint in (128) for future research. However, the results of my cross-linguistic survey show that the constraint in (128) is supported crosslinguistically.

It is important to notice that in all the structures proposed so far ((113b), (119) and (123)), ordinals appear in the phrase headed by a classifier. However, they are representations of ordinals but not cardinals. (128) only disallows (113b), (119) and (123) as the structures of cardinals. The structures proposed in this chapter thus follow the constraint in (128). In the next section, I will show that other attested patterns of ordinals in my sample of classifier languages obey the containment constraint in (128), and that they can be explained by the current analysis.

4.3.3 More on (im)possible constituent orders in classifier languages

So far, I focused on the constituent orders of three elements: #, ORD, and CLS. In this section, I extend the proposed analysis of ordinal markers to include nouns. In my sample,

I found the combinations of N, #, ORD, and CLS given in (129).

(129)

	Order	Langauges
✓	#-Cls-Ord-N	Japanese, Korean, Chontal, Ch'ol
✓	N-Cls-#-Ord	Atong
✓	Ord-#-Cls-N	Chinese, Xong
✓	N-Ord-#-Cls	Mokilese
✓	N-Cls-Ord-#	Abun, Thai, Lao
✓	Cls-N-Ord-#	Vietnamese

These attested constituent orders (129) can be captured under the current analysis, as will be shown in what follows.

Ord-#-Cls-N and N-Ord-#-Cls

These patterns are found in Mandarin Chinese and Mokilese. As shown in (130), Mandarin Chinese ordinals have Ord-#-Cls-N. Mokilese exhibits N-Ord-#-Cls as in (131).

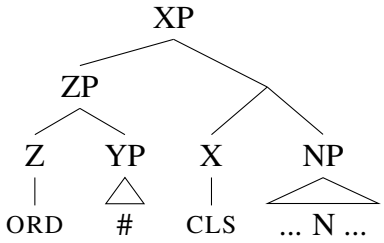
(130) Mandarin

qing dakai di er-shi yi-shan men
please open ORD 2-10 1-CLS door
'Please open the twenty first door.'

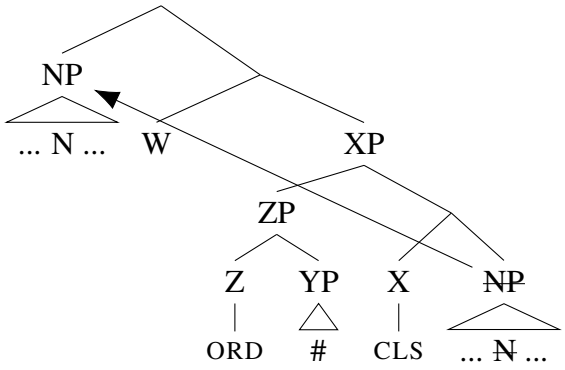
(131) *Ngoah ne wadekla puk ka-jilu-w-wo.* [Mokilese]
I ASP tally-away book ORD-three-CLS-DEM
'I've already read the third book.' [Harrison 1976: 102]

According to the present analysis, ordinals in Mandarin Chinese can have the structure represented in (132), and ordinals in Mokilese can be derived from (132) by NP-movement to a higher position in the extended nominal projection, as shown in (133).

(132) Mandarin



(133) Mokilese



N-Cls-#-Ord

Atong displays the N-Cls-#-Ord order in the ordinal construction as in (134).

(134) Atong [Sino-Tibetan]: van Breugel (2008: 197)

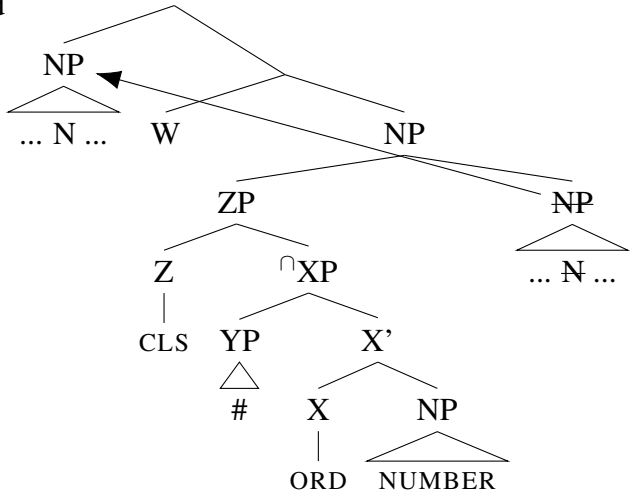
unasa boba məŋʔ sa-gaba teʔew abun boba
then crazy.person CLS.human one-ATTR/ORD now other crazy.person

nuk-ay-siga-ak=no
see-towards-ALT-COS=QUOT
'The first crazy person now saw another crazy person coming towards him, it is said.'

In the previous section, I provided the structure for the Cls-#-Ord order as in (123). The N-Cls-#-Ord order in Atong can be derived by moving the main NP in (123) to a higher position, as represented in (135). (Here, I assume that the relevant NP movement also takes place in Mokilese as in (133). However, the trigger of the NP movement may be different

in these languages. For instance, W in (133) and (135) can be a different functional head in the extended nominal projection.)

(135) N-Cls-#-Ord [cf. (123)]



#-Cls-Ord-N

This pattern is found in Japanese, Korean and the Tapotzingo dialect of Chontal Maya, where the ordinal marker immediately follows a classifier, as shown in (136).

(136) a. Japanese

kare-wa san-ko-me-no keeki-o tabeta.
he-TOP three-CLS-ORD-GEN cake-ACC ate
'He ate the third cake.'

b. Korean

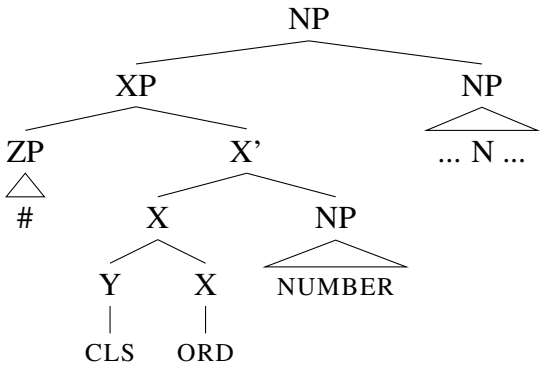
sumwul han pen-ccay-uy mwun-ul yele-cwu-seyyo.
twenty one CLS-ORD-GEN door-ACC open-please-HON
'Please open the twenty first door.'

c. The Tapotzingo dialect of Chontal Maya (Knowles 1984: 282)

?u ča? peč -ib ha?as
A3 two CLS;bunch -ORD banana
'the second bunch of bananas'

Under the present analysis, ordinal numerals in these language can have the structure in (137). Here, the classifier head adjoins to the ordinal head, forming the complex ordinal marker. Recall that I proposed in this chapter that ordinal markers and numeral classifiers are the same kind of syntactic heads which is used for measurement. Building on this analysis, I assume that the complex ordinal marker (i.e. the higher X in (137)) also functions as a measure element.

(137) #-Cls-Ord-N



Recall that under the approach to linearization adopted here, (137) yields the #-Cls-Ord-N order. (Under Kanye's LCA, specifiers/adjuncts generally precede the target constituent.)

N-Cls-Ord-#

Ordinals in Abun, Lao and Thai show the N-Cls-Ord-# order, as shown below.

(138) Abun [Papuan]: Berry and Berry (1999: 93)

An git weu (bo) do-at. [Abun]
3SG eat banana CLS ORD-four
'He is eating the fourth banana.' (Berry&Berry 1999: 93)

(139) Thai [Tai-Kadai]: Smyth (2002: 34)

a. *lûuk săam khon*
child three CLS
'three children'

b. *lûuk khon thîi săam*
child CLS ORD three
'the third child'

(140) Lao [Tai-Kadai]: Enfield (2007: 113, 136, 157)

a. *hùan2 thii1 sòòng3*
house ORD two
'the second house' [Arabic figures stand for pitch contours]

b. *hùan2 lang3 thii2 sòòng3*
house CLS ORD two
'the second house'

Recall that all languages which exhibit the N-Cls-Ord-# order use the relative clause strategy (cf. Section 4.3.1). Berry & Berry (1999) mentioned that *do* in Abun could be analyzed as a complementizer, which stems from the verb *du* 'to speak'. Lao, another Tai-Kadai language, also uses the relativizer *thii1* to form ordinals. In Thai, *thîi* is homophonous with a relative pronoun as in (141) (Warotmasikkhadit 1972: 56).

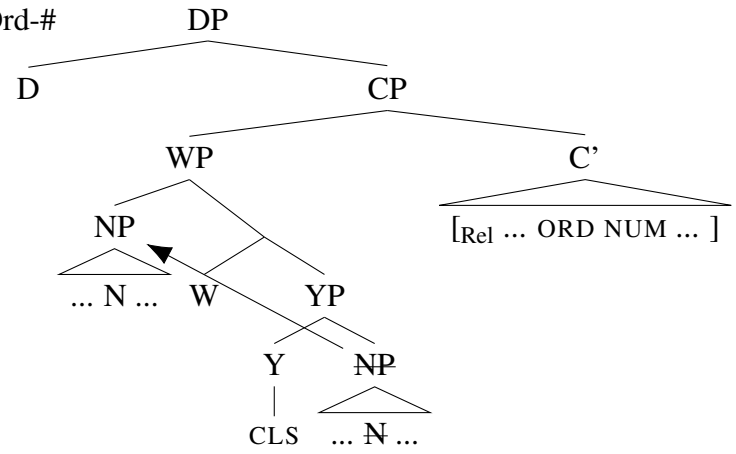
(141) Thai (Warotmasikkhadit 1972: 48)

a. [*măa tua nán thîi khun hĕn*] *kàt dèk*
dog CLS that THII you see bite child
'That dog which you saw bit a boy.'

b. *Khun hĕn* [*măa tua nán thîi kàt dèk*].
you see dog CLS that THII bite child
'You saw the dog that bit a boy.'

