

Chapter 1

Prologue: Textual Acts and the History of Science

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Abstract Scholarly texts usually combine a variety of elements: sentences, diagrams, tables and other specific types of inscriptions, layouts and notations. After a long period when History and Philosophy of Science mainly focused on the verbal aspect of these sources, in recent decades these disciplines have actively begun to investigate other dimensions, such as diagrams and symbolic writings. This book is an attempt to return to the verbal components of these documents and explore them from a new perspective.

The collective work that led to this book started in the fall of 2002. In the context of the seminar “History of Science, History of Text,” Karine Chemla (REHSEIS, CNRS & University Paris Diderot), a historian of science, and Jacques Virbel (IRIT, Toulouse), a linguist specialized in text linguistics, launched a series of workshops with the title “Textes de consignes et d’algorithmes. Approches historiques et linguistiques (Instructional Texts and Algorithm Texts. Historical and Linguistic Approaches).” This resulted in formation of a group that was enthusiastic about the collective work carried out in this framework. Before long it was focusing on the issues addressed in this volume. The group members included specialists of China, Europe, India and Mesopotamia. They were linguists as well as historians of mathematics, lexicography, zoology or medicine. The collective work continued for several years, during which colleagues learned about the theories and sources of each other’s disciplines, and each elaborated his or her own approach in the framework of this interdisciplinary enterprise. As a result, the book brings Linguistics and History of Science into close interrelationship, with the aim of helping the two fields to advance together. Each chapter of the book has been subjected to close scrutiny by the participants of the seminar and we are thus jointly responsible for any omissions or errors. We were able to complete the book thanks to Anthony Pamart, and to the generous hospitality of Silke Wimmer-Zagier and Don Zagier in Bonn, and Lorraine Daston and the Max Planck Institut fuer Wissenschaftsgeschichte in Berlin during summer 2012, as well as that of the Fondation des Treilles during summer 2013. We would like to express our heartfelt thanks to all of them. Bruno Belhoste, Ramon Guardans, and Skuli Sigurdsson have carefully read this introduction whole or in part, and we are grateful for their constructive comments. We would especially like to thank Karen Margolis for her immeasurable part in completing the introduction. Many thanks also to Sarah Diému-Trémolières, Shubham Dixit, and Neelu Sahu for their contributions during the publication process.

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1.1 Acting by Means of Scholarly Texts: A Research Program

Scholarly texts usually combine a variety of elements: sentences, diagrams, tables and other specific types of inscriptions, layouts and notations. After a long period when History and Philosophy of Science mainly focused on the verbal aspect of these sources, in recent decades these disciplines have actively begun to investigate other dimensions, such as diagrams and symbolic writings.¹ This book is an attempt to return to the verbal components of these documents and explore them from a new perspective.

1.1.1 *Assertions and other Types of Utterances*

When History and Philosophy of Science have dealt with the discursive part of scientific texts, both disciplines have laid great emphasis on the assertive dimensions of the statements they contain and the logical structures of their arguments. This is how one can express that, when reading the words that have come down to us from the practitioners of science, these disciplines have endeavored to determine in the most rigorous and fruitful way the bodies of knowledge available to actors, or created by them, on the basis of how actors described part of the world as they understood it, or reported on other topics of inquiry. However, as John L. Austin has emphasized, language can be used for other purposes. (Austin has since been followed by many others, including John Searle.) In addition to allowing its users to make assertions, language allows us to “do things with words.”² For instance, language can be used to change the “world.” Austin explains that this is the case with the famous sentence “I do (sc. take this woman to be my lawful wedded wife)” —as uttered in the course of the marriage ceremony.”³ In the proper circumstances, uttering the sentence modifies my status and others’ as well as my relationship to people and institutions. Clearly, the sentence does not assert a state of the world, but actually brings it about: the speaker performs an act by means of words. It is an act of communication, performed in a given context. Language can also be used to get someone to do something. For instance, I can suggest that a person shouldn’t go any further by uttering the sentence “There is a bull in the field.”⁴ More generally, Austin and his followers have attempted to determine all possible ways of using language and to provide a classification for them. In the classification of

¹ We can illustrate this trend by mentioning just a few books that deal with ancient and modern science, as well as various academic disciplines: (Galison 1997; Netz 1999; Klein 2003; Mancosu et al. 2005; Giaquinto 2007).

² This refers to the title of Austin’s posthumous book, which marked the opening of this field of inquiry: *How to Do Things With Words* (Austin 1962).

³ Austin (1962, p. 5).

⁴ Austin (1962, p. 32).

Austin's "speech acts" that John Searle has proposed and that has become standard, the utterance "I do," mentioned above, falls within the category of "declarative" use of language, whereas the latter, "There is a bull in the field," is referred to as "directive."⁵ We shall return to these terms below, as well as referring to the other categories that have been identified.

What can be said about these other uses of language in scientific texts? In which ways can History and Philosophy of Science usefully consider them? Moreover, can Speech Act Theory be applied directly in order to address these questions, or should it be developed specifically to suit this purpose? These, briefly, are the questions this volume intends to consider.

Such questions are not devoid of meaning: it suffices to point out that some scientific writings contain texts for mathematical algorithms or medical prescriptions. In other words, as soon as we look for uses of language that are not merely assertive, we find examples in our sources: texts for algorithms and prescriptions are texts *that make* readers *do* things. By extension, let us call such texts "directive."⁶ *How* these texts make readers do things is a question that has not been systematically examined so far. And yet, as we show in this volume, although inquiring into this question is by no means obvious, it casts a new light on actors' engagement with texts. At the very least, conducting a detailed survey of the various uses of language in scholarly writings will shed light on their textual complexity beyond the assertive function with which they have mostly been associated, or which has been sought for in them. This book aims not only to detect such uses, but also to analyze how actors performed these acts using language. As we will discover, the examination of these questions reveals features of scholarly writings that have been neglected so far.

1.1.2 *How to Do Things with Texts*

The two examples above—texts for algorithms and prescriptions—illustrate directly that Speech Act Theory can certainly be a source of inspiration, and that it has to be extended to enable us to reach our goal. Indeed, as the term "speech act" indicates, the theory was mainly conceived on the basis of an observation of circumstances in which language is used orally. We can also point out that historically, the study of speech acts has mainly been based on ordinary uses of language. It is true that Austin sometimes evokes "written utterances"⁷ or considers the written version

⁵ (Searle 1979, p. viii). See Chap. 2 by Virbel in the present book. The validity of Searle's classification has been questioned. See, e.g., (Vernant 2005). We shall not discuss these debates here; we only wish to call attention to a domain of research and modes of analysis that should prove fruitful for the History of Science.

⁶ For the sake of simplicity, we only focus on one of the things these texts do: they enable users to carry out computations or manage medical treatment. As we shall see, sometimes this is not the only thing they do.

⁷ (Austin 1962, pp. 8, 60–61). This expression seems to have an interesting history whose exploration falls outside the scope of the present book. We employ the expression "written utterances" below to refer to sentences as used in our sources.

of the speech act.⁸ However, the main thrust of his theory is to account for *oral* events, whereas the phenomena we want to consider occur in written documents.⁹ In fact, they occur in the framework of specialized uses of language. This is the first reason why Speech Act Theory needs to be reconsidered in the process of applying it for our purpose. Given this, in relation to our goal we shall use the expression “discourse act,” rather than “speech act.”

There is a second reason why Speech Act Theory must be extended. The theory was mainly devised to describe how *sentences* work in actual utterances.¹⁰ However, for our purpose, as has already become clear, we have to consider not only how sentences, but also how *texts*—we mean *actual* texts like that of an algorithm or that of a prescription—are used to carry out directives or declaratives. In some of the language acts he considered, John Searle used texts as examples, notably when he discussed the case of the shopping list devised by G.E.M. Anscombe in 1957.¹¹ The same list of items, he emphasized—that is, the same text—can be used to perform (at least) two different acts. It is to be interpreted as a “directive” when used by the person who does the shopping: the list then dictates what has to be bought. It can also be an “assertive,” if it is written down by a detective reporting on the shopper’s actions: the list documents the customer’s acts. However, seen from the viewpoint of these acts, we can observe that the phenomenon would be the same whether the list consists of a single word or a whole text. In this respect, the textual features of the list are “weak.”¹² One may also argue that Searle considers “actual” texts when he addresses the issue of the “logical status of fictional discourse.”¹³ Note that in this case the point where Searle does address the textual dimension of the fiction is

⁸ Austin (1962, pp. 57, 74–75).

⁹ This sentence is a rough description of our set of sources, which is to be taken as a first approximation. We are well aware, as we show below, that some of these written sources adhere to oral activity and even sometimes record texts composed and/or practiced orally. In this respect, Sanskrit documents are always a source of warning and inspiration, since some of the written documents deliver texts that were once, and still are, practiced orally. See (Filliozat 2004), and our remarks below. This illustrates the usefulness of considering scholarly texts on a broad basis. The present book deals more generally with textual issues by relying on sources produced in many different places in the world and in different time periods. In this respect, as in many others, we are working within the framework of the options elucidated in (Chemla 2004).

¹⁰ A similar comment occurs in (Vanderveken 2001) as an introduction to an attempt to describe speech acts not singly, but in the context of a conversation.

¹¹ (Anscombe 1957, pp. 56–57; Searle 1979, pp. 3–4).

¹² The example has a family resemblance with a whole class of texts—the “enumerations”—to which we devote Part II of this volume. Jacques Virbel analyses this example in Chap. 6, when he considers pragmatic features of enumerations (Sect. 6.4). In this context, he concentrates on the other dimension of the list, the enumeration. In the process he looks at the issue of how the list differs specifically from a single term.

¹³ Searle (1979, pp. 52–75).

that of its coherence. This leaves open the question we want to consider: how does one do things with texts?¹⁴

Formulating this question allows us to perceive directly, even though indistinctly for the moment, how History and Philosophy of Science can benefit from raising these questions. An inquiry into this range of language phenomena is likely to provide tools to discover, in written sources, evidence about aspects of the practices, and not only the knowledge, of actors. Further, we shall see that this type of investigation rapidly leads us to terrain where scientific practice intersects with questions of law, and reflects social environments.

1.2 Discourse Acts and Textual Acts—The Example of Instructional Texts

The first part of this book presents a preliminary exploration of various types of acts carried out by means of “textual utterances” in the context of scholarly writings.

Our research did not start from scratch. In the last two decades, a group of linguists, logicians, neuroscientists and computer scientists, which Jacques Virbel was part of, has been developing a multidisciplinary approach to the textual acts carried out by means of instructional (or procedural) texts.¹⁵ Texts giving instructions are meant to enable users to do things. As mentioned above, scientific documents also contain such types of texts, if we think of algorithms or prescriptions. It seemed natural to begin cooperating on this kind of “textual act.” This is also the starting point for the present book.

¹⁴ Barry Smith has raised similar questions in (Smith 2010 (August 23–26); Smith 2012). As mentioned above, Vernant has suggested reshaping the classification of discourse acts used by Searle. His main reason is to introduce “quotation” as a kind of discourse act. To do this, Vernant has introduced the more general concept of “metadiscursive acts,” or acts that perform an action on the discourse itself. In performing such acts, actors also do things with texts. We shall return below to a phenomenon of that kind. In the field of science studies, Brian Rotman, in the context of attempting to understand how mathematics persuades, has noted the capacity of mathematical texts to “give commands” (Rotman 1998). Our focus in this book will be different. (Fortun 2008) also invokes Speech Act Theory to understand the part played by “promises” as speech acts in the recent “rapid rise of the science and business of genomics.” The book analyzes how promises allow actors to raise funds and find biological materials. Fortun’s analysis focuses more on the actual promises than the textual acts as such.

¹⁵ Instructional texts were among the first types of texts approached as textual acts in linguistics. Results of this research work, done by Virbel and colleagues at IRIT (Institut de Recherche en Informatique de Toulouse—Toulouse Institute of Computer Science Research), were published in (Pascual and Péry-Woodley 1995; Pascual and Péry-Woodley 1997a; Pascual and Péry-Woodley 1997b; Grandaty et al. 2000; Virbel 2000). Their efforts and achievements convinced the historians of science who have contributed to the present book that we could draw on their expertise and the tools they had devised to tackle new problems in our discipline. This was the starting point of the present volume.

