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Overview

The central claim of this book is that a unified theory of distributivity, aspect, and measurement for natural language is feasible and useful.

1.1 Introduction

I claim that a number of natural language phenomena from the domains of aspect,[1] plurality, cumulativity, distributivity, and measurement, which are currently treated by separate theories, are in fact intimately related. Previous accounts of these phenomena either fail to generalize appropriately, or live on as limiting cases of a system presented here under the name of *strata theory*. This system is not a radical reorientation of the grammar. By subsuming and building on previous characterizations, strata theory retains much of what has been formerly gained, and provides a unified framework in which new correspondences are drawn between existing concepts.

The road to this claim starts with four semantic oppositions which are closely associated with the domains under consideration. These are the telic/atelic opposition, which is central to the study of aspect; the singular/plural opposition and the count/mass opposition, which are central to the study of plurality and measurement; and the collective/distributive opposition, which is central to the study of distributivity. These oppositions can be formally related to one another. This in itself is not a new insight. It has long been known that there are close parallels between the singular/plural and the count/mass opposition (e.g. Link 1983) and, likewise, between the count/mass and the telic/atelic opposition (e.g. Bach 1986). That these formal parallels can be extended to encompass the collective/distributive opposition has not been explicitly discussed as far as I know, but it is not difficult to do so.

The nature of the parallelism between all these oppositions can be described intuitively in terms of boundedness. Singular, telic, and collective predicates are

[1] "Aspect" is used in the literature to refer to many different things. Throughout this book, I use the term to refer to what has been variously called inner aspect, lexical aspect, temporal constitution, actionality, or aktionsart, as opposed to the phenomenon referred to as outer aspect, grammatical aspect, or viewpoint aspect. Broadly speaking, I understand inner aspect as referring to the telic/atelic opposition, and outer aspect as referring to the imperfective/perfective opposition. Outer aspect is not discussed in this book.

Parts of a Whole. First edition. Lucas Champollion.

delimited or bounded in ways that plural, mass, atelic, and distributive predicates are not. Making formal sense of the parallelism therefore amounts to characterizing the difference between boundedness and unboundedness. How to do this is one of the central questions which strata theory proposes to answer. I call it the *boundedness question*.

Answering the boundedness question amounts to specifying what it means for a predicate to be atelic, distributive, plural, or to have mass reference. It is not obvious that there should be a single property that is shared by all these predicates. As this book shows, however, it is indeed possible to isolate such a property. The identity of this property can be determined by analyzing a number of nominal and verbal constructions which have one thing in common: each is sensitive to one of the semantic oppositions listed above. These constructions are *for*-adverbials, which distinguish atelic from telic predicates, as in (1); pseudopartitives, which distinguish plurals and mass nouns from singular count nouns, as in (2); and adverbial *each*, which distinguishes distributive from collective predicates, as in (3). I refer to them collectively as *distributive constructions*.

(1) a. John **ran** for five minutes. *atelic*
b. *John **ran to the store** for five minutes. **telic*

(2) a. thirty pounds of **books** *plural*
b. thirty liters of **water** *mass*
c. *thirty pounds of **book** **singular*

(3) a. The boys each **walked**. *distributive*
b. *The boys each **met**. **collective*

These three constructions form the empirical basis of this book. However, they probably represent only a small sample of distributive constructions. For example, true partitives and comparative determiners accept the same classes of nouns and of measure functions as pseudopartitives do (Schwarzschild 2006). For present purposes, it is enough to focus on the three distributive constructions in (1) through (3), firstly, because they cut across the domains of distributivity, aspect, and measurement, and secondly because each of them is regarded as central to its domain in the sense that any theory of it must account for its behavior. More concretely, *for*-adverbials are regarded as the prime diagnostic of atelicity (Verkuyl 1989); *each* is the standard example of a distributive item (Link 1987b); and pseudopartitives are arguably the most prominent place in which natural language shows its sensitivity to formal properties of measurement (Krifka 1998, Schwarzschild 2006).