As discussed in Section (4.2.1) and (4.3.1), in the relative clause strategy, ordinals can be analyzed as the nominal predicate in a relative clause. Given this, I propose that in the N-Cls-Ord-# order, ordinals appear within a relative clause, as in (142).

(142) N-Cls-Ord-#



In (142), I assume that the classifier head and the main noun form a constituent. The main noun moves to a higher position than the classifier phrase, yielding the N-CLS order. I follow Jenks (2011, 2014) in assuming that the D head combines with the relative CP in Thai (cf. Kayne's (1994) raising analysis of relative clauses). I hypothesize that the other classifier languages that use the relative clause strategy also have the structure in (142).

Cls-N-Ord-#

In Vietnamese ordinals, the classifier and the numeral are separated by the noun and the ordinal marker, as shown in (143).[20]

(143) Vietnamese (Nguyen 2004: 51)

a. *Tôi là* [*ngư*́*ơi con* ***thứ bay*** *trong gia đình*].
I be CLS child ORD seven in family
'I am the seventh child in the family.'

b. *Đó là* [*căn nhà màu trắng* ***thứ hai*** *trên đư*̉*ơng này*].
That be CLS house color white ORD two on street this
'That's the second white house on this street.'

20. Notice that the example in (143) shows that when the ordinal marker *thứ* intervenes, Greenberg's unattested order of N, # and Cls (i.e. Cls-N-#) can be allowed in Vietnamese.

This constituent order can also be accounted for under the current analysis. There is evidence that Vietnamese adopts the relative clause strategy to express ordinals. As shown in (144), relative clauses in Vietnamese must follow adjectives in the post-nominal position. Importantly, the same pattern holds for ordinals, as in (145).

(144) Vietnamese (Nguyen 2004: 59)

a. *Tôi thích cái đâm* [$_{AP}$ *mới*] [$_{RC}$ *mà cô ấy chọn*].
I like CLS dress new that aunt that choose
'I like the new dress that she chose.'

b. **Tôi thích cái đâm* [$_{RC}$ *mà cô ấy chọn*] [$_{AP}$ *mới*].
I like CLS dress that aunt that choose new

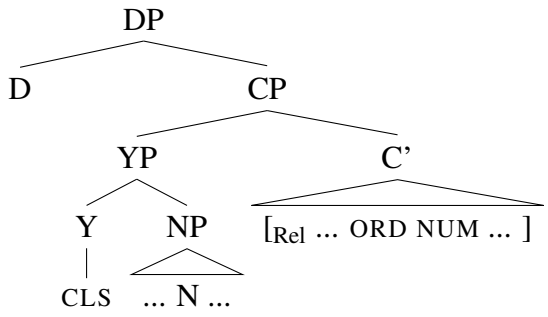
(145) Vietnamese: Thuy Bui, p.c.

a. *Khanh mua cuốn sách* [$_{AP}$ *mới*] [*thứ năm*].
Khanh bought CLS book new ORD five
'Khanh bought the fifth new book.'

b. **Khanh mua cuốn sách* [*thứ năm*] [$_{AP}$ *mới*].
Khanh bought CLS book ORD five new
'Khanh bought the fifth new book.'

Based on these data, I propose that ordinals occur in a relative clause in Vietnamese, like other classifier languages that use the relative clause strategy. The structure of ordinals in Vietnamese is given in (146).

(146) Cls-N-Ord-# [cf. (142)]



Unlike the structure in (142), the main NP remains in the base-generated position in (146). The ordinal appears in the relative clause, and the numeral classifier independently combines with the main NP. Given the specifier-head-complement hypothesis, (146) results in the Cls-N-Ord-# order.[21]

4.4 Summary

This chapter investigated the derivational patterns of ordinals on the basis of results of a cross-linguistic survey. Based on an examination of strategies of forming ordinals in both classifier and non-classifier languages, a common property of ordinals was identified: ordinals behave as nominal expressions. I also showed that ordinal markers display the same pattern as numeral classifiers regarding (im)possible constituent orders in combination with nouns and numerals. Building on this similarity, I proposed that ordinal markers and numeral classifiers occur in the same position in the extended nominal projection.

21. See Nguyen (2004) for a detailed analysis of post-nominal modifiers in Vietnamese.

Chapter 5

Fractional numbers

5.1 Introduction

In this chapter, I investigate linguistic expressions of fractional numbers (henceforth fractions) like (1).

(1) a. *Alex ate **two thirds** of the cake.* [English]

b. *Akira-wa sono keeki no* [***san-bun no ni***]*-o tabeta.* [Japanese]
Akira-TOP that cake GEN three-BUN GEN two-ACC ate
'Akira ate two thirds of the cake.'

I will first clarify the terms used in this chapter. Cross-linguistically, fractions consist of a numerator and a denominator, as shown in (2).

(2)

Numerator	Denominator		
two	*thirds*	*of*	*the cake*
Fraction			Main noun

This chapter will examine the limits of crosslinguistic variation in the linguistic expressions of fractions. The first thing to notice is that in the language sample discussed in this chapter, there is no language where the main noun intervenes between the numerator and the denominator: the main noun either precedes or follows the whole fractional number. The constituent orders [NUMERATOR N DENOMINATOR] and [DENOMINATOR N NUMERATOR] are not attested cross-linguistically. (I will discuss the lack of these patterns in Section 5.4.)

Fractions have received little attention in theoretical linguistics. However, they are commonly observed in numeral systems of human languages, unlike other mathematically developed concepts such as negative numbers or imaginary numbers (Greenberg (2000)). More recently, Ionin and Matushansky (2018) propose a detailed analysis of fraction from both the syntactic and the semantic perspective. This chapter will, however, point out some syntactic issues that are problematic for I&M's analysis on the basis of a cross-linguistic survey of fractions. It will also be argued that fractions are cross-linguistically formed by using a covert/overt element meaning 'part'. Building on my typological observations, I will then offer an alternative analysis of fractions.

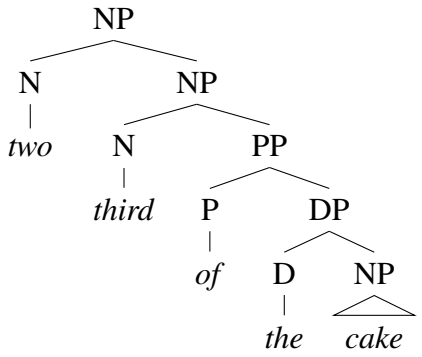
This chapter is organized as follows; Section 5.2 introduces Ionin & Matushansky's (2018) analysis and discusses some problematic data for them. Section 5.3 provides the results of my cross-linguistic investigation of fractions, which is unexpected under Ionin & Matushansky's (2018) analysis. It will be shown that there are languages which use an element meaning 'part' to form fractions. Building on a typological survey, I propose in Section 5.4 that the numerator and the denominator each include a covert/overt "part" noun in fractions. In Section 5.5, I investigate fractions in Japanese, showing that Japanese makes use of an overt "part" noun in fractions. Section 5.6 is the conclusion.

5.2 Previous analyses

Ionin & Matushansky (2018, Ch.10) (I&M henceforth) propose the cascading structure in (3) for fractions, building on Ionin et al. (2006).[1] In (3), the denominator *third* is a nominal head taking the PP-phrase as the complement. The numerator *two* combines with the noun phrase headed by the denominator *third*.

(3) a. *two-third of the cake*

b.



It should be noted that I&M (2018) assume that morphological similarities between fractions and ordinals that are found across languages are "coincidental and most probably due to crosscultural influence" (p. 328). In other words, they assume that *third* as a denominator has a different status from ordinal numbers.

Regarding the semantics of fractions, they propose that *third* as a denominator of a fraction in English has the denotation given in (4). Under I&M's analysis, denominators are of type $\langle e,\langle e,t\rangle\rangle$.

(4) $[\![third]\!] = \lambda y.\lambda x.\exists S.[\Pi(S)(y) \wedge |S| = 3 \wedge x \in S \wedge \exists \mu.[\mu \in M \wedge \forall s \in S.[\mu(s) = \mu(x)]]]$, where M is a contextually determined set of measure functions.

I&M do not provide the denotation of the noun modified by a fraction. In (5), I outlined

1. Recall that they also propose a similar cascading structure for multiplicative complex cardinals like *three hundred*, as discussed in Chapter 2.

the denotation of *two thirds of the cake* following their analysis. I&M assume that *of* in the fractional construction is semantically vacuous. I use the ι operator to convert the noun of type $\langle e,t\rangle$ into e. The denotation of *of the cake* is given in (5a). As shown in (5c), I&M propose that numerals are of type $\langle\langle e,t\rangle,\langle e,t\rangle\rangle$. The numeral *two* takes the *of*-phrase as its argument, yielding the denotation in (5d).