1.2.1 *Speech Act Theory*

In Chap. 2, Virbel begins by providing elements of Speech Act Theory that will yield a theoretical basis for the whole book. Using the example of instructional texts, he proceeds by illustrating possible extensions of the theory in order to describe “textual acts.” This example will constitute one of the main foci of the volume.

Let us start by mentioning some of the principal basic ideas and concepts of Speech Act Theory that Virbel introduces and that are taken up throughout this book. The central notion is that of the “illocutionary act,” which refers to the communication act performed by an utterance. Here we must introduce a distinction for the sake of precision. When a speaker utters a sentence, he or she performs an act that involves the body and produces a sound phenomenon. Speech Act Theory does not dwell on this dimension of the act of communication (known as a “locutionary act”); instead, it concentrates on the linguistic communication performed by the utterance. It is this dimension of the discourse act we are referring to when we use the expression “illocutionary act.” Following Searle, we take as our starting point the assumption that the “illocutionary act” constitutes “the minimal unit of linguistic communication.”

Any illocutionary act has a “purpose:” this is the first key feature that characterizes it. The “purpose” captures the actor’s intended action in performing a “discourse act.” For instance, the point of the declarative “I do,” mentioned above, is, by virtue of the utterance, for the speaker to enter the state of matrimony. Or the purpose of the utterance “I forbid you to go into the field” is to cause someone (not) to do something. The theory refers to such a purpose as “the illocutionary point” of the discourse act. The importance of this feature of the act is shown by the fact that it provides a tool to identify illocutionary acts, and establish a first fundamental classification of them. On the basis of a distinction between different types of illocutionary points, Searle surmised “five general categories of illocutionary acts.” We have already encountered three of them at the beginning of this chapter: the “directives,” the “declaratives,” and the “assertives.” The five general categories also include the “commissives,” whose point is to commit the actor to do something, and the “expressives,” whose purpose is to communicate our “feelings and attitudes.”¹⁶

These categories do not derive from an *a priori* approach to the topic, but from an observation of actual uses of language. Once they were constituted, however, Searle introduced the concept of “direction of fit” to explain the structure of the set and the differences between the types of act. The concept encapsulates differences among types of relationship between the world and the words that the various acts establish.¹⁷ It is best illustrated by the example of the shopping list. When it is used for buying, the text of the shopping list performs an act that makes the world fit the

¹⁶ Searle (1979, p. viii). In Chap. 2 of the present volume, Virbel provides illustrations for all these acts (commissives in particular in Sect. 2.3.3.1).

¹⁷ Searle (1979, p. 3–4), where the notion is introduced using the shopping list example. See also Chap. 2 in this volume, Sect. 2.2, § 9.

text. When, however, it is produced by a detective, the text makes the words fit the world. All these notions play a role in the approach to “textual acts” outlined in this book.

The identification of these different types of illocutionary acts raises two sets of issues.

To begin with, how can we capture the differences between the acts themselves? We have already introduced a first element that enables us to do so. This is the “illocutionary point.” It allows us to distinguish, for instance, between an “order” (“I forbid you to go into the field”) and a “commitment” (“I promise you I won’t go into the field.”) More generally, the “illocutionary point” provides a criterion to define general types of discourse act. However, if the distinction between the various types of acts were only based on this criterion, it would be rather crude. We also want to be able to distinguish, for instance, between an “order” (“I forbid you to go into the field”) and a “suggestion” (“There is a bull in the field.”) In relation to this issue, and following Austin’s first investigations, aside from the “illocutionary point” Searle suggested considering more broadly the “illocutionary force” with which an act is carried out. This force comprises a set of general features that enable one to characterize a discourse act and thereby distinguish between two acts. The “illocutionary point” is one of the components of this force. It contains others, and it is part of Searle’s achievement to have developed the analysis of its various components. We need not go into detail here; it suffices to refer to the function of the “illocutionary force.” Chap. 2 provides the description of the “force.” Let us simply mention that its components notably include various types of conditions of success (essential conditions, preparatory conditions, sincerity conditions, propositional content conditions).¹⁸ The components also include ways of describing the “modes of achievement” and “degree of strength” of the force.¹⁹

The first set of issues evoked in the previous paragraph looked at discourse acts from the viewpoint of *what* they perform. The second set of issues raised by the identification of illocutionary acts focuses rather on *how* these acts are carried out. The question is: how can we describe the differences between the utterances used to perform the illocutionary acts? In the terms just introduced, we can reformulate the question as: how are the illocutionary forces actually performed? In this vein, a study of the markers of illocutionary forces has been developed; Virbel alludes to this in Chap. 2. On the other hand, it is easy to see that the *same* utterance can carry out *wholly different* illocutionary acts. John. R. Searle 1969, pp. 70–71 discusses the phenomenon with the elementary example of, “It’s really quite late.” Depending on the context, the actor saying, “It’s really quite late,” can perform different acts. For instance, an act that corresponds to what the sentence means at face value, that is, the statement of a fact. By means of the same utterance, however, the actor can perform “an objection,” “a suggestion, or even a request,” or “a warning.” In

¹⁸ These conditions are explained in Chap. 2, Sect. 2.2, § 4, 7, 8, pp. 51–54. They are also illustrated for the case of commissives at the beginning of Sect. 2.3.3.2.

¹⁹ This element of the illocutionary force was introduced later; see (Searle and Vanderveken 1985, pp. 12–20).

the last four cases, we speak of an “indirect illocutionary act.” The term, “indirect illocutionary act,” refers to the use, in order to perform an illocutionary act, of an utterance that, when employed directly, performs another illocutionary act (in the example just quoted, that of stating the fact that it is late).²⁰ The act performed can depend on who utters the sentence as well as to whom it is addressed. For instance, the sentence, “Dinner is served at 8 pm,” uttered by the hotel manager is a directive when said to the chef; a commitment when addressed to customers; and an assertive in the context of an interview with a journalist.

It is obvious that these phenomena also occur with texts. We have already mentioned the case of the shopping list, in which exactly the same text can carry out different “textual acts” depending on the context. We can also refer to the text of the “program of a conference.” As a text produced by organizers for participants, the program is a commitment. But from the perspective of the program that the organizers hand over to a chairperson or a speaker, the same text performs a directive, and when recorded in a report for a research assessment agency, the text performs an assertive. We shall see that “written utterances” and texts contained in scholarly sources also testify to these phenomena.

In turn, such phenomena raise a new question: when a single utterance can carry out different illocutionary acts, how do users of language understand what is meant? Here, Austin introduces a fairly useful distinction to clarify the question. The issue of how users construe the discourse act does *not* bear on the understanding of the propositional content of the sentence. In fact, it bears on another dimension of the understanding: that which determines the illocutionary act performed. To distinguish between the two types of understanding, Austin introduces a technical term. He designates by the term “uptake” the specific type of understanding that allows the “hearer” to grasp the intended act, in contrast to his or her understanding of the propositional content. Again, we shall see that this concept is useful to describe “written utterances” in scholarly documents.

However, clarifying the question does not solve the puzzle: how do users of language understand what is meant? More generally, how can one anticipate and describe which utterance is likely to be used for a given illocutionary act? As Virbel explains in Chap. 2, in recent decades it has been possible to clarify these questions in an impressive way. In the event, the logical analysis of illocutionary forces referred to above provided essential tools that enabled researchers to address these questions.²¹

In the case of the scholarly texts discussed in this book, which were written in many different languages and contexts, the questions related to utterances all raise important and tricky issues. To begin with, how can we establish the illocutionary force of “written utterances,” that is, the nature of the illocutionary act they carry

²⁰ For an analysis of the various ways of carrying out, e.g., directive illocutionary acts, see Sect. 2.3.2.3 and 2.3.4.3 in Chap. 2 of the present book.

²¹ Searle and Vanderveken (1985), in particular Chap. 2. See also, in the present book, Chap. 2, Sect. 2.2, points 10 to 12, pp. 55–61, for a theoretical explanation, and Sect. 2.3.2.3, p.72, for an illustration by example.

out? Moreover, and perhaps more importantly, how do the ways in which “illocutionary acts” are carried out by means of actual utterances reflect the contexts in which they were produced or, more precisely, the local scholarly cultures to which they adhere? Some chapters of the book address these issues. More generally, as we shall see, the notions of Speech Act Theory that are presented in Chap. 2 and were developed for a study of “utterances” provide tools for dealing with the sentences that occur in scholarly texts and drawing interesting conclusions from them.

1.2.2 Instructional Texts

As the second part of Chap. 2 explains, these notions were also essential in enabling Virbel and his colleagues to sketch a linguistic and pragmatic treatment of “textual acts:” instructional (or procedural) texts. These texts are important for the present book.

The first step in extending Speech Act Theory to the treatment of instructional texts is to consider these texts as a means to carry out illocutionary acts. In this case, the acts of “giving instructions” are, at least partly, of a directive type. As such, the illocutionary point of their authors—and not that of a speaker, the “S” of Speech Act Theory—is clear: they aim to “help” a reader or a user—and not a hearer, the “H” of Speech Act Theory—to do something. In this respect, the illocutionary point is materialized precisely by what the actor does, that is, by the actions he or she performs in compliance with the text. This is how, even for documents from the past, these acts can be studied as such: the historians’ task is to find methods of reconstructing the acts readers, after familiarizing themselves with such documents, could perform.

In fact, through instructional texts authors often perform not only directives, but also other types of illocutionary acts. For instance, depending on the kind of instructions given, the acts of “giving instructions” can combine, in various ways, a directive and a commissive of some kind. The latter dimension captures the relationship of commitment established between the author and the user through the instructional text.

Virbel’s presentation allows us to distinguish three modes of contribution of Speech Act Theory to the study of acts of “giving instructions.” We shall now outline them, as they illustrate a general method that can be applied in the case of similar extensions.

Firstly, Speech Act Theory provides tools to describe the type of utterances to be encountered in instructional texts. In this book, in relation to the aim they pursue, Florence Bretelle-Establet (Chap. 3) and Karine Chemla (Chap. 9) make an inventory of this kind for medical and mathematical texts.

Secondly, Speech Act Theory provides a model for the study of new discourse acts. In particular, Virbel begins his study of the various types of illocutionary acts instructional texts can carry out by borrowing Searle’s approach to Speech Acts and considering “different types of differences between different types of instructional

texts.” Note that these types of differences offer a multitude of research paths to historians of science interested in the study of procedural texts, as well as other types of text.

Thirdly, Speech Act Theory provides a description of the various types of discourse acts to which verbs such as “advise” or “prescribe” correspond. For the sake of simplicity, we shall call these acts “verb acts.” Drawing on the study of “verb acts” described in Vanderveken 1990, Virbel shows how they form grids that allow him to situate any act of “giving instructions” as a discourse act by looking at its similarities and differences with respect to other discourse acts.

Virbel’s method is systematic. Looking at “verb acts,” he considers those to which instructional texts have some relation. Verbs that name “directives” include “order,” “prescribe,” “suggest,” and so on. Those that name “commissives” include “promise,” “guarantee,” and so on. Then, for each type of illocutionary act, he offers a classification of these verb acts by illuminating the key components of the illocutionary force that allow us to capture the differences and relations between these acts. By this method he can develop a robust backdrop against which he can situate any specific act of “giving instructions.”

Virbel begins by doing this with directives (See Sect. 2.3.2). He then turns to the area of commissives in order to situate within it the kind of “guarantee” that, depending on the context, the act of “giving instructions” involves (See Sect. 2.3.3). This analysis enables him to describe the combinations of directives and commissives that the acts of “giving instructions” constitute and to interpret the various possible meanings of the expression “with the help of” that characterizes instructional texts (See Sect. 2.3.3.2).

Virbel then considers assertives (See Sect. 2.3.4) as they are performed in instructional texts. On the one hand he highlights how, in this framework, assertions can combine with declaratives, in diagnostic texts, for instance. The reader will be given examples from medical books studied by Bretelle-Establet (Chap. 3), and publications on zoology described by Yves Cambefort (Chap. 4). On the other hand, Virbel focuses particularly on original forms of indirection that one encounters in instructional texts, for example modalities according to which assertions of the reasons for doing or not doing something perform directives. Such discourse acts occur in the medical books analyzed by Bretelle-Establet (Chap. 3) and in the texts for algorithms composed in ancient China, as examined here by Chemla (Chap. 9).