The novel angle of this book consists in considering the constructions in (1) through (3) as parts of a whole. Previous work has produced separate theories to account for the behavior of each of these constructions and for the phenomena that they exemplify. The resulting theories are often more limited in scope than they could be. For example,

work on distributivity has focused on how best to formalize distributive readings, rather than on extending the notion of distributivity. Likewise, the study of aspect has concentrated entirely on temporal phenomena, and the study of measurement in natural language has focused largely on mass terms, partitives, and comparatives. This development has obscured the view on the common properties of these constructions. However, this problem is not inherent in the approaches encoded in these theories. Once the connection between distributivity, aspect, and measurement is made formally explicit, it is easy to connect many existing theories to each other, and to extend them to domains beyond the ones in which they have traditionally been applied. One can then combine the strengths of each account, and synthesize them to extend their empirical coverage. This is the motivation behind this book.

The presence of distributive constructions in every one of the domains of interest makes it possible to place strata theory on a solid empirical foundation, because these constructions allow us to operationalize the boundedness question. Instead of asking abstractly what it is that atelic and distributive and mass and plural predicates have in common with each other, we can search for the property that the bold constituents in the acceptable examples in (1a), (2a), (2b), and (3a) have in common, to the exclusion of the unacceptable examples in (1b), (2c), and (3b).

In order to express generalizations over distributive constructions, I will deploy a common terminology. As is explained in more detail in Chapter 4, *Share* refers to the constituent whose denotation is distributed over the parts of the referent of the other constituent, which is called the *Key*. For example, (1a) distributes *ran* (Share) over *five minutes* (Key); (2b) distributes *water* (Share) over *thirty liters* (Key); and (3a) distributes *walk* (Share) over *the boys* (Key). I assume that these components are related by certain functions such as the function *runtime* in (1a), the function *volume* in (2b), and the thematic role *agent* in (3a). I use the term *Map* for these functions, since they always map entities (such as events or substances) associated with the Share to entities (such as intervals, degrees, or individuals) associated with the Key. These terms and relationships are illustrated in Table 1.1.

This approach results in new takes on a large and diverse number of linguistic phenomena, which are brought together here for the first time in one and the same theoretical picture.

Table 1.1. A bridge from distributivity to aspect and measurement

Construction	Example	Key	Share	Map
Adverbial *each*	The boys each walked	the boys	walk	agent
For-adverbial	John ran for five minutes	five minutes	John ran	runtime
Pseudopartitive	thirty liters of water	thirty liters	water	volume

The rest of this chapter outlines the intuition behind strata theory (Section 1.2), gives a brief overview of the contents of the rest of the book (Section 1.3), and closes with a set of suggestions regarding the different ways in which readers could navigate through the book (Section 1.4).

1.2 The central metaphor

The guiding idea behind this book is that the constructions illustrated in (1) through (3) exclude bounded predicates through a parametrized constraint which is introduced into distributive constructions through certain words such as *for*, *of*, and *each*. This constraint is formulated in terms of a higher-order property, *stratified reference*. This property requires a predicate that holds of a certain entity or event to also hold of its parts along a certain dimension and down to a certain granularity. Dimension and granularity are understood as parameters which distributive constructions can set to different values.

The dimension parameter specifies the way in which the predicate in question is distributed. Different settings of this parameter allow one and the same predicate to be atelic but not distributive, or vice versa. When the dimension parameter is set to time, stratified reference applies to atelic predicates, as in (1). When it is set to a measure function like weight or volume, stratified reference applies to mass and plural predicates, as in (2). When it is set to a thematic role like agent, stratified reference applies to distributive predicates, as in (3).

The granularity parameter specifies that the parts in question must be either atomic or simply smaller in size than the whole, as measured along the dimension. This parameter accounts for the differences between distributive constructions over discrete (count) domains, such as adverbial-*each* constructions, and those over domains involving continuous dimensions, such as *for*-adverbials and pseudopartitives.