(5) a. $[\![\textit{of the cake}]\!] = \iota z[\text{cake'}(z)]$

b. $[\![\textit{third of the cake}]\!]$

$= \lambda x.\exists S.[\Pi(S)(\iota z[\text{cake'}(z)]) \wedge |S| = 3 \wedge x \in S \wedge \exists \mu.[\mu \in M \wedge \forall s \in S.[\mu(s) = \mu(x)]]]$

c. $[\![\textit{two}]\!] = \lambda P.\lambda u.\exists R.[\Pi(R)(u) \wedge |R| = 2 \wedge \forall r \in R.[P(r)]]$

d. $[\![\textit{two thirds of the cake}]\!]$

$= \lambda u.\exists R.[\Pi(R)(u) \wedge |R| = 2 \wedge$

$\forall r \in R.\exists S.[\Pi(S)(\iota z[\text{cake'}(z)]) \wedge |S| = 3 \wedge r \in S \wedge \exists \mu.[\mu \in M \wedge \forall s \in S.[\mu(s) = \mu(r)]]]]$

In (5d), the first and the second conjunct together mean that the cover R of x has two members. For each member of R (i.e. r), there is a cover S such that (i) S is a cover of a contextually salient unique cake, (ii) the cardinality of S is three and (iii) r is a member of S. Furthermore, the last conjunct in (5) requires that each member of S is equal to r when they are measured by a contextually determined measurement function μ.

There is a potential semantic problem for I&M's analysis. Suppose that Ana finished her defense and had the first bite of a cake at the post-defense party. The cake was too big and there is a leftover as in (6).

(6) a.  [900gram]

Cake!

b.  [600gram]

Got bitten ...

Suppose now that in the cake context above, someone left a message as in (7).

(7) *We left two thirds of the cake. Please help yourself.*

What is important here is that there is a single cake in the current context. As shown in (5d), I&M's analysis requires that the cardinality of the relevant individual is two. Their definition of the partition function Π is repeated below.

(8) *I&M's definition of the partition function*

Π(S)(x) is true iff (i) S is a *cover* of x, and (ii) $\forall$z, y $\in$ S [z = y $\vee$ $\neg\exists$a [a $\leq_i$ z $\wedge$ a $\leq_i$ y]]

(9) *I&M's definition of covers*

A set of individuals C is a cover of a plural individual X iff X is the sum of all members of C: $\sqcup$C = X.

The denotation in (5d) refers to a set of plural individuals u. It is not clear whether the denotation is felicitous in the cake context above, in which there is a single cake left. Moreover, cardinality is defined based on atomic individuals under standard assumptions. The definition in (10) comes from Champollion (2017).

(10) *Cardinality*: Champollion (2017: 40)

For any sum x such that *Atom(x), the cardinality of x, written |x|, is defined as |{y | y $\leq$ *Atom(x)}|.

The gist of the problem here is that the denotation in (5d) requires the presence of two atomic individuals according to the definition of cardinality in (10). I am not claiming here that it is impossible for I&M's analysis to circumvent the problem in question. We have to divide the cake hypothetically into three portions such that each portion weighs 300gm. However, such hypothetical division does not follow directly from I&M's analysis.

It should also be noted here that they assume that the numerator and the denominator

are syntactic heads taking an NP as their complement. However, their analysis faces problems with typologically attested strategies of expressing fractions. An example of fractions from Mandarin is given in (11) (LINK = linker).

(11) Mandarin Chinese [Sino-Tibetan]

san-fen-zhi-er *de* *xuesheng*
three-part-LINK-two DE students
'two thirds of the students'

What is important is that in (11) the denominator *san* 'three' is separated from the main noun *xuesheng* 'student' by the linker *de* and the numerator *er* 'two'. Under I&M's analysis, the main noun must first combine with the denominator because the denominator performs a different semantic function from the numerator. A crucial aspect of the meaning of fractions stems from the denotation of the denominator. It is not clear how this type of fraction would be analyzed under I&M's analysis. Moreover, it should be noted that fractions in Mandarin contain *fen* 'part' following a denominator. I&M's analysis does not expect the "part" element in fractions.

A similar pattern of fractions is also observed in Eastern Armenian. Fractions in Eastern Armenian show the N-NUMERATOR-DENOMINATOR order as in (12).

(12) Eastern Armenian [Armenian]: Dum-Tragut (2009: 122)

Gyułac'i-n *stac'av* [*ir* *c'an-ac* *hac'ahatik-i* *mek* *hing-erord-ĕ*].
farmer.NOM-the receive-AOR.3.SG his sow-PTCP.RES grain-DAT one five-ORD-the
'The farmer received one fifth of his sowed grain.'

In (12), the main noun is marked by the dative case and the denominator is followed by the definite suffix. In Eastern Armenian, definiteness is expressed by attaching the suffix to the noun.Given this, it seems that the denominator functions as the main noun in (12).

Moreover, the numerator *mek* intervenes between the denominator the main noun, similarly to fractions in Mandarin Chinese. I&M's analysis of fractions does not expect this type of fractions. Note also that a construction similar to (12) is used in the possessive construction in (13).

(13) Eastern Armenian [Armenian]: Dum-Tragut (2009: 83)

[*Ašakert-i girk'-ĕ*] *nor ē*
pupil-dat book.NOM-the new it is
'The pupil's book is new.'

In (13), the possessor phrase is marked by the dative suffix and the possessed phrase is marked by the definite suffix. If the possessive construction in (13) and the fraction in (12) have a similar syntactic structure, then it seems reasonable to claim that in (12) the denominator functions as the main noun. Importantly, it is reported that the "part" element can appear in the fractional construction in Eastern Armenian, as in (14).

(14) Eastern Armenian [Armenian]: Dum-Tragut (2009: 122)

Yurak'anč'yur gyułac' -u tr-v-ec' havak' -v-ac
each farmer-DAT give-pass-AOR.3.SG gather-PASS-PTCP.RES

[*hac' ahatiki mek hing-erord-akan mas-ĕ*].
grain-DAT one five-ORD-DIST part.NOM-the
'The fifth part of the gathered grain was given to each farmer.'

What is important is here that the "part" element in fractions observed in Mandarin and Eastern Armenian is not expected under I&M's analysis. Their analysis only has three ingredients of fractional constructions; the numerator, the denominator and the main noun – their semantics of the denominator given in (4) is incompatible with the "part" element in fractions.

Fractions including an element meaning "part" are observed in other languages, too. For instance, Romance languages also have the "part" noun in fractions, as shown in (15).

(15) Fractions with "part" in Romance languages: Price (1992: 485)

a. Spanish

la tercera parte de ellos
the third part of them
'one third of them'

b. Portuguese

duas quintas partes
two fifths parts
'two fifths'

c. Catalan

quatre quinzenes parts
four fifteens parts
'four-fifteenths'

Even in English, there is a fractional expression including "part" (e.g. *a tenth part of the income*). As will be shown in the next section, the presence of "part" in fractions is common cross-linguistically. Based on this cross-linguistic pattern of fractions, this study will offer a semantic analysis of fractions that include "part".[2] In the next section, I will give additional typological data about the "part" in fractions.

5.3 Data: "Part" in fractions

As discussed above, fractions including "part" are common cross-linguistically. Regarding the distribution of "part", in my sample, I found the patterns summarized in (**??**).

2. It should be noted that I&M (2018: 359) briefly mention the fractional "part" in a footnote, leaving the issue it raises for their analysis unresolved.

(16) *Patterns of fractions with "part"* [order irrelevant]

a. [Numerator PART] [Denominator PART]:

E.g. Burmese [Sino-Tibetan], Garo [Sino-Tibetan], Xong [Hmong–Mien]

b. [Numerator PART] [Denominator]:

E.g. Mokilese [Austronesian], Telugu [Dravidian]

c. [Numerator] [Denominator PART]:

E.g. Cantonese [Sino-Tibetan], Catalan [Romance], English [Germanic], Eastern Armenian [Armenian], German [Germanic], Japanese [Japanese], Mandarin [Sino-Tibetan], Portuguese [Romance], Samoan [Austronesian], Spanish [Romance], Vietnamese [Austro-Asiatic]

What this shows is that either the numerator, or the denominator, or both can occur with "part" cross-linguistically.

5.3.1 [Numerator PART] [Denominator PART]

In (16a), the "part" element is expressed both in the numerator and the denominator. This pattern is observed in Burmese, Garo and Xong. The relevant examples are given below.

(17) Burmese [Sino-Tibetan] Jenny and Hnin Tun (2016: 72)

a. *θòun-boun* *də-boun*
three-CLS_{part} one-CLS_{part}
'one third'

b. *ŋà-boun* *hnə-boun*
five-CLS_{part} two-CLS_{part}
'two fifths'

Jenny & Hnin Tun classified *poun/boun* as a noun meaning 'a pile'. However, Burling (1965: 256) introduces the same item as a classifier used in constructing fractions together with the meaning 'part'. Following Burling, I assume that *poun/boun* is a noun denoting a certain quantity. Notice also that the denominator precedes the numerator in Burmese, like

in fractions in Mandarin Chinese (cf. (11)).

In Garo, the classifier for portions or parts is used in fractional numbers.

(18) Garo [Sino-Tibetan]: Burling (1961: 53)

bak-gittam-ni *bak-gini*
CLS_{part}-three-of CLS_{part}-two
'two thirds'

The suffix *-ni* is a linking element that appears in the possessive construction as in (19). It can also be used in other type of connective constructions, as in (19b).