In conclusion, the purpose of approaching “giving instructions” as a language act has led Virbel to develop Speech Act Theory further, notably with the shaping of local classification of “verb acts.” Conversely, Speech Act Theory inspires here an approach to text as the carrying out of acts. In particular the “illocutionary point” of the author(s) when writing a text, as well as other elements that have proved essential in describing a language act, appear to provide analytical tools to develop a linguistic and pragmatic approach to texts. In the present book, Agathe Keller (Chap. 5) and Chemla (Chap. 9) concentrate on procedural texts, as Virbel does. However, Bretelle-Establet (Chap. 3) and Cambefort (Chap. 4) extend the approach presented in Virbel’s contribution beyond instructional texts. They, too, draw on the

concepts and methods of Speech Act Theory to address other forms of textual acts. The succeeding chapters of Part I consequently describe specific acts carried out by means of texts, while at the same time the authors consider the issues at stake for History of Science.

1.3 How to Make Readers Do Things: An Inquiry into the Variety of Scholarly Writings

The chapter by Bretelle-Establet is devoted to Chinese medical writings. The key question she wants to address, and for which she finds the description of “textual acts” fruitful, can be formulated as follows: a huge number of medical books has been composed and published in the whole territory of China since the seventeenth century. How can we grasp differences between them without using observers’ categories, which are in fact fairly superficial? Indeed, to understand contrasts between some of these books, historians have often employed opposites such as “scholarly” and “popular,” and have attempted to classify them into genres. Are these categories meaningful?—and, if so, which sense can we attach to them? To tackle these questions, Bretelle-Establet puts forward a subtle and powerful strategy which promises to yield results for a much wider set of sources than those she bases her approach upon. She defines several criteria that allow us to perceive a variety of textual features in these books and that can be used to characterize the different ways in which authors have textualized medical knowledge.

1.3.1 The Definition of a Corpus and its Key Features

Bretelle-Establet’s strategy begins with the definition of a corpus. She concentrates on books produced since the seventeenth century in the southernmost provinces of China, that is, at the margins of the empire and, like most of the writings that have come down to us from that time period, outside the central institution of medicine. Some of her selected books were compiled in prosperous urban areas, whereas others were used in poor, rural regions where physicians were scarce. In addition, Bretelle-Establet chooses to focus on books written by authors whose social status differs quite considerably. The contexts of production of the selected books vary in these two main respects. Furthermore, the authors’ motivations for producing these books, and hence their intended readership, were diverse. Some authors wrote a textbook that could be used in the context of medical studies; others wrote for family use and to enable relatives to self-medicate; and there were others who wrote to facilitate emergency care in urgent cases where no physician was available. Bretelle-Establet notes that all these books aim to enable readers to do things, whether the action be learning or healing. This means our framework here is the study of texts carrying out “directives.” However, in the terminology introduced by Searle

and explained by Virbel in Chap. 2, there is a difference between the “illocutionary points” of the books—what they intend to make readers do.

On the basis of this corpus, Bretelle-Establet develops her questions as follows: in which respects are these books different and how can we correlate the differences highlighted with the geographical environment in which the books were written, or the social status of the authors, or the purpose of the book? Bretelle-Establet focuses on how each of these books deals with the same nosological entity, which she translates as “sudden disorder.” These are the actual “texts” she uses as a basis for her analysis of how the “textual acts” are carried out.

In the first part of her analysis, where she concentrates on the semantic features of the texts, Bretelle-Establet examines the types of information provided, and, where applicable, she compares the information of the same type found in the various selected writings. It comes as no surprise that the texts differ in this respect. The reason is that the understanding of the ailment and the theories expounded do not concur. These differences, Bretelle-Establet emphasizes, illustrate that medicine in China was by no means a unified body of knowledge and practice, a fact that historians have endeavored to understand better in recent decades. However, the texts also differ in the *nature* of information of a given type that is provided, and this fact reveals an essential issue for the present volume. For instance, the various kinds of clinical signs the texts provide to help users diagnose an ailment demonstrate that the authors did not assume the same types of competency in their intended readers. The competency and knowledge required for readers to use a text have not been a topic of systematic inquiry in the History of Science—yet this issue proves to be very fruitful, as the present volume shows. In terms of “textual acts,” these aspects characterize the conditions an author assumes with respect to his or her readers in order for the act to be successful. In the case of the directives analyzed, these types of competency and knowledge are part of what John Searle and Daniel Vanderveken have described as their “preparatory conditions.”²² We shall return to these issues below.

In this first stage of her analysis, Bretelle-Establet does more than simply comparing the types of information given by the various texts: she tries to determine whether differences in this respect can be correlated with factors characterizing the contexts in which the books were written. Here she obtains her first surprising result. The types of information contained in a text correlate less with the author’s social status than with the declared aim of the book and its intended readership. To begin with, this conclusion suggests that the opposition between “scholarly” and “popular” texts is apparently not meaningful in this context. More generally, it invites reflection on the use of observers’ categories in descriptions of historical writings. The following, however, is more important for the purpose of our book: if we reformulate the conclusion in the terms of the formula “who writes for whom and to make them do what?” what Bretelle-Establet shows is that, for this part of the analysis, the “whom” and the “do what”—the illocutionary point

²² Searle and Vanderveken (1985, pp. 16–18), Searle and Vanderveken (2005, pp. 123–124).

of the texts—prove to be the key factors that allow her to account for distinctive features of texts.

1.3.2 Books Meant for Different Readings in Different Kinds of Places

The second part of Bretelle-Establet's analysis bears on syntactical properties of the writings. She identifies several features as meaningful for identifying differences between the texts selected, distinguishing between syntactical properties at the level of the whole text (e.g., the choices made in organizing the information²³) or at the level of propositions. One conclusion she derives from the examination of all these features is notable for the present volume: differences with respect to syntactical properties can all be correlated to the distinct types of use for which the books were intended. Some writings were suited to pragmatic reading which could be done during a journey and enabled the reader to act, even quickly, whereas other books were more appropriate for slower reading, maybe in the reader's own study, and were designed for understanding first and acting only afterwards. All this can be captured in a whole collection of formal features of the texts. These remarks highlight a key fact: the illocutionary point of a text is reflected, on the one hand, in syntactic features of the text—both global and local—and, on the other, in the specific type of reading for which the text is suited. Once again, among all the possible explanatory factors, it is the illocutionary point of a book that appears most important in accounting for distinctive textual features.

Among the syntactical features at the level of propositions that Bretelle-Establet examines, one is particularly important for us here: the distinct uses she shows authors make of “textual connectors” and “discourse markers.” Both these entities correspond to what in classical Chinese are called “particles,” and in principle they are dispensable. The former category of particles is mainly used to make links between successive propositions explicit, whether these links are logical, temporal, or relate to other kinds of connections. The latter category is even more dispensable; it is a linguistic resource an author can use to express attitudes with respect to a given sentence. On the one hand, Bretelle-Establet argues that the number and variety of particles used probably reflect the author's attempt to write in a scholarly style. One of the longest texts, which is full of particles, was written by a polymath. It is probably not accidental that, of all the authors considered in Bretelle-Establet's chapter, he enjoyed the highest official status and compiled his book for the study of medicine. On the other hand, Bretelle-Establet suggests, the choice to limit the use of such particles could relate to the intention of keeping a book to a handy size. It is revealing that the two books that explicitly mention the issue of portability use barely any

²³ What is important about this feature is that it reflects Florence Bretelle-Establet analyzes texts rather than sentences. In the same way as for the parts of a sentence, different ordering of the sentences in a text makes different pieces of information salient and creates a hierarchy between them which correlates to the point of the texts.

discourse markers, if at all (see Table 3.5 in the chapter under consideration). This particular syntactical feature endorses the general conclusion mentioned above that Bretelle-Establet draws from her overall study of these features.

1.3.3 *How do Authors Attempt to Achieve their Aims?*

As we shall see, the reason why “discourse markers” are particularly important here is because they are related to the third part of the analysis developed by Bretelle-Establet. In this part she addresses the issue of *how* authors “guide their readership to follow their first intentions.” The texts, as mentioned above, aim at making readers do something. It is in order to analyze *how* authors achieve their aim in different ways by means of textual features that Bretelle-Establet makes use of Speech Act Theory, but this time at the level of the sentences that make up the texts. In other words, she needs to examine the acts performed in the “written utterances” to carry out her analysis of the “textual acts.”²⁴ The first noteworthy result is the significant number of “written utterances” performing “directives” in all these texts (see Table 3.7), a confirmation that the authors specifically intended to make readers do things. Bretelle-Establet also shows the variety of types of assertives as well as directives that these texts contain. To use the terms introduced by Virbel in Chap. 2, we find directives of the following types: direct, implicit, and indirect, by stating conditions of success or reasons for performing (or not performing) the action. Bretelle-Establet illustrates these categories in the translations of the texts given in the appendix of the chapter. More generally, “directives” are a type of “discourse act” which constitute a primary focus of this volume. We shall encounter these distinctions again.

Here we should note an important and general point that Bretelle-Establet emphasizes for the case of her medical sources: the intention of enabling readers to do things is not in contradiction to developing theoretical explanations. It has been often argued in the History of Science that writings aimed at enabling action were meant for lowbrow users limited to doing things without understanding them. This thesis has often been advanced with respect to algorithms in mathematical sources. We can see in the case of medical writings, as we shall also see in the case of algorithms, that this assumption does not fit with the evidence we have—a fact which becomes evident when we observe precisely how directives are carried out. This is one of the questions at issue in our study of “written utterances.”

To return to medical books, what is most striking is Bretelle-Establet’s conclusion that we can distinguish between different kinds of “textual directives” and identify the various types of goals assigned to books if we observe the distinct

²⁴ The exploration of the relationships between these two levels is an open question raised by applying Speech Act Theory to texts. Should we approach this question by looking at how “written utterances” are combined to make the “textual act,” or is there a specific textual level? We leave this question open. It has been touched upon in (Nef 1980; Smith 2010 (August 23–26), Smith 2012; Vanderveken 2001).

distributions among various types of discourse acts performed by the “written utterances” contained in each text.

So far, the issue of how authors determine ways to achieve their goals for the reader was approached using the discourse acts carried out in their texts. The issue can also be viewed from another angle, that of the authors’ textual self-fashioning. The last set of questions Bretelle-Establet raises that are worth noting for their general implications deals with this very point.²⁵ Bretelle-Establet begins by remarking that the various texts differ in the way they make readers feel the presence of the author. This is the point where “discourse markers” are important. They represent one of the textual techniques some authors use to make their presence strongly visible, as opposed to those who produce “highly impersonal texts.” Interestingly enough, as Bretelle-Establet shows, only texts where the presence of the author is marked contain quotations by authors from the past. These texts establish and display their authors’ authority in a specific way and by means of specific acts. Given this, Bretelle-Establet demonstrates how the same specific techniques display not only the presence of the author, but also his or her commitment with respect to the book’s content. By contrast, Bretelle-Establet suggests that impersonal texts establish their authority in a different way, and this fact echoes the specific way in which they achieve the intended effect on the reader. (In the technical terms of Speech Act Theory, we would say this is how these texts fulfill their perlocutionary goal.)

To sum up, rather than offering a theory of genres for classifying all medical texts produced in China, Bretelle-Establet provides an analytical grid that enables historians to rely on textual features of the writings to capture differences and similarities between texts in a much more differentiated way. In particular, she offers a reflection on the various features by means of which a text reveals how an author performs the act of making his or her prospective readers do things. In our view, this is one of the key issues in a close examination of the texts inspired by Speech Act Theory.

²⁵ This gives us the opportunity to qualify the statements made at the beginning of this introduction. In recent decades, several books have focused on a rhetorical approach to scholarly texts. See, e.g., (Loveland 2001, pp. 17–23), which provides a useful survey of recent publications on the topic; (Ceccarelli 2001; Gross 2006). These rhetorical approaches also explore a dimension of scholarly texts which is not purely assertive. A review of research paths developed in this context would exceed the scope of this book. In relation to what Bretelle-Establet explores here, we can simply note that several of these books have used rhetorical analysis as a useful tool for understanding how an author attracted readers or persuaded them of the validity of his or her arguments. However, they still focus mainly on the assertive aspects of the text. Here, Bretelle-Establet considers the author’s self-fashioning through textual shaping by means of other textual acts.