The names *dimension*, *granularity*, and *stratified reference* are derived from a visual metaphor, which I develop here. Let me stress that I use this metaphor only for the purpose of conveying the intuitions behind strata theory. It does not have any formal status, it does not occur in the formulation of the theory, and it is not claimed to have any psychological or cognitive reality—unlike, for example, the diagrams in the cognitive grammar literature (Langacker 1986).

The metaphor is based on the idea that individuals, substances, and events occupy regions in an abstract space. The dimensions of this space include the familiar spatial and temporal dimensions as well as any measure functions and thematic roles that happen to be defined for the entity. (To understand a thematic role as a dimension, we assume that the individuals that correspond to these roles are ordered in an arbitrary but fixed canonical order, such as the alphabetical order given by their first and last names.) An object whose weight is large corresponds to a region with a large extent along the weight dimension. An event whose agent is a plural entity corresponds to

a region with a large extent along the agent dimension, while an event whose agent is singular corresponds to a region which is not extended along the agent dimension at all. A temporally and spatially punctual event whose thematic roles are all singular entities corresponds to a point. A temporally and spatially punctual event that has plural entities as its agent and theme corresponds to an infinitely thin rectangle that is extended along the agent and theme dimensions.

Consider the old intuition that any atelic predicate has the subinterval property (Bennett & Partee 1972). This property says that whenever a predicate holds at an interval *t*, it also holds at every subinterval of *t*, all the way down to instants. Put in event-semantic terms, a predicate like *run* is atelic because we can "zoom in" to any temporal part of a running event to find another running event. We cannot do that with a telic predicate like *run to the store*, because any temporal part of an event of running to the store that does not include the end point (the store) does not itself qualify as running to the store. In the metaphor, the subinterval property translates to the following picture: any event in the denotation of a predicate that has the subinterval property can be divided into infinitely thin layers that run perpendicular to the time dimension and that are also in the denotation of this atelic predicate. This gives rise to the well-known "minimal-parts problem": strictly speaking, there are no instantaneous running events, for example. If the subinterval property is to have any viable chance, it must therefore be amended so that the event layers are constrained to be thinner than the whole event, but do not have to be infinitely thin. Formally, this effect is achieved by adding a granularity parameter to the subinterval property. I call these layers *strata*. This name is chosen to remind the reader of geological strata, the layers of rock which can be observed in geological formations in places such as the Grand Canyon. A geological stratum can be just a few inches thick (though not infinitely thin) and extend over hundreds of thousands of square miles. This aspect is mirrored in the theory, where strata are constrained to be thin along one dimension, but may be arbitrarily large as measured in any other dimension.

The metaphor I have used to describe the subinterval property involves layers or strata rather than points or pebbles, because the subinterval property does not constrain any dimensions other than time. This feature is not accidental. While the relevant parts of running events must be short, or thin, in the temporal dimension, they may have plural entities as agents or themes, they may be extended in space, and so on. This view leads to a natural generalization. Normally, geological strata are horizontal, but due to geological movement, they can also be oriented along another dimension. For example, they can run vertically. Similarly, I have introduced the concept of temporal strata as resulting from dividing an event along the temporal dimension, but we can also imagine spatial or "agental" strata—subevents that are constrained based on their spatial extent or based on their number of agents. Once this step is taken, the atelic/telic opposition can be related to the collective/distributive opposition in a Neo-Davidsonian setting. Distributive predicates require any event in

their denotation to be divisible into strata that are constrained to have atomic thickness on the dimension of the appropriate thematic role. For example, any plural event in the denotation of a predicate like *smile* or *read a book* must be divisible into strata that have atomic agents and that belong to the denotation of the same predicate. Lexical predicates like *smile* have this property due to world knowledge, and phrasal predicates like *read a book* can acquire it through a modified version of the distributivity operators known from Link (1987b) and Schwarzschild (1996). Collective predicates like *be numerous* do not satisfy stratified reference on the thematic role of their subjects, because their subjects can be plural entities whose parts are not themselves numerous.

1.3 Overview of things to come

This section briefly previews the contents of the remaining chapters of the book. A more extended summary is found in Chapter 11. Section 1.4 offers a set of suggestions regarding the different ways in which readers can navigate through the book.