(19) Garo: Burling (1961: 46)

a. *aŋ-ni jak*
I-of hand
'my hand'

b. *u-a-ma'ŋ-ni gi-sep-o*
they-of among
'among them, their among'

In Xong, both the numerator and the denominator are followed by the classifier *gut*, which refers to parts or portions. Sposato (2015: 291) reports that "fractions are syntactically discontinuous in Xong". As shown in (20), the denominator phrase is separated from the numerator phrase, which appears in a post-verbal position. (The main noun follows the denominator phrase.)

(20) Xong [Miao-Yao]: Sposato (2015: 291, attributed to Chenghua Long's field notes)

Bieib-gut *mianx* *monl* *diul* *bub-gut.*
four-CLS_{part} person go complete three-CLS_{part}
'Three fourths of the people have left.'

5.3.2 [Numerator PART] [Denominator]

In (16b), the “part” element appears only in the numerator phrase. This pattern is attested in Mokilese and Samoan.

In Mokilese, the classifier *-kij* follows the numerator in fractions. The classifier *-kij* is used to count nouns that represent pieces or parts (Harrison (1976: 96)). It should be noted that the classifier *-pas* is used for long objects such as pencils and canoes. Given this, it seems that the classifier following the denominator matches the main noun with regard to its sortal restriction in (21).

(21) Mokilese [Austronesian]: Harrison (1976: 101)

lim-kij *won-pas* *in* *suhkoa-hk*
five-CLS_{part} six-CLS CONST tree-that
‘five sixth of the trees’

As shown in (22), Samoan uses the noun *vaega* ‘part’ in fractions. The Samoan adjective is always placed after the noun it qualifies, either directly following, or in combination with *e*. The particle *e* is also used in (22).

(22) Samoan [Austronesian]: Neffgan (1918: 39)

a. *’o ke* [*vaega e tolu*]
ART.SG part E three
‘a third’

b. *lua* [*vaega e fitu*]
two part E seven
‘two sevenths’

5.3.3 [Numerator] [Denominator PART]

The last pattern where the “part” element is associated with a denominator is observed in many languages. Romance languages and English, as mentioned above, belong to this type. There are also other languages that show this pattern. In Mandarin, *fen* follows

a denominator in combination with *zhi*, which used to be a linking element in Archaic Chinese.

(23) Mandarin [Sino-Tibetan]: Jin 2015: 93

a. *san-fen-zhi-yi* *huaxiao*
three-part-ZHI-one cost
'one third of the cost'

b. *huaxiao de san-fen-zhi-yi*
cost DE three-part-ZHI-one
'one third of the cost'

Cantonese also exhibits the same pattern as in (24).

(24) Cantonese [Sino-Tibetan]: (Chui Yi Lee, p.c.)
saam^{1}-fen^{6}-jet^{1} *go* *pingguo*
three-portion-one CLS apple
'one thirds of the apple'

In Telugu, the "part" noun follows the numerator as shown in (25). Note that the "part" noun in (25) is followed by the plural suffix *lă*.

(25) Telugu [Dravidian]: Ponamgi (2012: 821)
mu:Rŭ-lo: *rĕNDŭ* *ŏntŭ-lă pĭl:ă-lŭ* *e:Rŭs-ta:-rŭ.*
three.NONHUMAN-LOC two.NONHUMAN part-PL child-PL.NOM cry-IMPF-3.PL.HUM
'Two thirds of children cry.'

Vietnamese also uses the "part" noun *phần* in fractions as in (26).

(26) Vietnamese: Thompson (1965: 187)

a. *hai phần ba*
two part three
'two thirds'

b. *chín phần ba mươi hai*
nine part three ten two
'9/32'

At first glance, it is difficult to determine whether the “part” noun forms a constituent together with the numerator or with the denominator because the “part” noun intervenes between them. However, when the numerator means ‘one’, the “part” noun and a denominator can be used as a fractional number without an overt numerator, as in (27).[3]

(27) Vietnamese [Austro-Asiatic]: Thompson (1965: 187)

a. *phần tu*
part four
‘a fourth’

b. *một phần tu*
one part four
‘one fourth’

The acceptability of (27a) can be taken as a piece of evidence that the “part” noun is associated with a denominator but not with a numerator. Vietnamese is analyzed as involving the [Numerator] [Denominator PART] pattern.

I analyze Japanese as a language which displays the [Numerator] [Denominator PART] pattern. As shown in (28), fractions in Japanese contain *bun*, which is followed by the genitive linker *no*, similarly to Mandarin and Cantonese.

(28) Japanese [Japanese]

[*san-bun no ichi no*] *gakusei*
three-part GEN one GEN student
‘one third of the student’

As will be discussed in Section 5.5.4, *bun* is affixal and appears in environments other than fractions. I will discuss the nature of *bun* in Section 5.5.4 and propose that *bun* is a light noun meaning “part”.

Although most of the languages in (16) are (optional/obligatory) classifier languages, it is not the case that the fractional “part” appears only in classifier languages. As men-

3. The omission of the numerator meaning ‘one’ can be analyzed as involving 1-deletion (cf. Hurford (1975)). See Chapter 2 for relevant discussion.

tioned in the previous section, Romance languages have "part" nouns in fractions (cf. (15)). English also has a similar fractional expression, as shown in (29)

(29) English

a. *a tenth part of the income*

b. *This mixture is two parts alcohol and three parts water.* [Jackendoff (1977: 138)]

German also shows the "part" element in fractions. In German fractional numbers are generally neuter, and the denominator is followed by the suffix *-tel*, which is a short form of *Teil* 'part' (Dodd et al. (2003: 246)), as shown in (30).

(30) German [Germanic]: Sabine Laszakovits, p.c.

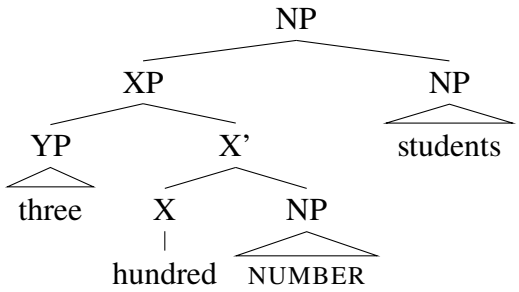
Jan hat zwei Drittel des Buches gelesen.
Jan have two three.part of.the book read
'Jan has read two thirds of the book.'

To summarize, in this section, I have shown that the "part" element is observed in many languages. Building on this observation, in the next section, I will pursue a uniform analysis in which the numerator and the denominator each combine with a covert/overt "part" element in fractions.

5.4 Analysis

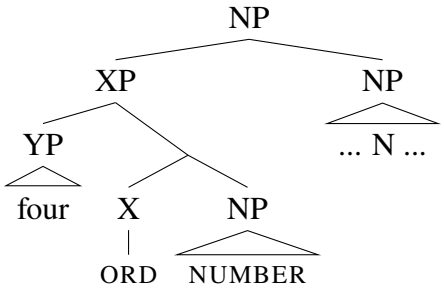
In the previous section, I showed that fractions contain an overt element meaning 'part' in many languages. This pattern of fractions is not expected under I&M's analysis. We therefore need an alternative approach to fractions with "part". Recall that in Chapter 2, I proposed that multiplicative complex cardinals can include the silent *number* in some languages. The proposed structure is repeated here as (31).

(31) *Multiplicative complex cardinals with the silent* NUMBER



A similar structure was also proposed for ordinals in some languages such as Serbo-Croatian, as in (32).

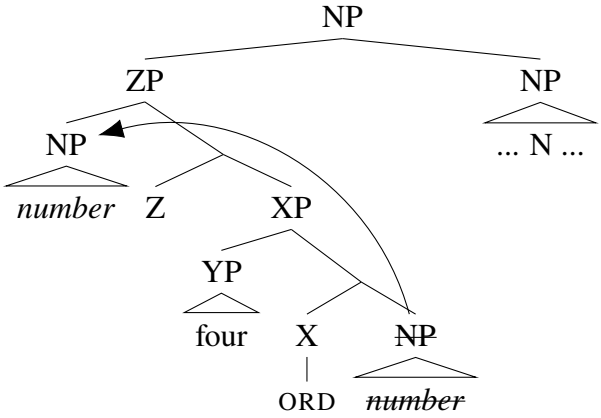
(32) *Ordinals with the silent* NUMBER



Moreover, as discussed in Chapter 4, I proposed that the ordinal construction including an overt element meaning 'number' (i.e. ordinals expressed by the overt "number" strategy) can be derived from the structure in (32) via movement of an overt "number" to a higher position in the extended nominal projection, as represented in (33).

(33) a. *the question number four*

b.



Building on these proposals, I propose that there is a nominal element meaning 'part' in fractions, similarly to the "number" element in multiplicative complex cardinals and ordinals given above. Specifically, based on the occurrences of the "part" element in fractions summarized in (16), I pursue an analysis in which either the numerator or the denominator (or both) can combine with the "part" element, as represented in (34).

(34) *Schematic representation of fractions* (Order Irrelevant)

[Numerator (PART)] [Denominator (PART)] FRAC [Main noun]

In (34), PART stands for a covert/overt "part" element. I will argue that numerators and denominators are the same kind of numerical expressions. To make the distinction between a numerator and a denominator, I assume the FRAC function, as will be discussed in detail later in this section.

The denotation of "part" in fractions is given in (35). Here, PART stands for a covert/overt "part" element. The existence of a covert "part" element can be marked by an appropriate classifier in some languages like Burmese, Garo, Mokilese and Xong.

(35) *Fractional "part"*

$[\![\text{PART}]\!] = \lambda n.\lambda X.[\mu(X) = n]$

Based on that the fractional "part" can appear with either a numerator or a denominator or both, I propose that a numerator and a denominator can occur with the "part" element, which can be covert or overt. For instance, *two thirds of the cake* in English can be analyzed as in (36).