1.4 Christening Organisms: Declaratives as Textual Acts in Zoology

Cambefort's chapter is devoted to zoology and focuses on the examination of another type of "textual act," a declarative. Cambefort analyzes declaratives in his study of the way in which zoologists use publications following certain rules to institute a name for an organism (or more precisely, a group of organisms), as well as instituting and describing this group—a "taxon," e.g., a species, to which the organism belongs. Interestingly enough, zoologists themselves refer to such texts as performing a "nomenclatural act." In this case, then, the idea of a "textual act" is an actors' category.

By means of its very performance, a successful "nomenclatural act" changes the state of the world. This is why, using the criteria John Searle introduced to distinguish between speech acts, Cambefort suggests that the act the text performs belongs to the category of "declaratives." Before it is carried out, some animals are unknown. The species—in the case where the taxon is a species—does not exist, and nor does the name as Cambefort explains it. Once the act is performed successfully, a species has been created, the organisms observed are stated to belong to it, and the name will be attached to them both forever, or at least as long as zoologists retain their nomenclatural practices unchanged. In a sense, the act introduces something in the world—a taxon, to which a previously unknown being now belongs—and something in our language that is attached to it by virtue of the "declarative."

1.4.1 *The Historical Shaping of a Textual Act—Its Textual and Legal Features*

The creation of both the taxon and the name also has a legal dimension. This is made explicit in, and governed by, an *International Code* drawn up by the International Union of Biological Sciences and regularly updated. It stipulates the formal conditions governing all aspects of the "textual act." Many interesting issues are at stake here. Firstly, in dealing with the rules governing the texts as such, we immediately encounter legal and social dimensions of scientific practice. We also see facets of the texts that we would miss if we considered the publications carrying out this act as simply descriptions. Attempting to describe the institutions created to perform such "textual acts," and the consequences of these acts, is a way to perceive more precisely what is at issue in these texts. It is also a method of understanding how the publication of texts relates to other features of scientific practice. Lastly, the regular updates of the *International Code* express the part of the scientific work carried out by biologists that is devoted to working out formal rules for publications. We shall return to this point later. It testifies to how designing textual acts has been an important component of scientific activity.²⁶

²⁶ This was discussed in (Chemla 2004).

These are some of the questions at issue for historians of science. It is also interesting to consider these texts from the viewpoint of the acts they perform and ask how they compare to other types of declaratives. In exploring the specificities of this type of “textual act,” Cambefort underlines differences which reflect standards instituted by the discipline of zoology governing how such names and the taxa they designate should work when properly handled.

Firstly, conditions of success of the “textual act” include that only unknown organisms can be named, and the names must satisfy particular rules of formation adopted in the discipline. A proof that a condition is not fulfilled can be a reason to nullify a “nomenclatural act.” This statement reveals that in the wide class of “declaratives,” that which introduces a name and a taxon is one of the contestable “textual acts.” Practitioners of zoology regularly dispute the validity of this kind of declarative. The scientific activities that are then done to confirm or invalidate the “textual act” highlight the role of these declaratives in zoological practice today. These activities are materialized in the form of the various types of publications, or “secondary nomenclatural acts,” which contest, confirm, correct, or augment the “original description,” or “primary nomenclatural act.”

The reasons why a declarative can be contested reflect the various dimensions of the act. It can be invalidated because of the *name* introduced. In particular, if the name is shown to be already used for a similar purpose, another name has to be introduced. The importance of this aspect of the declarative is materialized by the tools created within the discipline, such as registers, to assist practitioners in designing names. It can also be contested on account of the *taxon*, for instance, if its novelty is in doubt. The recognition of this refutation as valid leads to canceling the declarative: the “textual act” is declared to have failed using a similar procedure to that which aims to perform it. In such cases, there is a rule determining which name should be kept for the taxon: the first printed name has absolute priority, while the names introduced later remain as “synonyms.” This highlights the fact that a declarative of that type is invalidated in an unusual way: the part that deals with the creation of the taxon remains the only one affected by the failure, while the creation of the name in general is successful, with the name leaving a permanent trace in the attributes associated with the taxon in the specialist publications. It also reveals the emphasis zoologists have placed on defining rules for the management of names and taxa. They have elaborated the conditions for defining “naming” as a “textual act.”

Secondly, present-day zoologists recognize the name and the taxon as effectively created only if they are “notified” in a specified way: the text carrying out the “declarative act” must be printed and published. Oral introductions and other modes of publication are not accepted as valid. The discipline of zoology has thus progressively defined formal conditions for a “declarative” to achieve success and, as Cambefort explains, the conditions are constantly under discussion. In Chap. 2, Virbel called attention to the distinctions between language acts, as well as between textual acts, with respect to their promulgation. We now see how the modality according to which this has been realized has been a topic of discussion and elaboration for zoologists. As part of a history of scientific practice, History

of Science can set itself the task of inquiring into the historical shaping of these “textual acts” and their management principles. Cambefort goes on to describe the specifications of the textual artifact for achieving these “declaratives” today. It is also worth considering how each of these features was historically designed and came to be part of the “declarative,” and also how the “textual act” as such was shaped accordingly.

Let us now mention some of these features to highlight issues of interest to us. To be successful, the “nomenclatural act” must not only create a name, but also provide a description of a specimen. It must also designate the specimen and specify where it can be found. As Cambefort formulates it, the “holotype”—the modern term for the specimen—is intended to remain the object of reference for the species name, and serves as a “proof” of the textual “act.” Accordingly, the *Code* demands that the holotype be deposited in a public collection and freely available for consultation. We thus see how the discipline designed public collections in close connection with publications. Cambefort notes present-day debates about the rules governing the materiality of the holotype. This indicates the interplay of forces that brings about the transformations effected in zoological practice.

For any type of declarative, the status of the person performing the act is essential for it to achieve success (John Searle 1979, p. 26.) In recent decades, Cambefort indicates, zoology as a discipline has diminished to the benefit of other subfields of biology. Nomenclatural acts have partly become amateur endeavors, as they once were in former centuries. As the status of the author of the declarative changes, the role of his or her status in the success of the nomenclatural act becomes increasingly visible. It is interesting to examine, as a key feature of the “textual act,” an author’s attempt to establish his or her authority in the text to perform the act. Cambefort outlines means to fulfill this aim, including ways of naming, or acknowledgements. Interestingly, he suggests how the degree of emphasis in stating the authority is partly a function of the nature of the nomenclatural act performed.

1.4.2 Encountering a First Enumeration

The “nomenclatural act,” Cambefort notes, as it is performed in a publication fulfilling all mandatory criteria, requires several other kinds of “textual acts” to be carried out. Two kinds of these play an important role: enumerations and “directives.” For instance, the description of the specimen, as well as the diagnostic features characterizing the taxon, are textualized as enumerations. On the other hand, “instructions” are given to enable one to determine whether a given organism belongs to the taxon and to situate the taxon in relation to cognate taxa. Enumerations and “directives” are two kinds of textual acts to which the succeeding chapters return. From the perspective of how they are written down, the instructions, as illustrated on pp. 311–312 (see Fig. 1.1) of the first example given by Cambefort, display interesting textual features that are important for the theses of the present book. We shall now focus on them to introduce some notions that will subsequently prove useful.

The text of these instructions takes the form of an enumeration whose individual items are introduced by a number. This yields a combination of a directive and an

KEY TO SPECIES OF *CARINOSQUILLA* MANNING, 1968

- 1. Eyestalk with irregular dorsal carinae 4
- Eyestalk without dorsal carinae 2

- 2. Dorsal carinae on either side of midline of TS5 transverse. Inner margin of uropodal protopod spinose 3
- Dorsal carinae on either side of midline of TS5 longitudinal or oblique, not transverse. Inner margin of uropodal protopod crenulate *C. lirata*

- 3. Mandibular palp present. Telson prelateral lobe with sharp apex *C. multicarinata*
- Mandibular palp absent. Telson prelateral lobe with blunt apex *C. carita*

- 4. Ocular scales with bifurcate apices 5
- Ocular scales with apices entire, not bifurcate 7

- 5. Posterior margin of AS1-4 between submedian carinae lined with spines *C. spinosa*
- Posterior margin of AS1-4 between submedian carinae unarmed 6

- 6. AS1-2 with unarmed submedian and intermediate carinae *C. redacta*
- AS1-2 with armed submedian and intermediate carinae *C. carinata*

- 7. Merus of raptorial claw with single longitudinal carina on outer margin 8
- Merus of raptorial claw with vermiform sculpture on outer margin 9

- 8. AS6 without posteriorly armed supplementary carinae between submedian and intermediate carinae. Distal segment of uropodal exopod entirely dark *C. australiensis*
- AS6 with one or two posteriorly armed supplementary carinae between submedian and intermediate carinae. Uropodal exopod distal segment dark on proximal third *C. balicasag*

- 9. Dactylus of raptorial claw with five teeth. Dorsal carinae of AS6 and telson entire, not forming field of spines *C. thailandensis*
- Dactylus of raptorial claw with six or seven teeth. Dorsolateral carinae of AS6 and telson divided, forming field of spines *C. mcLaughlinae* n. sp.

Fig. 1.1 Excerpt from “A new species of Carinosquilla...” Shane T. AHYONG. (Example 1, in Chap. 4, by Y. Cambefort)

enumerative act. Each item of the enumeration is composed of a pair of sub-items, the second sub-item beginning with a dash. At the end of each line, the reader finds either a number or an italicized name, which is the name of a taxon. The reader knows that each list of two sub-items represents an alternative. Formally, the text lists key diagnostic alternatives, which enable one to distinguish between taxa. It states them all as similarly essential for the desired aim. This is the first thing done with the text. We shall return later to this dimension of the act performed using the enumeration. In fact, as its title indicates, the text constitutes a “key” or “table.” In this respect it carries out an assertive and a directive simultaneously, as with the shopping list or the program of a conference referred to above. However, it is easy to see that in the present case the method for handling the text of the enumeration differs from the use of the shopping list or the program. Accordingly, the “key” has a characteristic textual feature: the numbering of the items.

When using the “key,” the reader knows he or she should begin reading at the first item. Whether the reader opts for a sub-item with the aim of determining the taxon of an organism under observation (text as directive), or reads the relationships

between the taxa whose names appear in italics in the “key” (text as assertive), he or she knows that at the end of the first or the second line of item 1, the number indicates the number of the next item to be read. This principle holds true for all items, except when the italicized name of a taxon occurs at the end of a line. The use of the text as “key” thus leads to a reading of the enumeration in the form of content of a tree. The end of the lowest branches of the tree is found to contain either the name of the taxon for an organism or the list of the taxa classified, depending on the type of reading (text read as instructions or as description).²⁷

What is important here is that, whether it is read as a directive or as an assertive, for appropriate use the text requires various types of textual competence. An essential feature of these types of competence is the knowledge of how to circulate in the text to work out its content adequately. The reader needs these types of competence to *do* his or her diagnosis *with the text*. Relying on the intended readers’ textual competency is a requirement for “securing uptake.” In this respect we are transposing Austin’s expression to the use of texts (Austin 1962, p. 116.) Note that in this example, the circulation must be achieved in a precise way, in contrast to the circulation in the shopping list, which is more open. Despite superficial similarities, the two texts do not carry out directives in the same way. This correlates with the different types of textual competence the users require.

In some of the texts analyzed by Bretelle-Establet, particularly those suitable for reading slowly, textual circulation within the book was also an ability the authors relied on in organizing the information presented in the book. Illuminating the various types of textual circulation expected from readers for different kinds of texts written in different contexts is one of the important results presented in this book. The variety of such circulation and other types of textual competency that our sources require to “secure uptake” demonstrate the various cultural backgrounds forming the context of production of the texts under analysis, as well as their different purposes. In particular, as we shall see in Christine Proust’s chapter, some mathematical tablets from Mesopotamia share several common features with the tables described by Cambefort. However, the tablets present distinct textual realizations of trees.