Chapter 2, "The stage," presents a distilled picture of the crucial issues in the theoretical background assumptions, and develops the framework on which strata theory is built. This framework is essentially a synthesis of the work by Lønning (1987), Link (1998a), Krifka (1998), Landman (2000), and others. Its mathematical foundation is classical extensional mereology, which is presented and discussed at length. The overview in this chapter is intended as a reference point for future researchers and spells out the relevant background assumptions as explicitly as possible, especially in the case of choice points where the literature has not yet reached consensus on a preferred analysis. Issues discussed in this chapter include the meaning of the plural morpheme, the question whether the meanings of verbs are inherently pluralized, the formal properties of thematic roles, and the compositional process.

Chapter 3, "The cast of characters," presents the three constructions listed in (1) through (3) (*for*-adverbials, pseudopartitives, and adverbial *each*) by means of some typical examples. Building on the foundations laid out in Chapter 2, this chapter develops a baseline theory for the syntax and semantics of these constructions and their constituents, keeping things symmetric across domains as much as seems reasonable so that the parallels drawn in subsequent chapters are not obscured more than necessary. The chapter discusses various properties of these constructions, and introduces simplified Logical Forms for them that provide a scaffold on which the theory in the rest of the book is built.

Chapter 4, "The theory," presents stratified reference as an answer to the boundedness question. The parallelism between the telic/atelic, collective/distributive, singular/plural, and count/mass oppositions is captured in a unified framework. After a brief overview of the empirical phenomena that have been discussed under the rubric of distributivity, the notion of stratified reference is gradually developed as a

generalized notion of distributivity. It is then used to formulate a single constraint that explains each of the judgments in (1) through (3), and to predict distributive entailments of lexical predicates via meaning postulates.

Chapter 5, "Minimal parts," is about the minimal-parts problem: some eventualities and substances fail to distribute at very small scales because they have parts that are too small to satisfy certain mass terms and atelic predicates (Dowty 1979). Focusing on atelic predicates modified by *for*-adverbials, the chapter discusses some previous attempts to solve the problem before presenting a novel solution in detail. It is shown that stratified reference not only avoids problems that infinitely small parts cause for proposals based on the subinterval property and related notions, but also makes the right predictions as far as the interaction between the respective predicate and the length of the interval denoted by the complement of *for* is concerned.

Chapter 6, "Aspect and space," models the relation between temporal aspect (*run for an hour* / **run all the way to the store for an hour*) and spatial aspect (*meander* / **end for a mile*) previously discussed by Gawron (2009). The chapter shows that *for*-adverbials impose analogous conditions on the spatial domain and on the temporal domain, and that an event may satisfy stratified reference with respect to one of the domains without satisfying it with respect to the other one as well. This provides the means to extend the telic/atelic opposition to the spatial domain. The chapter argues in some detail that stratified reference is in this respect empirically superior to an alternative view of telicity based on divisive reference (Krifka 1998).

Chapter 7, "Measure functions," explains the linguistic relevance of the difference between extensive measure functions like volume and intensive measure functions like temperature, as illustrated by the pseudopartitives *thirty liters of water* vs. **thirty degrees Celsius of water* (Krifka 1998, Schwarzschild 2006). Subsuming these previous accounts, stratified reference correctly predicts the monotonicity constraint: such constructions disallow measure functions that generally return the same value on an entity and on its parts. For example, in order for **thirty degrees Celsius of water* to be acceptable, it would have to describe a water entity whose parts are colder than itself; but there are no such entities. Stratified reference relativizes unboundedness to just one dimension or measure function at a time. This makes it possible to account for examples like *five feet of snow* even though not every part of a five-foot layer of snow is less than five feet high.