(36) *two* FRAC [*third* PART-*s*] *of the seats*

Here, the denominator combines with the covert PART nominal, and the plural suffix *-s* attaches to it. The denotations of the numerator and the denominator in *two thirds* are given

in (37).

(37) a. $[\![$ two $]\!] = 2$

b. $[\![$ [three PART] $]\!] = \lambda X.[\mu(X) = 3]$

In (37), the denominator is a nominal expression of type $\langle e,t\rangle$. In this respect, it is worth noting that English expresses ratio by using *part* like *This mixture is two parts alcohol and three parts water.* (The example is taken from Jackendoff (1977).) This kind of expression of ratio is semantically (and mathematically) related to fractions. I propose that fractions actually include the same "part" expressions used in ratio as their ingredients.

To convert these elements of type $\langle e,t\rangle$ into numerical expression of type n, I make use of the $\cap$ function. The $\cap$ function converts an element of type $\langle e,t\rangle$ into its individual correlate (Chierchia 1984, 1998, Partee, 1986, Scontras 2014, 2017). Following Rothstein (2013, 2017), I assume that the $\cap$ function derives a numerical expression of type n from a property defined by the measurement function μ and possibly other information bundles.[4] In other words, numerators and denominators denote a correlate of the property of being *n* individuals whose members are uniform in quantity.[5] The denotations are given in (38).

(38) $[\![\cap$[three PART] $]\!] = 3$ (in quantity)

We now have two numerical expressions of type n; the numeral *two* and the denominator $\cap$[three PART]. In addition to them, we also need an element which makes a distinction between a numerator and a denominator. For this purpose, I assume the FRAC function defined as in (39). (This may correspond to some linking elements appearing in the fractional constructions.)

4. Recall that the $\cap$ function is also used to account for cross-linguistic behavior of multiplicative and additive complex cardinals as discussed in Chapter 2 and 3.

5. Scontras (2014, 2017) also proposes that *amount* in English is a nominalized property defined by the measurement function μ. Intuitively speaking, both *part* and *amount* in English denote a certain type of quantity; the semantic similarity between them is not surprising under the current analysis.

(39) $[\![\text{FRAC}]\!]^c$

$= \lambda n_1.\lambda n_2.\lambda u.\lambda v.\exists S.[\Pi(S)(u) \wedge |S|=n_2 \wedge \exists \mu \in M.[\forall s,s' \in S.[\mu(s) = \mu(s')]]$

$\wedge \exists S' \subseteq S.[v = \sqcup S' \wedge |S'|=n_1]$,

where M is a contextually determined set of measurement functions (cf. I&M (2018)).

The first argument of FRAC functions as a numerator, and the second as a denominator. The denotation of *two thirds of the seats* in English is given in (40).[6]

(40) $[\![$ *two* FRAC [*third* PART-*s*] *of the seats* $]\!]^c$

$= \lambda v.\exists S.[\Pi(S)([\![\textit{the seats}]\!]) \wedge |S|=3 \wedge \exists \mu \in M.[\forall s,s' \in S.[\mu(s)=\mu(s')]] \wedge \exists S' \subseteq S.[v=\sqcup S' \wedge |S'|=2]$

Suppose that there are six seats ({a, b, c, d, e, f}) in the context. What each part of the denotation in (40) means is given below.

(41) a. $\Pi(\mathbf{S})([\![\textbf{\textit{the seats}}]\!]) \wedge |\mathbf{S}| = \mathbf{3}$:

S is a non-overlapping cover of $[\![$*the seats*$]\!]$, and the cardinality of S is 3.

b. $\exists \mu \in \mathbf{M.[\forall s,s' \in S.[\mu(s)=\mu(s')]]}$:

All members of S are equal to each other with respect to the measurement function μ.

(E.g. μ(s)=2, ^{OK}{a, b | c, d | e, f}, $^{\#}${a, b, c | d | e, f})

c. $\exists \mathbf{S' \subseteq S.[v=\sqcup S' \wedge |S'|=2]}$

There is a cover of v such that it is a subset of the cover S and its cardinality is 2.

(e.g. {a, b | c, d} or {c, d | e, f} or {a, b | e, f}).

When the denotation in (40) is existentially closed, the denotation in (40) gives the correct interpretation of *two thirds of the seats* in the current context (i.e. there are four seats).

The current analysis is also compatible with the example where the main noun is singular, repeated here as (43), which is problematic for I&M's analysis.

6. In this thesis, I assume that *of* in the fractional construction is semantically vacuous, similarly to I&M's analysis.

(42) *The cake context*

a.  [900gram]

Cake!

b.  [600gram]

Got bitten ...

(43) *We left two thirds of the cake. Please help yourself.*

The denotation of *two thirds of the cake* in the cake context in (42) is given in (44). Following I&M, I assume that denominators are not ordinals. Any morphological similarities between denominators and ordinals would then be independent. Notice also that ordinals do not appear in fractions in some of the languages given in the previous section.

(44) $[\![$ *two* FRAC [*third* PART-*s*] *of the cake* $]\!]^c$

$= \lambda v.\exists S.[\Pi(S)([\![\textit{the cake}]\!]) \wedge |S|=3 \wedge \exists \mu \in M.[\forall s,s' \in S.[\mu(s)=\mu(s')]] \wedge \exists S' \subseteq S.[v=\sqcup S' \wedge |S'|=2]$

In the cake context, the measurement function μ in (44) can be a hypothetical division which yields three portions such that each of them weighs 300gm (e.g. μ_{300gm}). What each part of the denotation in (44) means is given below.

(45) a. $\mathbf{\Pi(S)([\![\textit{the cake}]\!]) \wedge |S| = 3}$:

S is a non-overlapping cover of $[\![$*the cake*$]\!]$, and the cardinality of S is 3.

b. $\mathbf{\exists \mu \in M.[\forall s,s' \in S.[\mu(s)=\mu(s')]]}$:

All members of S are equal to each other with respect to the measurement function μ.

(E.g. μ(s)=300gm, ^{OK}{300gm | 300gm | 300gm}, $^{\#}${300gm | 200gm | 400gm})

c. $\mathbf{\exists S' \subseteq S.[v=\sqcup S' \wedge |S'|=2]}$

There is a cover of v such that it is a subset of the cover S and its cardinality is 2.

(e.g. {300gm | 300gm} or {300gm | 300gm} or {300gm | 300gm}).

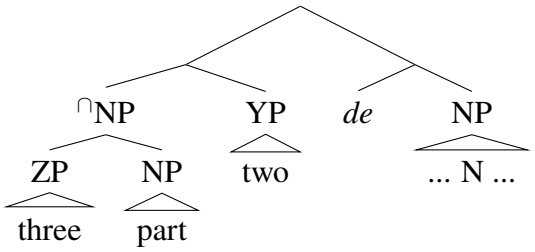
When (44) is existentially closed, (44) gives the correct interpretation of *two thirds of the cake* in the context in (42) (there is 600gm of the cake).

The current analysis is compatible with the cross-linguistic pattern of the "part" element in fractions. Under I&M's analysis, the "part" element is not expected. Notice also that the present analysis does not require the denominator to combine with the main noun first, to the exclusion of the numerator. Numerators and denominators are numerical expression of type n and their functions stem from the covert function FRAC. This means that the present analysis has room for cross-linguistic variation in the constituency of the numerator, the denominator and the main noun.

For instance, fractions in Mandarin, where the denominator and the main noun are separated by the "part" element and an overt linking element, do not cause problems under the current analysis. Since the core meaning of fractions comes from FRAC, not from the denominator, the left-branching structure in (46) is available for fractions in Mandarin under the proposed analysis. (I leave open whether *de* projects its own phrase or not (cf. e.g. Saito et al. (2008))) In (46), the numerator combines with the denominator, which include the overt/covert "part". The fraction then combines with the main NP.[7]

(46) a. *san-fen-zhi-er* *de* *xuesheng*
three-part-LINK-two DE students
'two thirds of the students'

b.



7. In what follows, I will omit FRAC in syntactic trees, leaving open what kind of role, if any, it plays in syntactic derivations.

In contrast, it is not clear how I&M's cascading structure given in (3) accommodates Mandarin type fractions, which are attested in many languages. Recall also that in my language sample, there is no language where the main noun intervenes between the numerator and the denominator; the main noun either precedes or follows the whole fractional number. This cross-linguistic pattern is also expected under the structure in (46).

However, it is important to note that I am not claiming in this chapter that the cascading structure like the one proposed byn I&M is impossible cross-linguistically. The data from Xong, where the denominator and the main noun are separated from the numerator, may indicate that the denominator and the main noun can form a constituent in Xong. Similarly, the nominal ellipsis test shows that in English the denominator and the main noun form a constituent that can be a target of nominal ellipsis. The relevant examples are given in (47).

(47) English [Germanic]: Nicolaus Schrum, p.c.

a. *Ana drank one fifth of the whiskey, and Bill drank three fifths of the whiskey*

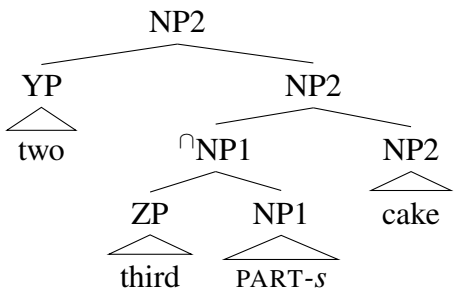
b. *Ana drank one fifth of the whiskey, and Bill drank three* Δ .