1.5 Texts for Directives in the Context of a Scholarly Culture: The Uptake Issue

Before returning to our focus on enumerations and the question of textual circulation in documents, we will continue our exploration of the important issues for History of Science in considering textual acts attested to in scholarly sources. The two examples discussed above illustrated different types of agenda for which focus-

²⁷ (McCarthy 1991) shows a similar interest in how writings can shape users’ scholarly knowledge. McCarthy examines how the *Diagnostic and Statistical Manual of Mental Disorders* (1980) shapes psychiatrists’ approach to illness, their gathering of information, their diagnosis, and how they communicate the acquired knowledge.

ing on textual acts benefits History of Science. In particular, Bretelle-Establet and Cambefort approach the question of “how authors do things with texts” from different perspectives. In Bretelle-Establet’s case we have seen how a book’s semantic, syntactic and pragmatic features reflected the textual directive the author aimed at performing. She also emphasizes that the nature of the directive carried out correlated with the expected type of reading and the intended environment for the book’s use. Lastly, Bretelle-Establet revealed ways in which textual features demonstrate the various modalities by which authors established their authority in relation to the achievement of their goals. Establishing the author’s authority also proved important in the case studied by Cambefort for the fulfillment of a “nomenclatural act.” As we have seen, Cambefort correlated the modes of displaying this authority with the social status of the author in the context of a discipline where the balance between amateurs and professional actors was changing. However, there seem to be other issues at stake in Cambefort’s chapter, relating to a discipline’s historical shaping of valid textual acts, and the way textual acts actually shape practitioners’ actions and knowledge.

These two examples show how awareness of the textual acts performed with texts enables us to perceive and interpret their specificities. They also provide two approaches to the question as to “how authors made readers do things with texts.” The final chapter of Part I of the book (Chap. 5) examines documents that also attest to the performance of directives by means of texts. The chapter aims, however, at highlighting from a different angle the possible benefits to both History of Science and the study of “textual acts” from considering textual acts performed in scholarly documents. We focus on texts for algorithms as found in treatises written in Sanskrit in the fifth and around the tenth century. Establishing that these texts carry out directives, and how they do this, proves to be a real challenge. On the other hand, if we failed to attempt to describe the textual acts performed there, we would risk misinterpreting the sources and misrepresenting the authors’ utterances. As Keller shows, this has often occurred in the past. What is at stake here is interpretation by means of identifying the textual act carried out in a source. To transpose Austin’s specific term for the phenomenon to the use of texts once again, the problem is to “secure uptake.”

1.5.1 Perceiving Textual Acts and the Issue of Interpretation

To introduce the problem and argue a solution, Keller relies on a corpus of five key texts, selected from Sanskrit mathematical texts composed between the fifth and presumably the twelfth century.²⁸ The composition method of the corpus is similar to that used by Bretelle-Establet in her study of the variety of Chinese medical texts from Southern China. The five key texts for Keller all deal with square root

²⁸ This is a coarse presentation. The reader will find in the chapter more precise information about the corpus.

extraction and even with the same algorithm to perform this operation.²⁹ The key point is that the textual contexts they belong to differ. Two of these texts are found in versified treatises, whereas the three others were composed as part of prose commentaries on these treatises. In addition, the first treatise, the *Aryabhatiya*, completed by Aryabhata at the end of the fifth century, is a theoretical astronomical book that devotes one of its four chapters to mathematics. In fact, many Sanskrit mathematical sources are chapters in astronomical treatises. By contrast, the *Patiganita*, composed by Sridhara in around the tenth century, is a book entirely devoted to mathematics and is presented as dealing with “practical mathematics.”³⁰ Two of the commentaries analyzed by Keller in Chap. 5 bear on the *Aryabhatiya*. They are the seventh-century commentary written by Bhaskara I, and the twelfth-century commentary by Suryadeva Yajvan. The third, whose author and dating are both unknown, bears on the *Patiganita*.

We shall now focus on the case of the *Aryabhatiya* to explain the problem Keller tackles in Chap. 5. The treatise, like all those of the same type, is composed of *sutras* (rules) formulated in verses. Aryabhata devotes a single verse to square root extraction. The question is: what does the verse say on the topic? We don’t know the context in which the book was written. We have no evidence as to how Aryabhata intended his verses to be read or how readers at that time understood them. However, there are two commentators, and their reply to the question is unanimous. In their opinion, Aryabhata “states a square root computation.” He provides a text to enable readers to compute square roots. In our terms, the textual act carried out by Aryabhata’s verse is a directive.

The next question is: how does he carry out this textual act? In fact, we can establish the algorithm that is the subject of the *sutra*. Keller’s Fig. 5.2 summarizes its thirteen or fourteen steps. If we observe Aryabhata’s verse, “stating the computation,” we can’t help being surprised. To elucidate this, we shall outline its content against the backdrop of Fig. 5.2, p. 187. In our view, the verse does not state the point of the computation. It contains no explicit indication as to where the procedure should begin or end. It provides no description of the analysis of the decimal expansion of a number according to a place-value system, on which the algorithm essentially relies. Indeed, key to the formulation of the *sutra*—and to the algorithm—is the opposition between “square places” and “non-square places,” which is used without prior explanation.

Finally, the verse has two parts. We shall quote them here to convince the reader that their interpretation is by no means obvious.³¹ The verse’s first half performs two directives, one directly, one indirectly. It reads: “One should divide, repeatedly, the non-square [place] by twice the square-root.” This corresponds to step 10 in Fig. 5.2. The second half contains an assertive regarding

²⁹ In fact, it is the same algorithm up to details that do not matter for the questions Keller addresses.

³⁰ The real meaning of this category is beyond the scope of the present discussion, but Keller’s description of the text in the *Patiganita* devoted to square root extraction offers elements for discussing this issue.

³¹ In her chapter, Keller explains in detail how the commentators make sense of these statements.

the status of partial results and, indirectly, another directive. It reads: “When the square has been subtracted from the square [place], the result is a root in a different place,” which corresponds to step 5 in Fig. 5.2. Incidentally, we depend on the commentators to understand that the various occurrences of the term “square” in the verse sometimes mean the square of a value, and sometimes the name of positions in a decimal expansion—namely positions corresponding to powers of ten that are squares.

Clearly, if we rely on how we handle texts for algorithms nowadays, there is no way we could learn to carry out a root extraction on the basis of this cryptic text. Many of the steps made explicit in Fig. 5.2 seem to have been skipped. Keller captures the problem in its widest form when she identifies the “paradox of *sutras* which both prescribe and are cryptic.” How did users understand what to do with the text and which actions did they derive from studying it? These are the first questions raised. However, their elliptical nature is not the only odd feature of these texts. Another key feature illuminates the fact that the text does not conform to our expectations with respect to ways of writing algorithms. As we have noted above, the first part of the verse refers to step 10, whereas the second refers to step 5. In other words, the text inverts the order of the only steps it mentions in the process of root extraction. To summarize, the text not only fails to formulate all the steps of the computation, but also lists those that are mentioned in an order that doesn’t seem appropriate for action.

1.5.2 Observing Actors’ Reading as a Key to the Identification of a Textual Act

The key fact is that the commentators fail to express surprise about the order in which the steps are formulated. They also apply reading techniques that illustrate how they derive the intended procedure from the text. The commentators use these techniques to make clear why they read a directive in the text, and they show how they capture this textual act. In other words, in this context they demonstrate how one could do things with this text. Noting which features of the text are meaningful for them and how they make sense of them is an essential task for us in learning to understand textual acts in this context. This brings us to another question: what accounts for our inability to read the directive?

Aryabhata’s *sutra*, as well as Sridhara’s, represent texts whose intention, at least partly, is to enable practitioners to perform computations. As we have seen, this is how commentators have interpreted them. However, none of these texts conform to the expectation historians have spontaneously developed with respect to texts of that kind. Indeed, it is commonly assumed that texts from the ancient world prescribing algorithms are ordered lists of operations practitioners followed step by step to execute a given computation. As Keller notes, this belief evokes the “descriptive fallacy,” exposed by Austin when he coined the notion of speech act. With this, Austin designated the central mistake he aimed at exposing in his William

James Lectures: “the mistake of taking as straightforward statements of fact utterances which are *either* (in interesting non-grammatical ways) nonsensical *or else* intended as something quite different.” (Austin 1962, p. 3). The fallacy Keller’s chapter aims to expose is the idea that a text designed to enable a practitioner to carry out an algorithm must have had the form of a list of operations to be executed in the order in which they are prescribed in the text. Such an assumption caused historians to be bewildered by Sanskrit *sutras* and to propose ad hoc hypotheses to account for *sutras*’ unusual ways of formulating mathematics (see p. 194). The fallacy Austin exposed related to the nature of the speech acts carried out by utterances. The fallacy Keller is interested in relates to the nature of the texts used to carry out the textual act “giving an algorithm.” What she brings to light in Chap. 5 is that algorithms can be given by textual acts of a type we will call “indirect directives.” Just as it was a complex task to identify which utterances can carry out a directive, it appears that the texts used to perform directives sometimes display unexpected features. Describing these ways of performing directives is a tool for reading our sources. It is also an essential means to “secure uptake,” if, as historians, we don’t want to read these sources anachronistically, but aim instead at restoring their authors’ illocutionary point.

The identification of these textual acts doesn’t mean the end of our inquiry. There are still unanswered questions of interest for the project of the present book. Why did Aryabhata and Sridhara choose to state algorithms in this way? In particular, why did Aryabhata choose to invert the order of the two steps he explicitly mentions, with respect to the order in which they occur in an actual computation? Once again, our only documentary resource for addressing these questions, aside from the *sutras* themselves, is provided by the commentaries. These documents of evidence suggest a twofold answer to the questions.

Let us start by considering the inversion. As Keller shows, Bhaskara reads a theoretical statement in Aryabhata’s promotion of the division that occurs in step 10 of the algorithm at the beginning of his *sutra*, as well as in other related syntactical features. The inversion thus relates to another dimension of the act the text carries out. This fact illustrates how closely we have to read the sources if we want to identify the full dimensions of the textual acts. More generally, Bhaskara’s commentary suggests that *at the same time* as Aryabhata refers to the algorithm in a way that allows the commentator to grasp it, he formulates a view on what constitutes the gist and inner structure of the algorithm.³² According to this reading, the order Aryabhata formulates appears not to be the order of actions to be performed, but of a hierarchy of operations in root extraction—a hierarchy that distinct kinds of verbal forms express. In other words, what accounts for the way of formulating and organizing knowledge in the *sutra* is the fact that it carries out a combination of two textual acts, both indirectly: an assertive at the same time as a directive. The assertions that the *sutra* makes about the algorithm can be correlated with the genre of the treatise in which it occurs. The nature of the *sutra* reflects that we are in the context of a “theoretical treatise.” Keller is able to show

³² Incidentally, the steps his *sutra* propounds are entirely general and constitute the kernel of the computation without specifying any instrument that could be used to execute it.

in which respects a contrast can be established on these points with Sridhara's *sutra* and its commentary.

The conciseness of Aryabhata's—and Sridhara's—statement of the algorithm is a second specific feature that particularly interests us. It expresses more broadly the genre of the treatise to which the *Aryabhatiya*—and the *Patiganita*—belonged, and the constraints affecting the formulation of the *sutras* they contain.³³ In relation to their formulation, *sutras* were supposed to be maximally compact without a trace of redundancy. As for their meaning, commentators like Bhaskara expected to find in them the seed that exegesis had to develop to capture the meaning of the “written utterance.” In other words, readers such as Bhaskara approached these texts with assumptions as to how these texts were making sense. Note that both compacting and unpacking required literary as well as mathematical knowledge. In this context, conciseness also reflects how *sutras* were brought into play: to be used, they were supposed to be appropriated with the help of a commentary and memorized. In this context, the *sutra* cited above was most probably meant to allow the user, who had memorized and studied it with the help of commentaries, to unfold all its layers of meaning when needed. This implies the combination of directive and assertive that we have shown was carried out by means of a text that displayed features and required action, both specific to the scholarly culture in which this form of communication developed. This is especially striking when we work with ancient sources handed down from the Indian subcontinent. However, it holds true as general rule. To confirm this, it suffices to mention the “nomenclatural acts” described by Yves Cambefort. The texts by means of which these acts are carried out were also written in the context of a scholarly culture that shaped ways of composing them. The interpretation of these texts requires that we inscribe them in the textual culture they belong to. This is supported by other illustrations presented below. All these cases show the importance of the background for the way discourse acts are carried out and for their uptake. This conclusion concurs fully with Searle's analysis of a discourse act.