Chapter 8, "Covert distributivity," investigates and formalizes different sources of covert distributivity. Apart from lexical distributivity effects, which are modeled by meaning postulates, phrasal distributivity is captured via two operators: (i) a D operator distributing over atoms only (Link 1987), and (ii) a cover-based Part operator, which can also distribute over nonatomic pluralities under contextual licensing (Schwarzschild 1996). These operators are couched within strata theory and equipped with its granularity and dimension parameters. The granularity parameter captures

the difference between atomic and nonatomic distributivity. The dimension parameter makes an extension to the temporal domain possible, which explains why indefinites in the syntactic scope of *for*-adverbials tend not to covary (*?John found a flea on his dog for a month*, Zucchi & White 2001). The resulting theory surpasses accounts in which nonatomic distributivity is freely available, or not available at all; furthermore, it correctly predicts differences between lexical and phrasal nonatomic distributivity.

Chapter 9, "Overt distributivity," explains the crosslinguistic semantic differences between distance-distributive items such as English *each* and German *jeweils* by treating them as overt versions of the atomic and the nonatomic distributivity operator respectively. The proposed analysis explains why *jeweils* can distribute over salient occasions and why this is never possible for *each* (Zimmermann 2002b). It also accounts for the fact that distributive determiners can take part in cumulative readings with items outside of their syntactic scope, and for their ability to interact with nondistributive event modifiers (Schein 1993, Kratzer 2000, Champollion 2010a).

Chapter 10, "Collectivity and cumulativity," develops a theory of the word *all*. In some respects, such as its incompatibility with certain collective predicates like *be numerous* (Dowty 1987, Winter 2001) and its limited ability to take part in cumulative readings (Zweig 2009), this word is similar to distributive items like *every* and *each*. In other respects, such as its compatibility with collective predicates like *meet* and its ability to license dependent plurals, it differs from distributive items. This tension between the distributive and the nondistributive facets of *all* is resolved via stratified reference, which is used to formulate the semantics of *all* in terms of a subgroup distributivity requirement and to formulate meaning postulates for collective predicates like *meet* that give rise to distributive inferences to subgroups.

Chapter 11 concludes the book by summarizing its main insights and results. A detailed chapter-by-chapter summary provides a bird's-eye view of strata theory and stratified reference. The summary highlights the conceptual and theoretical moves as well as their empirical payoff. It contrasts the property-based perspective on stratified reference introduced in Chapter 4 and developed in Chapters 5 through 7 with the operator-based perspective that is central to Chapters 8 and 9, and it sketches how both perspectives come into play in Chapter 10. The book concludes with a list of open problems and suggestions for further research, including a brief discussion of connections to other frameworks such as cognitive and conceptual semantics.

1.4 Ways to read this book

This book presupposes graduate-level knowledge of theories of formal semantics of natural language, as can be found in various textbooks such as Heim & Kratzer (1998). Although this book is self-contained, readers who are new to mereology and algebraic semantics may find it useful to consult the following handbook articles:

for an introduction to classical extensional mereology and an overview of algebraic semantics, Champollion & Krifka (2016); and for an empirical overview of distributivity along with collectivity and cumulativity, Champollion (to appear). These articles overlap in part with this book, but they go into more depth on certain issues, such as aspectual composition in the case of Champollion & Krifka (2016) and psycholinguistic findings as well as crosslinguistic facts in the case of Champollion (to appear).

Readers who are already familiar with these topics, or who are chiefly interested in the linguistic issues discussed in the book, may want to skip Chapter 2 and come back to it in order to clarify questions that come up as they read further.

Champollion (2015c), a target article, provides a self-contained overview of the theory in this book, and can be read as such, especially when taken together with some amendments to the theory described in the last section of the reply article, Champollion (2015b). The theory in this book has been updated to take these amendments into account.

Everyone unfamiliar with these papers who would like to understand just one or two parts of the book should start by reading Chapters 3 and 4; the chapters following these two are modular. Readers who are particularly interested in just one of the topics covered in this book—aspect, measurement, and distributivity—may find it useful to concentrate on the following parts: for aspect, Chapters 5 and 6, and Section 8.6; for measurement, Chapter 7; and for distributivity, Chapters 8, 9, and 10. The detailed chapter-by-chapter summary in Chapter 11 may be helpful as a way to get a bird's-eye perspective on the theoretical and empirical coverage of the book.