(meaning 'Bill drank three fifths of the whiskey.')

The fact that the elided part in (47b) can be interpreted as 'three fifths of the whiskey' indicates that the denominator and the main noun can form a constituent at least in English, as proposed by I&M (2018). Under the proposed analysis, this type of fractions can be analyzed as having the cascading structure given in (48).

(48) a. *two thirds of the cake*

b.



In (48), the intermediate NP2 can be the target of nominal ellipsis. At first glance, the structure in (48) is similar to I&M's cascading structure (cf. (3b)). However, (48) is different from I&M's in that neither the denominator nor the numerator project their own phrases. In other words, the main noun is the NP2 (*cake*) in (48).

What is important is that I&M's analysis alone cannot capture the whole range of the typological variation regarding fractions. As discussed above, fractions in Mandarin are separated from the main noun by the linking element, and I argued that the numerator and the denominator form a constituent to the exclusion of the main noun as in (46). The structure like (46) is also needed for fractions in Serbo-Croatian. As shown in (49), the fraction can undergo Left-branch extraction in Serbo-Croatian.

(49) Serbo-Croatian [Slavic]: Ivana Jović p.c.

a. *Ivan je pozvao* [*dvije petine studenata*].
Ivan CL invited two fifths student.GEN.PL.M
'Ivan invited two fifths of the students.'

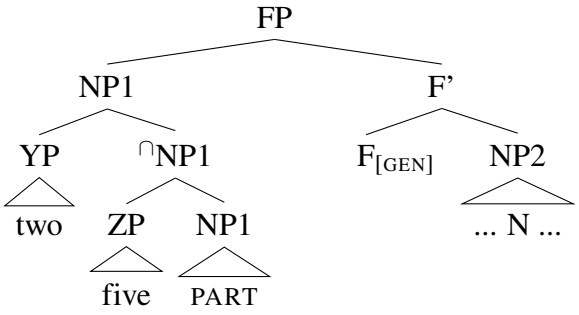
b. ?[*Dvije petine*] *je Ivan pozvao* [Δ *studenata*].
two fifths CL Ivan invited student.GEN.PL.M

c. *[*Dvije*] *je Ivan pozvao* [Δ *petine studenata*].
two CL Ivan invited fifths student.GEN.PL.M

Following standard assumptions, I assume that LBE can be applied only to a phrasal constituent (see Chapter 2). The acceptability of (49b) shows that the numerator and the denominator form a single phrasal constituent to the exclusion of the main noun. (For details of the LBE test, see Chapter 2.) This pattern can be explained by assuming that fractions in Serbo-Croatian have the left-branching structure in (50).[8]

8. In Serbo-Croatian, the numerator precedes the denominator unlike Mandarin Chinese. However, this is not problematic for the current analysis at all. Semantically, FRAC requires two arguments of type n, but it does not matter whether the numerator linearly precedes the denominator in the left-branching structure.

(50) [cf. (46)]



In (50), I assume that the denominator includes the covert "part" element (PART). The topmost NP1 can be the target of LBE in this structure.

Under the proposed analysis, the syntax thus allows for two structures for fractions: the left-branching structure as in (46)/(50) and the cascading structure as in (48). Some languages such as Chinese and Serbo-Croatian only have the left-branching structure like (46) and (50). In the next section, I will investigate fractions in other languages such as Spanish, German, Vietnamese and Japanese. In these languages, fractions show some variation. I will show that the relevant patterns can be accounted for under the proposed analysis of fractions. It will also be shown that some languages allow for both the left-branching structure and the cascading structure.

5.5 Two types of fractions

5.5.1 Fractions in Spanish

Spanish has two types of fractions as shown in (51).

(51) Spanish: Gabriel Martínez Vera, p.c.

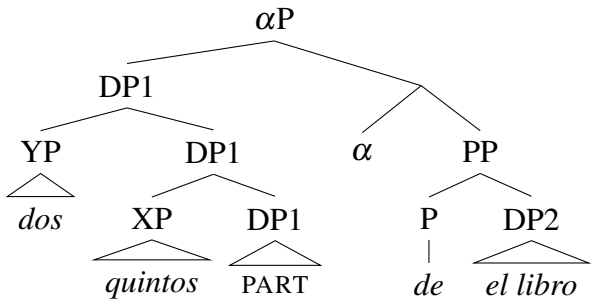
a. *Juan leyó* [*dos* ***quintos*** *del libro*].
Juan read two fifths.M of.the book
'Juan read two fifths of the book.'

b. *Juan leyó* [*dos* ***quintas*** *partes del libro*].
Juan read two fifths.F part of.the book
'Juan read two fifths of the book.'

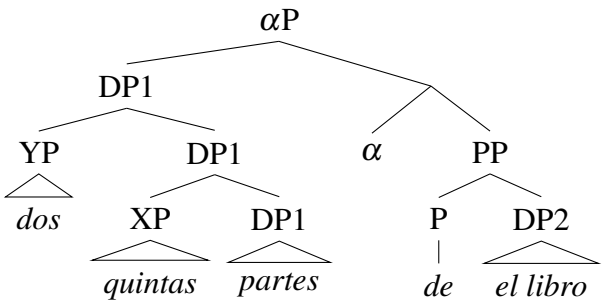
In (51a), the denominator *quintos* shows masculine plural form. In (51b), on the other hand, the denominator combines with the overt "part" element *partes* and shows feminine plural agreement with the "part" element. This indicates that in (51b), the denominator agrees with the feminine noun *partes*, but not with the main noun *libro*. In other words, the denominator is a modifier of *partes*. Under the current analysis, the two types of fractions in Spanish in (51) can be analyzed as having the structures in (52).[9]

(52) Fractions in Spanish

a.



b.



I propose that fractions in Spanish quite generally include the "part" element. In (52a), the "part" element is covert. Following Harris (1991), I assume that masculine is the default

9. Recall that I adopt Kayne's (1994) LCA as discussed in Chapter 4. In (51), I introduce the projection headed by a functional head α, to ensure that the fraction precedes the preposition phrase. However, nothing hinges on this assumption.

gender in Spanish (see also López (2020) for recent discussion). I propose that the silent "part" lacks the relevant gender feature, in contrast to the overt counterpart. In (52a), the denominator then fails to agree with the closest nominal, and hence exhibits the default masculine form. On the other hand, in (52b), the "part" element is overt and the denominator agrees with it, showing feminine plural agreement. The default status of the masculine form in (51a) can be seen in the following examples.

(53) Spanish: Gabriel Martínez Vera, p.c.

a. *Juan limpió* [*dos* ***quintos*** *de la mesa*].
Juan clean two fifths.M of the table.F
'Juan wiped two fifths of the table.'

b. *Juan limpió* [*dos* ***quintas*** *partes de la mesa*].
Juan clean two fifths.F part of the table.F
'Juan wiped two fifths of the table.'

(54) Spanish: Gabriel Martínez Vera, p.c.

a. *Juan escribió* [*dos* ***quintos*** *de la carta*].
Juan write two fifths.M of the letter.F
'Juan wrote two fifths of the letter.'

b. *Juan escribió* [*dos* ***quintas*** *partes de la carta*].
Juan write two fifths.F part of the letter.F
'Juan wrote two fifths of the letter.'

As shown in (53a) and (53b), even when the main noun is feminine, the denominator exhibits the masculine form in the absence of the overt "part" element. This shows that the masculine gender on the denominator in (51a) does not come from the noun *libro*.

Support for the structures in (52) comes from nominal ellipsis. As shown in (55c) and

(56c), unlike English, it is impossible to elide the denominator and the main noun, while leaving the numerator intact in Spanish.

(55) Spanish: Gabriel Martínez Vera, p.c.

a. *Juan leyó* [*dos quintos del libro*] *y María leyó* [*tres quintos del libro*].
Juan read two fifths.M of.the book and Maria read three fifths.M of.the book
'Juan read two fifths of the book and Maria read three fifths of the book.'

b. *Juan leyó* [*dos quintos del libro*] *y María leyó* [*tres quintos* Δ].
Juan read two fifths.M of.the book and Maria read three fifths.M
'Juan read two fifths of the book and Maria read three fifths of the book.'

c. **Juan leyó* [*dos quintos del libro*] *y María leyó* [*tres* Δ].
Juan read two fifths.M of.the book and Maria read three
'Juan read two fifths of the book and Maria read three fifths of the book.'

(56) Spanish: Gabriel Martínez Vera, p.c.

a. *Juan leyó* [*dos quintas partes del libro*]
Juan read two fifths.F part of.the book

y María leyó [*tres quintas partes del libro*].
and Maria read three fifths.F part of.the book
'Juan read two fifths of the book and Maria read three fifths of the book.'

b. *Juan leyó* [*dos quintas partes del libro*] *y María leyó* [*tres quintas partes* Δ].
Juan read two fifths.F part of.the book and Maria read three fifths.F part
'Juan read two fifths of the book and Maria read three fifths of the book.'

c. ?*Juan leyó* [*dos quintas partes del libro*] *y María leyó* [*tres quintas* Δ].
Juan read two fifths.F part of.the book and Maria read three fifths.F
'Juan read two fifths of the book and Maria read three fifths of the book.'

d. **Juan leyó* [*dos quintas partes del libro*] *y María leyó* [*tres* Δ].
Juan read two fifths.F part of.the book and Maria read three
'Juan read two fifths of the book and Maria read three fifths of the book.'