1.6 Enumerations: A Key Textual Act in Scholarly Texts

So far in the present book, we have considered “textual acts” of a type comparable to the “speech acts,” identified in Searle's taxonomy. To recapitulate, we have encountered assertives, directives, declaratives and commissives. However, there are other types of “textual acts” which are more specific to the level of the text, even though they are not limited to that level. We shall elucidate this claim by considering the textual object “enumeration,” and the acts that can be carried out by means of it. Part II of the book focuses on that type of textual act and the issues it raises. Jacques Virbel introduces this part of the book with a chapter devoted to a lin-

³³ Keller (2006, pp. I:xvii, xliii–xlvi) gives an overview of Aryabhata's *sutras* and describes Bhaskara's exegetical techniques to make sense of them. The following remarks rely on that reference.

guistic analysis of “textual enumerations,” illustrated by numerous examples. As in Part I, this introductory chapter provides the main tools required for the subsequent chapters.

1.6.1 *Defining Enumerations*

We already encountered an example of enumeration in our discussion on Cambeport’s contribution to the book. In this case, the enumeration was clearly not limited to the framework of a sentence, but was composed of multiple phrases (see Fig. 1.1). Moreover, we then sketched how a directive was carried out through the enumeration. As Virbel explains, this fact is typical of the way enumerations can be combined with all types of discourse acts. More generally, enumerations are frequently found in scholarly texts, not least in instructional texts. The types of questions they raise include: Why do authors choose the form of an enumeration? Which kinds of textual act do enumerations perform? Which purpose do they fulfill? How are enumerations materialized in different sources? As we will see, consideration of their properties and purposes brings to light interesting features of our sources and opens fruitful domains of inquiry for History of Science.

In Chap. 6, Virbel begins by introducing criteria that can be used to define enumerations. In the subsequent chapters, these criteria play an essential role in the investigation of enumerations in scholarly texts. We shall mention some of them here, for the purposes of our discussion. The key criterion is, not surprisingly, that an enumeration contains a list of items, the items that are enumerated. From our perspective, what distinguishes lists from enumerations, or from other forms of enumeration, is the fact that lists simply contain items and nothing else. As Virbel emphasizes, this is where the range of enumerations could begin. The exact place at which we decide to cut into the continuum of similar textual phenomena to single out enumerations is merely a matter of convention.

Unlike lists, enumerations can contain other components. The set of items can be introduced by an initial phrase. Sometimes the initial phrase includes a classifier (also called a “hypernym,” or “organizer”) which makes the nature of the items listed explicit (e.g., the term “point” in the initial phrase, “here are the *points* characterizing an enumeration...”). Sometimes this phrase also indicates the number of items listed (e.g., the expression “four parts” in the sentence, “here are the four parts that make up Chap. 6 by Virbel...”).³⁴ The set of items can also be concluded by a final phrase governed by the same options. An example is given below. Virbel analyzes the various features these elements can display in enumerations, focusing particularly on the markers that signal the presence of an enumeration, its beginning or the beginning of the items, and its end or the end of the items.

³⁴ In fact, the expression we took as an example for designating the items in the initial phrase should be quoted more precisely as “the four parts.” Expressions of this kind may or may not assert the exhaustive character of the listed items. Virbel examines these assertives. Using examples found in classical texts, he shows that the statement of exhaustivity does not imply that the actual list of items corresponding to it conforms to it exactly. Interestingly, some lists of items differ from the information given in the initial phrase. Virbel discusses the issue of interpretation this raises.

The markers indicating items include lexical markers (e.g., “firstly,” “secondly,” etc.), symbols (e.g., numbers), signs (e.g., hyphens, indentations) and specific arrangements on the page.³⁵ Some of these markers are specific to modern texts of enumerations. We shall encounter other ways of shaping the texts of enumerations in ancient texts.

In fact, in scholarly texts as the example of Cambefort shows, enumerations that fulfill part or all of these criteria are multi-phrasal events. This indicates that, in addition to sentences, sections or paragraphs, texts have other types of components, and some of these go beyond the limits of sentences. Consequently, as Virbel suggests, the study of enumerations is one step towards an inquiry into the textual objects that can enter into the constitution of texts. It is to be hoped that the description and analysis provided here can contribute to the development of such a line of research.

Looking at the various methods of writing down enumerations reveals another theoretical option that is essential to how Virbel approaches enumerations. As we indicated briefly above, enumerations can take the form of fully developed “discursive formulations” in which the items are lexically marked (e.g., firstly, secondly...). However, they can also be textualized by means of “visual properties,” including the use of typographical and dispositional markers that express their structure and characterize their spatial inscription on the surface of the written texts. Virbel considers both types of formulations as linked by means of linguistic transformations, and approaches the visual properties within his chosen theoretical framework, as the reduction of discursive formulations. The result is that the visual dimension of the texts of enumerations—and, in fact, of texts in general—is considered meaningful, and its study belongs within the same logico-linguistic description as other dimensions of the text.³⁶ In this context the choice of a spatial inscription of a text, whether an enumeration or not, is a textual act of a metalinguistic kind: it can be seen as a declarative, which brings out structural features in the text. In fact, reflections of the theoretical option outlined here can be found more generally in the present book.

1.6.2 Enumerations as Textual Acts

After an exploration of the syntactic features of enumerations based on the theoretical options summarized above, Virbel discusses semantic aspects of enumerations. The method he follows is similar to that deployed for the act of “giving instructions” we outlined in Sect. 1.2 of this introduction. The act of enumerating is approached through an analysis of its relation to verbs that name similar acts. These verbs can be classified into several groups. Linking “enumerating” with these groups highlights the various dimensions of meaning of the term: an enumeration forms categories, making them into a group and connecting the related items. These conclusions emphasize an essential fact that characterizes enumerations in

³⁵ In his study of “quotation,” Vernant (2005) sketches the various ways “quotations” can be marked.

³⁶ This is an option that derives from the Textual Architectural Model to which Virbel subscribes and which he sketches in Chap. 6.

contrast to other related acts. Most importantly, as Virbel emphasizes, enumerating requires cognitive operations to be carried out and additionally makes other cognitive operations possible. These two issues are crucial for the History of Science. They also provide a foundation for Virbel's analysis of the logical features of "enumerations."

The final section of Chap. 6 is devoted to pragmatic features of "enumerations." The first point to note derives from reexamining the shopping list example. As evidenced by this example, the syntactic and semantic features of an enumeration are not sufficient to grasp the illocutionary force of the textual act carried out through the enumeration. This simple fact illustrates why a pragmatic approach to texts is absolutely indispensable. In Virbel's words, to secure uptake we must have "knowledge of the history of the document." We will have to examine how this can be understood in the case of scholarly documents.

More generally, one of Virbel's key remarks with respect to "enumerating" as an act is that it is a textual act that can be combined with any other act because "it allows any type of illocutionary act *to be performed in a particular way*." (Virbel's emphasis) We have already seen an example of this phenomenon with the enumeration quoted in Cambefort's example.³⁷ This derives from the fact that "enumerating" like "quoting," constitutes a discursive meta-act. Virbel goes one step further and highlights specificities of this meta-act. He emphasizes that one key dimension of the illocutionary point of such an act is to divide a matter into items and perform the co-enumerability of the items. From this perspective, we can see "enumerating" carries out a declarative. This feature of "co-enumerability" is essential to account for important facts that Virbel uncovers in his empirical study of enumerations. On the one hand, enumerations found in written sources are not always merely coordinating items: other types of relationship between items are shown to exist. On the other hand, the items enumerated are not always similar in form. We shall encounter examples of these phenomena below. The motivation for carrying out this meta-act can be to help the reader perform cognitive operations on the text that is materialized in this way. Once again, the enumeration quoted in Cambefort's chapter illustrates this point immediately. Another dimension that appears and will prove worthy of exploration is the assertion some enumerations carry out with respect to the items listed. Seen from the perspective of scholarly documents, enumerations are clues to intellectual acts that authors perform on their own discursive production. What do these clues tell us about their cognitive work? Why and how do actors enumerate? These are the key questions we will now address to evoke results that can be obtained in the History of Science by observing these acts as such.

³⁷ With respect to Austin's "expositives," which can relate to all types of discourse acts, Vernant (2005) suggests a similar conclusion.

1.7 The Production of Enumerations and their Interpretation

1.7.1 *Identifying Enumerations: A Key for Interpreting Ancient Documents*

The distinction between lists and enumerations introduced by Virbel is essential for the new interpretation that Michel Teboul offers in the present book for the meaning of the oldest dictionary of Chinese characters that has come down to us: the *Erya* or *Approaching Perfection*, which is dated to the third century BCE.

The *Erya* deals with Chinese characters entirely differently from the approach developed in the subsequent dictionary, *Shuowen jiezi*, completed by Xu Shen around 100 CE. The latter treats characters on the basis of a graphic analysis of the writing. In the *Erya*, the point is to elucidate the characters' meaning by listing them with characters of related meaning. Evidence for the connection between the meanings of these characters derives from earlier commentaries on the Classics. As a result, the nineteen extant chapters of the dictionary are composed of what has been interpreted until recently as lists of characters of related meanings. Each entry simply appears to give, successively, characters that are all positioned at the same level and semantically close to each other. This is the meaning of the term "list," that is used to refer to them. Often concluded by the character *ye* 也, which marks their end, these lists have been referred to as "semantic lists."

Briefly, the dictionary is a book merely made of lists, or of what has been understood as lists up until now. Consequently, understanding what is at stake with these "lists" is a central issue for its interpretation. The key questions Teboul addresses to the original text are simple: what is the format of these lists and what is the underlying structure of the dictionary? The main observation that enables him to offer a new answer to these questions is that the role of the last character in a "list"—the one placed right before the particle *ye* mentioned above—is not symmetrical to that of the other characters in the items sequence. This is an initial indication that the items listed are not all placed at the same level, or, in other words, are not all co-enumerable. But there is more to come.

This observation leads Teboul to discover that the sequence of characters is not a mere list, but an enumeration, in which the last character actually plays the part of the "classifier" or "hypernym." Accordingly, this character is not on the same level as the others, and, in fact, its function is wholly different. In other words, we have a dictionary composed not of lists, as scholars previously believed, but of enumerations. More precisely, Teboul establishes that each entry has a "headword"—in this case, we should rather say, a "tailword." And the characters listed before this "tailword" are, in fact, stated to fall equally under the scope of the "tailword." They are "types in the category of" tailword and, unlike the "tailword," they only are co-enumerable. The structure that proves to account for the meaning of each entry is thus entirely different from a list of items with equal status.

That result enables Teboul to offer a new interpretation of each enumeration and of the whole book as well. This illustrates the importance of focusing on enumerations as textual phenomena to deal with scholarly sources. Indeed, some authors notably opted for enumerations as a key mode of writing down knowledge. Here moreover, we have a clear-cut case in which a reflection on the structure of enumerations effects a shift in the interpretation of a book. Given the importance of this dictionary for the interpretation of the Chinese classics, the impact of Teboul's discovery shouldn't be underestimated. Yet it would remain mere speculation if there were no historical evidence supporting it. Teboul accounts for the validity of this new interpretation by providing evidence he found in the ancient commentaries on the *Erya*. The interpretation Teboul advances thus elucidates the structure of the dictionary and the meaning of its constituents. In doing so, it reveals more clearly how the book can be useful to researchers. It also clarifies the work carried out by the authors to produce enumerations. In our terms, the interpretation indicates how the dictionary's compilers carried out their lexicographic activity with texts. It reveals the work required to perform the act of enumerating.

Teboul can, in fact, take this one step further. In the case under consideration, enumerations are a method the dictionary employs to express relationships of meaning. In addition, Teboul goes on to suggest that the order in which items were arranged in each enumeration is meaningful. Incidentally, this observation offers an illustration of a remark Virbel made in Chap. 6 in his discussion of the "logical aspects of enumerations." Virbel addressed the issue of the "conditions of identity" of an enumeration and, in particular, raised the question of the role of the order of the items in the identification of the enumeration. With Teboul's interpretation of the *Erya*, we have a clear example in which the order of the items does, indeed, contribute to the identity of the enumerations and therefore to the meaning of the text. Last but not least, this new reading allows Teboul to offer solutions for vexed questions related to the *Erya*.