The unacceptability of the c-examples in (55) and (56) can be explained by assuming that the numerator and the denominator form a constituent to the exclusion of the prepositional phrase containing the main noun *libro*, as shown in (52). The present analysis can also account for the acceptable examples in (55) and (56). (55b) and (56b) can be derived by eliding the PP containing the main noun. When the overt "part" element is elided in addition to the PP, the structure in (52b) yields (56c) (cf. feminine gender of *quintas*).

Note that the structures in (52) are essentially similar to what Jackendoff (1977) proposed for partitive constructions, as represented in (57).[10]

(57) Jackendoff (1977)

a. *many of the men*

b. $[_{N'''}\ [_{Q'''}$ many] $[_{N'}\ [_{N}$ PRO] of $[_{N'''}$ the men]]]

Jackendoff (1977) proposes that "PRO is interpreted by the Partitive Projection Rule, which gives PRO the reading UNIT or AMOUNT." (Jackendoff 1977:135). The Partitive Projection Rule is given in (58).

(58) *Partitive Projection Rule*: Jackendoff (1977:110)

$$\text{PRO}_{\text{N}} \rightarrow \text{UNIT} \,/ \begin{bmatrix} \text{X} \\ \\ \text{+partitive} \end{bmatrix} \_\_\_\_$$

His analysis is consistent with the current analysis. The denominator would bear the [+par-

10. Similarly, Abney (1987) assumes a structure that contains a covert nominal, as represented in (i).

(i) Abney (1987: 344)
$[_{DP}\ [_{D}$ *the*] $[_{AP}\ [_{A}$ *better*] $[_{NP}\ [_{N}\ \varnothing\ ]\ [_{PP}$ *of the two*]]]]

titive] feature, and PRO in Jackendoff (1977) corresponds to the "part" element.

5.5.2 Fractions in German

In the previous section, I showed that the two types of fractions in Spanish have the left-branching structure. German also has two types of fractions as in (59). Recall that in German fractions, the denominator is followed by the suffix *-tel*, which is a short form of *Teil* 'part' (Dodd et al. (2003: 246)).

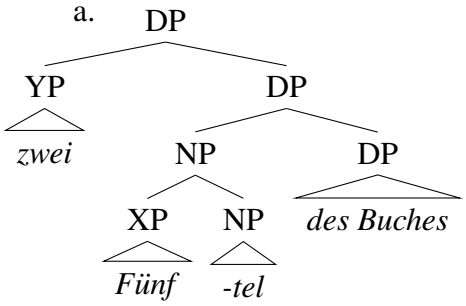
(59) German [Germanic]: Sabine Laszakovits, p.c.

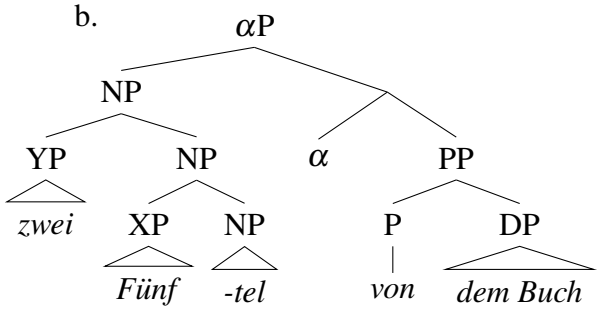
a. *Jan hat [zwei Fünftel des Buches] gelesen*
Jan have two five.part the.GEN book.GEN read
'Jan read two fifths of the book.'

b. *Jan hat [zwei Fünftel vom Buch] gelesen*
Jan have two five.part of.the.DAT book read
'Jan read two fifths of the book.'

In (59a), the main noun bears adnominal genitive. On the other hand, in (59b), the main noun appears inside of the *von*-phrase (*vom* is a contracted form of *von* 'of/from' and the determiner *dem*). I suggest that German allows for the two structures in (60) for fractions.

(60) Fractions in German

a.


b.


(60a) is the cascading structure. Here, the numerator and the denominator independently modify the main noun. On the other hand, in (60b), the numerator and the denominator

form a constituent to the exclusion of the *von*-phrase containing the main noun.

Support for the assumption that fractions in German have two different structures comes from split topicalization of fractions. As shown in (61), only fractions appearing with the *von*-phrase can undergo split topicalization.

(61) German: Sabine Laszakovits, p.c.

Context: Jan is supposed to read two thirds of the book or the newspaper, and four fifths of the other. He can choose of which he reads which amount. The teacher asks me whether he achieved the task.

a. *[*Zwei drittel*] *hat Jan* [Δ *des Buches*] *gelesen,*
two three.part have Jan the.GEN book.GEN read
und vier Fünftel der Zeitung.
and four five.part the newspaper
'Jan read two thirds of the book and four fifths of the newspaper.'

b. OK[*Zwei drittel*] *hat Jan* [Δ *vom Buch*] *gelesen,*
two three.part have Jan of.the.DAT book read
und vier Fünftel von der Zeitung.
and four five.part of the newspaper
'Jan read two thirds of the book and four fifths of the newspaper.'

The contrast in (61) can be accounted for under the current analysis. (61a) has the cascading structure in (60a). In this structure, the numerator and the denominator do not form a single constituent and cannot undergo split topicalization. On the other hand, the fraction in (61b) has the structure in (60b). Here, the topmost NP can be the target of split topicalization.

To summarize, I argued in this section that the two structures for fractions I proposed in this Chapter are actually realized as different constructions in German.

5.5.3 Fractions in Vietnamese

Fractions in Vietnamese also exhibit interesting patterns. As shown in (62), Vietnamese has two types of fractions.

(62) Vietnamese: Thuy Bui, p.c.

a. *Khanh đọc [hai phần ba cuốn sách].*
Khanh read two part three CLS book
'Khanh read two thirds of the book.' (e.g. reading 60 pages of the book that has 90 pages)

b. *Khanh đọc [hai phần ba số sách].*
Khanh read two part three number book
'Khanh read two thirds of the books.' (e.g. reading four books out of six books)

In (62a), the numerator is followed by the "part" element, and the denominator is separated from the main noun by the classifier *cuốn*. In (62), the denominator is followed by *số* 'number' instead of the classifier. Recall that some common nouns in Vietnamese can be modified by a numeral without a classifier, as in (63a). However, *sách* 'book' is an obligatory-classifier noun, and the presence of an overt classifier is required, as in (63b).

(63) Vietnamese [Austro-Asiatic]: Simpson and Ngo (2018: 213-214)

a. *bốn (cuón) phòng*
four CLS room
'four rooms'

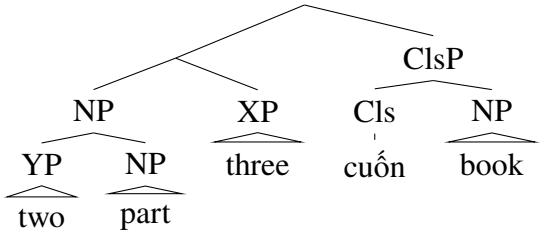
b. *bốn *(cuón) sách*
four CLS book
'four book'

Given this, the absence of the classifier in (62) must be explained. It should also be noticed that there is another difference between (62a) and (62b), regarding possible interpretations. In (62a), the main noun is interpreted as singular, whereas the same noun is interpreted as plural in (62b), as indicated by the translations.

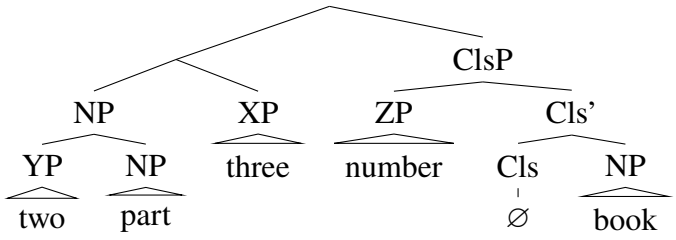
To account for these differences between (62a) and (62b), I propose that fractions in Vietnamese have the structures given in (64).

(64) Fractions in Vietnamese (cf. Nguyen (2004))

a.



b.



In both structures in (64), the numerator and the denominator form a constituent to the exclusion of the main noun. The only difference between these structures is that only in the latter, the classifier phrase (ClsP) includes the measure word meaning 'number'. As discussed by Nguyen (2004), measure words in Vietnamese block the presence of a numeral classifier, as shown in (65) and (66).

(65) Vietnamese: Nguyen (2004: 105)

a. *kí* *sách*
kilogram book
'kilogram of book-stuff'

b. **kí* *cuốn* *sách*
kilogram CLS book

c. **cuốn* *kí* *sách*
CLS kilogram book

(66) Vietnamese: Nguyen (2004: 105)

a. *thùng cam*
box orange
'box of orange-stuff/oranges'

b. **thùng quả cam*
box CLS orange

c. **quả thùng cam*
CLS box orange

This is entirely parallel to the distribution of "number" and the classifier in fractions. As shown in (67), the "number" and the classifier cannot co-occur with each other, just like the measure words in (65) and (66).

(67) Vietnamese: Thuy Bui, p.c.

a. **Khanh đọc hai phần ba số* ***cuốn*** *sách.*
Khanh read two part three number CLS book

b. **Khanh đọc hai phần ba* ***cuốn*** *số sách.*
Khanh read two part three CLS number book
'Khanh read two thirds of the books.'

Given this, it is reasonable to assume that the "number" in Vietnamese fractions is a measure word. Importantly, when a noun appears with a measure word, the noun can be interpreted as plural as in (66a). It is also expected that the main noun in fractions with "number" receives a plural interpretation.