In this latter case, focusing on enumerations leads to a fresh interpretation of a classical work whose text lists enumerations. In the succeeding chapter, which is also devoted to ancient documents, examining enumerations illuminates the work done by actors to produce and read enumerations. It offers us a case in which the enumeration is at the level of the whole text.

1.7.2 Writing Enumerations: An Encounter with Complex Textual Acts

Chapter 8, written by Christine Proust, is devoted to an extraordinarily complex and remarkable enumeration recorded in cuneiform mathematical sources. The enumeration occurs in the context of specific types of texts called "series texts," which are characterized by the fact that, unlike many texts that fit onto a single tablet, they are usually recorded on dozens of tablets. Although no mathematical series text has survived in its entirety, colophons found in tablets belonging to series indicate the

number of the tablet in the series. These numbers therefore provide information on the length of the series.

Several tablets belonging to mathematical series have survived. They all contain lists of statements of problems without recording any procedure for solving them. As far as mathematical writings are concerned, this characteristic distinguishes this type of text from “procedure texts” in which the statement of a problem is followed by a text of a procedure for solving this problem. Proust suggests that this may explain why historians interested in understanding the resolution methods to which cuneiform tablets bear witness have so far paid less attention to series texts than to texts dealing with solutions of problems.

The tablet on which Proust mainly focuses in Chap. 8, Tablet A 24194, is kept in Chicago. Discovered in illegal excavations, its origin and date are unknown, even though we may assume it was composed in the first half of the second millennium BCE. Series texts are characterized by their conciseness; however, in comparison, tablet A 24194 is extremely concise. This is easily seen by the fact that it records more or less 240 statements of problems on the obverse and reverse of a square tablet where each side measures roughly 10 cm (see the copy of the tablet in Appendix 1 of Chap. 8.) The question such tablets raise, and which is posed even more sharply by Tablet A 24194, is simple: what was the purpose of writing down these texts? Scholars like Neugebauer who studied them thought they were a repository of problems collected by teachers as a teaching aid. Proust convincingly argues that this interpretation scarcely matches the evidence contained in the tablet. Her own tentative answer to the question derives from a close analysis of Tablet A 24194. Let us consider some of its features.

In addition to recording a tablet number, the colophon of Tablet A 24194 says it contains 240 “sections.” These sections are inscribed on the surface of the tablet in the form of boxes bounded by horizontal and vertical lines. The vertical lines define the columns that divide each face of the tablet, and the boxes are inscribed in these columns. They are separated from each other by horizontal lines drawn inside the columns. Proust points out that there are three sizes for the boxes containing sections: long, medium and short. Roughly speaking, the number of sections also corresponds to the number of problems stated on the tablet, with each statement usually recorded in a box. Each problem has the same structure, as far as its meaning is concerned. However, the formulation of the problem statement differs sharply between the boxes due to the compaction techniques used to write down all the items on the surface of the tablet. In other words, 240 similar items are listed on the tablets. They are given material expression by the format. With the descriptive terms introduced by Virbel in Chap. 6, this gives us an enumeration. The colophon, which concludes the tablet, can be considered as the final phrase that states the performance of the enumeration the text carries out.³⁸ In this case, the final phrase includes a classifier that indicates the nature of the items

³⁸ The tablet could also be considered as an item in itself in the enumeration that the series constitutes. However, we lack the evidence about this series to develop this line of inquiry.

listed according to the scribe of the text. It also indicates the number of items listed.

The interesting issue Proust addresses is to find evidence that could allow us to understand the work done to perform and textualize the enumeration. In this case, the scribe who wrote on the tablet didn't use indentation or punctuation. Nevertheless, many elements were brought into play, or even specially designed, to format the text of the enumeration physically, and these are precisely what Proust focuses on.

To begin with, a type of statement was shaped that allowed elision as well as classification. Proust distinguishes four levels to characterize the structure of problem statements. Each problem is stated in two sentences. Level 4 corresponds to the first sentence and is common to all problems whose statement is recorded on Tablet A 24194. This first sentence probably changed from one tablet to the next in the series. In the case of Tablet A 24194, it is stated at the beginning of the tablet and then elided throughout. This is the first example of an elision of something common to a set of items. The whole tablet makes systematic use of this resource.

Distinguishing between levels 3 to 1 allows Proust to describe the formulation of the second sentence that concludes the problem statement. We shall now describe the content of these second sentences and the organization of their enumeration. Level 3 corresponds to the formulation of a main expression P , level 2 to the formulation of a secondary expression S , and level 1 to the statement of a relationship linking P and S that constitutes the second sentence of the problem statement. This relationship is formulated by means of operations bearing on P and then on the result of the latter and S . Proust gives the details in Chap. 8; here we shall merely note the result that the second sentence of a problem statement has the following structure: P — S —relationship R . This is true both of its meaning and its syntax. It is on this basis that the actors can render the enumeration recorded in Tablet A 24194 in the form of a tree, similarly to the case in Cambefort's chapter (see Fig. 1.2, which shows a modern version of the tree; we shall describe below how it was realized on the tablet). The enumeration first leaves P and S unchanged, and changes the relationship sequentially with each successive item. It can thus be represented as P_1 — S_1 — R_1 , P_1 — S_1 — R_2 , P_1 — S_1 — R_3 ,.... Let us call such a set of items a sub-enumeration at the level of "leaves." Then, after the end of this sub-enumeration, P is kept unchanged, S is changed in the next item, and then again a sequence of items is listed in which only the relationship is modified from one item to the next one. We thus have a second sub-enumeration at the level of leaves (roughly speaking, it can be represented as P_1 — S_2 — R_1 , P_1 — S_2 — R_2 , P_1 — S_2 — R_3 ,....). A key feature, to which we shall return, is that the list of changes of the relationship is more or less the same from one sub-enumeration at the level of leaves to the next. Observed at this level, the text enumerates several sub-enumerations at the level of leaves (if we separate the sub-enumerations by a semicolon we can represent the items as: P_1 — S_1 — R_1 , P_1 — S_1 — R_2 , P_1 — S_1 — R_3 ,....; P_1 — S_2 — R_1 , P_1 — S_2 — R_2 , P_1 — S_2 — R_3 ,....) Let us call these higher-level enumerations "sub-enumerations at the level of lower nodes." Each of their items is a sub-enumeration at the level of leaves. At the end

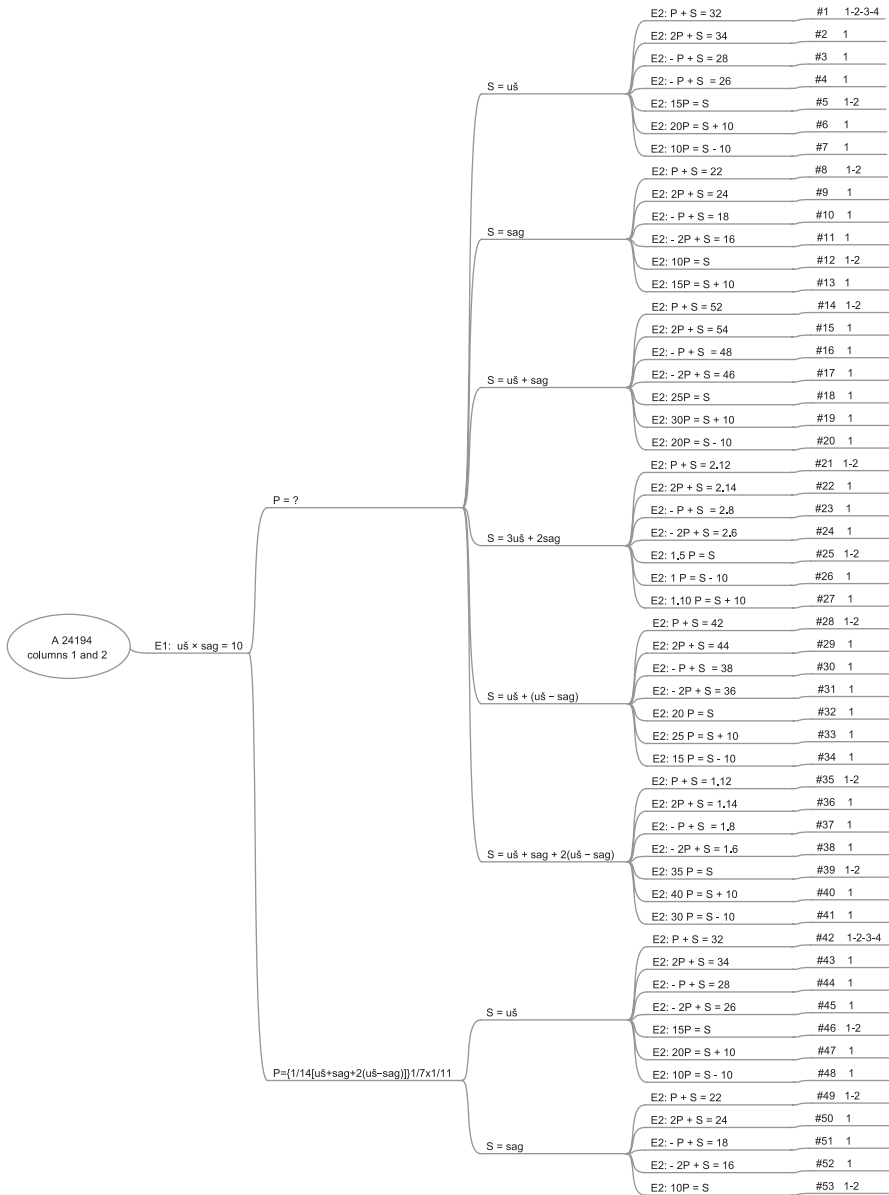


Fig. 1.2 The structure of the enumeration examined in Chap. 8 by Christine Proust

of this higher-level enumeration, P is changed, and with this new P, the text deploys again a “sub-enumeration at the level of lower nodes” (roughly speaking, we have: $P_1-S_1-R_1$, $P_1-S_1-R_2$, ...; $P_1-S_2-R_1$, $P_1-S_2-R_2$, ...; $P_2-S_1-R_1$, $P_2-S_1-R_2$) Clearly, this tablet holds a set of items whose content forms a sequence of embedded enumerations, while the whole tablet displays an “enumeration at the level of higher nodes.”

1.7.3 *Methods and Reasons for Enumeration*

As we have seen, all the problem statements found in Tablet A 24194 have exactly the same structure. We emphasized above that the syntax of the second sentences of all the problems has the same structure as its content: it is formulated as: P–S–relationship R. This parallel between the meaning and the syntax of the sentence enables the system of elision to which Tablet A 24194 attests to work. Let us now move from considering the content of the items and their organization to considering how items are realized and the enumeration as a whole textualized. We are moving from the act of enumerating to the act of shaping the text of the enumeration. At this point the parallel with the enumeration cited by Cambefort breaks down.

In the textualization of the sub-enumerations at the level of leaves, P and S are elided if we omit the first item, which states the expression of S for all the others. In the other items, only the relationship is stated. Consequently, if we look at the second sub-enumeration at the level of leaves, the text looks like this: S_2-R_1 , R_2 , R_3 ,.... The last two items appear in the short sections. By contrast, the first items of these sub-enumerations are in medium-sized sections, in which P is elided, but S stated. As for sub-enumerations at the level of lower nodes, their first item, in which P and S are modified, are both stated. We are in the long sections (see, for example, the first item in the sub-enumeration $P_1-S_1-R_1$, R_2 , R_3 ,....). We can see how the structure shaped for the statement of a problem closely correlates with the way the enumeration is materially formatted and information is distributed between boxes. In addition, Proust establishes how the expression selected at each level for the operations makes the whole system of formulation possible. Again, we have a correlation between local syntactic choices and the structure of the whole. In conclusion, all items recorded in boxes are strictly of the same form as regards their content. However, the sentences formulating them differ according to their position in the enumeration. This point illustrates a key feature of enumerations that Virbel insisted on: the items enumerated are not always similar in form.