In contrast, when a classifier appears with fractions, the main noun receives a singular interpretation. This behavior is also predicted under the present analysis. Note that in Vietnamese, when a bare classifier precedes the main noun, the modified main noun is interpreted as singular, as shown in (68).

(68) Vietnamese: Nguyen (2004: 17)

Cuốn sách hay lắm.
CLS book interesting very
'The book is very interesting.'

The obligatory nature of the singular interpretation of the bare classifier construction can be seen in the examples in (69). The bare common noun is interpreted as plural, as in (69a), whereas the noun modified by a bare classifier must be singular, yielding the unacceptability of (69b).

(69) Vietnamese: Nguyen (2004: 17)

a. *Sách rất nhiều.*
book very a lot
'There are a lot of books.'

b. **Cuốn sách rất nhiều.*
CLS book very a lot
'There are a lot of books.'

What is important is that under the current analysis, the fraction construction in (62a) has the structure in (64a), where the main noun appears in the complement of the bare classifier phrase. It then follows that the main noun in this type of fractional construction must receives a singular interpretation.

5.5.4 Japanese *bun*

In this section, I investigate fractions in Japanese based on the analysis proposed in the previous sections. I proposed that in fractions, the numerator or the denominator combine with a covert/overt "part" element. In this section, I argue that this also holds for Japanese fractions. As shown in (70), the denominator *san* 'three' is followed by the affixal element *bun* in Japanese fractions. The denominator phrase is then associated with a numerator by means of the intervening genitive linker *no*.

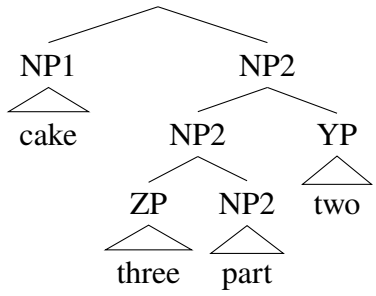
(70) Japanese

Ayaka-wa sono keeki no [***san-bun no ni***]*-o tabeta.*
Ayaka-TOP that cake GEN three-BUN GEN two-ACC ate
'Ayaka ate two thirds of the cake.'

I analyze *bun* as an overt "part" element corresponding to *fen* in Mandarin Chinese. This means that Japanese displays the [Numerator] [Denominator PART] pattern. As observed in the previous section, there are two types of the "part" element in fractions; a noun meaning 'part' and a classifier for a "part" noun. Japanese is an obligatory classifier language; we need to determine whether *bun* is a noun or a classifier. In this section, I will argue that *bun* is a noun meaning 'part'.

I am pursuing an analysis where either the numerator or the denominator include the "part" element. I propose that the fraction in (70) has the structure in (71). In Japanese, when a nominal modifier precedes a noun phrase, the genitive linker *no* occurs between the pre-nominal modifier and the noun phrase (e.g. *gengogaku-no gakusei* linguistics-GEN student 'students of linguistics'). Following Kitagawa and Ross (1982), and Watanabe (2006), I assume that the genitive linker *no* is morphologically inserted .

(71) Fractions in Japanese [cf. (46b)]



The analysis discussed in this section can thus be applied straightforwardly to Japanese fractions. The numerator or the denominator include the covert/overt "part". What is noteworthy about Japanese is that the "part" element *bun* can appear in some environments other than fractions, in addition to the fractional construction. In what follows, I will show

that the distribution of *bun* gives support for the current analysis of *bun*, namely the assumption that *bun* is the overt "part" nominal.

First of all, *bun* can in fact function as a main noun when it is modified by a prenominal modifier or a relative clause, as shown in (72).

(72) *Bun* as a nominal expression

a. *Akira-no bun*
Akira-GEN part
'Akira's portion'

b. [$_{Rel}$ *Banri-ga katta*] *bun*
Banri-NOM bought part
'a portion that Banri bought'

In these examples, *bun* is used as a main noun. I assume that *bun* is a light noun in the sense of Hiraiwa (2016a). Japanese has several light nouns such as *no* 'thing', *yatsu* 'person', *toki* 'time', etc. Light nouns need a licensing element and cannot stand alone. This property also holds for *bun*, as shown in (73). It always needs a "host" (a modifier as in (72) or a numeral as in fractions).

(73) Japanese

a. *Atsushi-wa* [*Banri-no bun*]*-o tabeta.*
Atsushi-TOP Banri-GEN part-ACC ate
'Banri ate Akira's portion (of something).'

b. **Atsushi-wa bun-o tabeta.*
Atsushi-TOP part-ACC ate

Regarding the semantics of *bun* in non-fractional contexts, I hypothesize that the variable for numbers (type n) is existentially closed, as shown in (75).[11] The non-fractional *bun* is

11. There is another way to implement the effect of existential closure here: to assume the silent numeral ONE functioning as the first argument of *bun*. Some languages like Mandarin Chinese allow for the covert "one". For instance, in (ia), the bare numeral classifier *ge* is used without an overt numeral, but still requires the whole nominal expression to be interpreted as singular. As shown in (ib), the noun modified by the demonstrative *zhe* is ambiguous between plural and singular interpretations in the absence of a numeral classifier. Based on the contrast in (i), Wang (2019) assumes that (1a) includes the silent YI 'one'. In other

a light noun of type ⟨e,t⟩ under the current analysis. If (75) is existentially closed, it means that there is an individual X such that it yields a certain quantity (i.e. the closed n) when it is measured by a contextually determined measurement function. In other words, (74) denotes a set of abstract quantities.

(74) $[\![bun_{\text{non-fractional}}]\!] = \lambda X.\exists n.[\mu(X) = n]$

The denotation of (72a) is given in (75). Here, I assume that the denotation of the pre-nominal modifier includes the contextually determined relational function R because the noun phrase in (72a) can actually have various interpretations depending on the context. It could mean 'a portion of food that Taro will eat later', 'a portion of homework that Taro has to finish this weekend', etc, depending on the context.

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words, the presence of a numeral classifier entails the presence of the silent ONE.

(i) Mandarin: Wang (2019)

a. *zhe ge xuesheng*
this CLS student
'this student'

b. *zhe xuesheng*
this student
'this student' or 'these students'

If the silent ONE were available in Japanese as well, it would be expected that Japanese classifiers could appear without overt numerals when a classifier phrase is interpreted as having the numeral "one", like Mandarin Chinese, contrary to the fact. Japanese never allows for bare numeral classifiers. However, as discussed by Watanabe (2014), some measure words in Japanese can be used without an overt numeral in certain limited environments. Some examples are given below. In these examples, the measure words are interpreted as having the numeral "one".

(ii) Japanese: Watanabe (2014: 252)

a. Kilograms
kiro san-zen-en-no kome
kilo three-thousand-yen-GEN rice
'rice that costs three thousand yen per kilo'

b. Days
hi-ni san-kai-no tooyaku
day-per three-time-GEN medication
'three medications per day'

c. Weeks
syuu-ni san-kai-no kaigi
week-per three-time-GEN meeting
'three meetings per week'

If *bun* is similar to the measure words in (ii), it could still be possible to posit the silent ONE in the examples of non-fractional *bun*. As far as I can see, existential closure of the number variable of *bun* and insertion of the silent ONE in effect yield the same result. I use existential closure for the expository purposes, leaving this theoretical choice for future research.

(75) a. $[\![$ *Akira-no* $]\!] = \lambda Y.[R(Akira)(Y)]$

b. $[\![$ *Akira-no bun* (=(72a)) $]\!]^c = \lambda X.\exists n.[\mu(X) = n \wedge R_C(Akira)(X)]$

[via Predicate Modification in Heim and Kratzer (1998)]

(72b) also includes a similar modification relation as in (76).[12]

(76) a. $[\![[_{Rel}$ *Banri-ga katta* $]]\!] = \lambda Y.[bought(Banri)(Y)]$

b. $[\![[[_{Rel}$ *Banri-ga katta* $]$ *bun* $]$ (=(72b)) $]\!] = \lambda X.\exists n.[\mu(X) = n \wedge bought(Banri)(X)]$

[via Predicate Modification in Heim and Kratzer (1998)]

The nominal usage of *bun* in (72) can be captured by the current analysis. Furthermore, it provides support for the present claim that *bun* in fractions is an overt noun meaning "part".

5.6 Chapter summary

In this chapter, I argued that either the numerator, or the denominator, or both can include a covert/overt "part" noun in fractions, on the basis of a cross-linguistic survey. I showed that I&M's (2018) analysis does not expect the "part" element in fractions and provided an alternative analysis for both syntax and semantics of fractions. The analysis proposed in this chapter leaves room for typological variations in the constituency of the numerator, the denominator and the main noun in fractions.

It should be noted that the existence of the "part" noun in fractions is also consistent with the analysis developed in other chapters of the present thesis. Thus, I proposed in Chapter 2 that multiplicative complex cardinals contain the silent *number* in some languages. Also, Chapter 4 showed that some languages make use of the overt "number" noun to form ordinals. The "part" noun can also be covert or overt. I proposed that Japanese uses the overt "part" noun *bun*. However, in other classifier languages such as Burmese,

12. In (76), I omit the details of the semantics of the relative clauses for the expository purposes. As far as I can see, nothing hinges on this.

Garo, Mokilese, etc, the existence of the “part” noun is marked only by an appropriate numeral classifier. Under the current analysis, bare numerals essentially obtain different functions such as multiplicative complex cardinals, ordinals and fractions by means of the overt/covert nominal elements.

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