This means that a type of statement was specifically created for these enumerations, while at the same time a type of text was shaped to textualize the enumeration. These two developments are interrelated. This is interesting in itself for the History of Science. But what does the foregoing analysis tell us about why and how the enumeration was produced? A first hypothesis could be that this type of text was used to classify problem statements that existed prior to the enumeration. However,

that seems rather unlikely. The existence of similar lists of variations of the relationship that concludes the statement (R_1, R_2, R_3, \dots) in subsequent sub-enumerations seems to indicate that the enumeration does not record pre-existing problems. On the contrary, the text of the enumeration appears to have provided a framework for systematic production of problems statements. The form of the text was a tool for producing the enumeration, that is, its text as well as the items enumerated. This observation raises the issue of the knowledge needed to produce the enumeration. We have seen that it required knowledge about syntax of operations and forms of texts. Proust also emphasizes the mathematical knowledge needed to produce the items, as well as the textual competence to inscribe them in the tablet.

As concerns the purpose of producing the enumeration, Proust observes something that leads her to question the validity of Neugebauer's hypothesis. The "procedure texts" that have come down to us record only few problems of the type enumerated in Tablet A 24194, and these are only some of the simplest ones. It seems unlikely that the enumeration's goal was to provide teaching material. It would probably make sense to look for the enumeration's aim in the effort that led to the author writing it, that is, in the production of a set of statements that could be textualized in this highly skilled way. In this context extreme conciseness appears to be a key feature. On the one hand, it singles out Tablet A 24194 from similar tablets. On the other hand, Proust finds clues indicating that the scribe who wrote down the tablet actually placed great value on conciseness. In addition, most of the tablet's features that Proust highlights can be related to the ambition of utmost conciseness: the syntax chosen for the statement, the system of elision, and the principle of the text. If we assume that the purpose of creating the inscribed tablet is related to the attempt to achieve conciseness, then the production of the enumeration appears to have been an end in itself. In any case, it is an important feature of the knowledge that this tablet attests.

These conclusions reveal various facets of the knowledge required to carry out the meta-act of enumerating. They reveal the effort needed for the production of the text as such. This is what actors, i.e., scribes, do using texts. However, we can also look at the tablet from another viewpoint: the reader's. The reading of the enumeration also required various types of competency and knowledge, and the challenge it posed to readers was perhaps one of the driving forces behind the display of virtuosity the enumeration shows. Proust also considers the knowledge readers needed to possess to grasp an item of the enumeration, once these items were realized in their respective boxes. In addition to mathematical knowledge, which could be used to control the reading, the user of such a text couldn't do without some knowledge of the principles by which the enumeration was physically formatted. Nor could readers ignore the kind of circulation within the text required to grasp the statement of a recorded problem, e.g., in a short section. This remark brings us back to the issue of the kind of circulation within a text actors need familiarity with to make proper use of technical texts. Various types of competency of that sort are also discussed in the next chapter.

1.8 One Enumeration can Conceal Another: Strange Texts for Directives

Chapter 9 combines the tools of Speech Act Theory and the description of enumerations to examine texts used to write down algorithms. This brings us back to textual acts of a directive type—even more precisely, to instructional texts.³⁹ The exploration is carried out using texts for algorithms from Chinese writings composed between the second century BCE and the seventh century CE. As we shall see here, the issue of how directives are performed, on the one hand, and of enumerating on the other, are intertwined in an original way.

The sources considered include a manuscript excavated from a tomb sealed in the second century BCE, and documents handed down through the written tradition. Two classics are examined: *The Nine Chapters on Mathematical Procedures* (hereafter: *The Nine Chapters*), probably completed in the first century CE, and the *Mathematical Classic by Zhang Qiujian*, which dates approximately from the second half of the fifth century. Two commentaries on these classics are also useful: the commentary on *The Nine Chapters* Liu Hui completed in 263 and the commentary Li Chunfeng completed in 656 on the *Mathematical Classic by Zhang Qiujian*.⁴⁰ In effect, Chemla focuses on algorithms recorded in these sources that mostly deal with the multiplication and division between quantities combining integers and fractions. The key fact is that these documents contain different kinds of texts prescribing the same actions—i.e., the same operations to be done. One of the main aims of Chap. 9 is to understand what accounts for the differences between them.

We have already alluded to the shortcomings of the standard view about ancient texts for algorithms. This holds that texts of this kind allegedly list terms directly referring to operations in the order in which a practitioner should execute them. In other words, such texts would display a simple one-to-one correspondence between terms for operations and actions. In the case of Sanskrit sources, as we have seen, this representation did not match the facts. In particular, we showed then that the textual directives that texts for algorithms carried out in Sanskrit treatises were by no means simple combinations of discourse directives.

Chemla also shows that the widespread conception of texts for algorithms is a poor representation of the reality of texts in ancient Chinese sources. She describes how some of the textual acts of the directive type to which these sources attest are not merely combinations of discourse acts. This conclusion is a strong argument for the need to consider textual acts as such. However, this conclusion imposes itself on the basis of the Chinese material in a specific way. In Chap. 9, Chemla reveals two essential reasons why the reality of texts for algorithms is much less simple than

³⁹ In fact, Chemla focuses specifically on how these texts prescribe actions. However, texts for algorithms also occur in the context of proofs, where they do not carry out textual directives. Once the former issue is dealt with, it will be interesting to focus on the texts of algorithms that occur in the latter context.

⁴⁰ Again, these are broad descriptions. For more detail, we refer the reader to Chemla's chapter.

posited by the standard view. One of these reasons relates to how “written utterances” carry out directives. We shall now proceed to outline it.

1.8.1 Different Ways of Prescribing the Same Operations

The texts of algorithms Chemla considers usually start with the stereotyped phrase, “the procedure says...” This is followed by an apparently ordinary list of operations. In most cases, however, appearances are misleading. Despite this, one feature of the list conforms to an important property of enumerations identified by Virbel: the granularity of the items is more or less uniform. In other words, the flow of actions to which these texts refer was divided into operations of approximately the same “size.” This corresponds to what Virbel called the “co-enumerability” of the items.

To begin with, Chemla leaves the text as a whole aside, and focuses on its items, that is, the discourse acts of the directive type which the text of an algorithm uses to prescribe operations (in Virbel’s terms, the thing in the world to which the item corresponds). Indeed, the modes of prescription of the same operation show an unexpected variety.

One would spontaneously assume that operations are prescribed by means of a term referring to them, such as “multiply.” This is, in fact, only one of many different ways of prescribing. Chemla shows that even this simple prescription can be less straightforward than it seems. In addition, we can identify several indirect ways of carrying out the directives. For instance, multiplication is sometimes prescribed by asserting the result to be obtained. We can also find—and this is the most interesting phenomenon for us—operations prescribed by the reasons for carrying out the operation.⁴¹

It is interesting to consider the competence the reader needs to understand such prescriptions. On the one hand, he or she needs to understand the mathematical situation in which such a discourse act is performed in a way that allows the directive to make sense. This implies that the comprehension of the situation is not merely an understanding of the values obtained, but also of their meaning. Consequently, encountering such directives in texts highlights cognitive operations performed by the successful users of these texts. On the other hand, readers need to understand the reasons stated. This is the meaning of the utterance, if it was carried out directly, and corresponds to Austin’s “understanding;” but the nature of this “understanding” calls for analysis. The meaning corresponding to the “propositional content” of the prescription in such cases is part of a proof of why the procedure is correct. Lastly, to secure “uptake” the user must know how to determine the actual operations corresponding to these reasons. This outline analysis indicates how interesting it would be to examine Austin’s opposition between “understanding” and “uptake” in the context of texts for algorithms more closely. In the last type of case examined, as in

⁴¹ At the level of the reasons of the correctness of an algorithm, this way of prescribing is comparable to the previous case.

others, there may not be a one-to-one correspondence between the term in the text and the actions in the world.

The indirect mode of prescribing by stating the reasons for performing the operations is interesting for the historian of science in two main respects. Firstly, the fact that directives of that kind are used implies that these algorithms texts refer to the reasons why algorithms are correct at the same time as they prescribe actions to be done. Moreover, only practitioners who understand the algorithm at this level are able to use the text as it is formulated. Secondly, as Chemla brings to light, the *ways* in which reasons are stated in algorithms texts seems to have undergone a transformation between the second century BCE and the first century CE. In the earliest texts, the reasons are expressed at a material level, whereas later they are grasped formally. This transformation enables us to distinguish between ways in which reasons for the correctness are approached and formulated. Historians have not yet focused on this transformation, which only becomes perceptible if one observes how texts for algorithms carry out indirect directives. This shows the kinds of results we can anticipate by turning our attention to the ways of carrying out discourse acts in our texts.

1.8.2 Different Textual Acts for Algorithms

After exploring the local modes of prescribing evidenced by these Chinese texts for algorithms, Chemla turns to consider the texts as a whole. She identifies two kinds of texts shaped by practitioners for writing down algorithms. This element of analysis accounts for the main differences between texts for algorithms found in Chinese sources.

The first type brings nothing unexpected. The texts list prescriptions in the order in which operations are carried out. The second type of text, recorded between the second century BCE and at least the seventh century CE, is much more surprising. It corresponds to texts able to deal with the various cases to which the algorithm can be applied. The list of operations to be carried out varies according to the case. The text, which integrates the treatment of distinct cases, is formed in such a way that it yields the correct list of actions for each of the cases.

As Chemla shows, the mode of integration seems to have required prior work on the method of handling the different cases. Their treatments were made similar to each other as far as possible. In one instance the list of operations required for case 3 contains that for case 2, which in turn contains that for case 1. However, the integration also required work on the text itself. Chemla shows that such texts have a fairly specific structure. They begin with a list of operations that actually corresponds to a case chosen as fundamental. Then conditions occur in the text, followed by the list of operations to be prefixed to that of the fundamental case to achieve appropriate treatment of the case covered by the condition. In the example above, the text has the following structure: first, operations for case 1; then

condition A, corresponding to case 2, followed by operations to be prefixed to the operations for case 1 to deal with case 2; then condition B, corresponding to case 3 and again followed by operations to be prefixed to the operations for case 1 to deal with case 3.

This type of text requires several remarks. First, clearly, such a text requires the user to carry out a specific circulation within its sentences in order to derive the operations to be performed from the text. This is where we again encounter the issue of circulation in texts, as a textual gesture practitioners had to learn to perform with texts to be able to work efficiently with them. In this context, for the text to provide the correct operations to execute in each case, the practitioner was clearly expected to handle the text, beginning with the conditions, i.e., to start in the middle of the text. The reason for starting from the conditions was to determine whether the actor dealt with case 2, 3 or 1. Using clues found in the texts, Chemla proves that the practitioner was *not* expected first to execute the operations listed at the beginning of the text. This is confirmed by examination of the commentaries. This feature of the text for algorithms is the second main way in which these texts do not conform to the standard view.

The textual artifact just described constitutes the tool used to make a text encompass different lists of operations according to the cases. If historians of science failed to investigate how texts prescribe, the interpretation of those texts would remain tentative and would lack arguments to support them. Moreover, they would miss an entire aspect of the work done by actors to write down these types of texts for algorithms.

Secondly, the way the text is written down determines that the fundamental case should be at the beginning. It is the case to which all the other cases will be reduced. The text organizes the arrangement of the cases from the most fundamental to the most complex. In fact, the text carries out an enumeration of a type completely different from the previous kind of texts, and different from the spontaneous assumptions of the standard view about texts as well. Its initial phrase states the fundamental operations, after which the text lists items that are each composed of a condition and the method for extending the list of fundamental operations to cover other cases. This enumeration carries out a textual act of the directive type for all cases. We can see from this how the textual act can't be considered as a mere combination of discourse directives.

This brings us to an unexpected conclusion, and this is where we find the mutual connection of the issues of how directives and enumerations are carried out. The first kind of phenomena revealed, the indirect prescription by means of stating the reasons, seems to occur mainly, if not exclusively, in the second kind of texts for algorithms, that is, the texts covering several different cases. The textual phenomena that require specific competence at local as well as global level to enable exploitation of the texts for algorithms seem to be concentrated in a specific kind of text. These texts were probably more theoretical. They were also more general. Perhaps the two types of texts represent traces of different professional groups that used texts for algorithms in China. Let us leave the question open for the moment. Whatever the case, Chemla's description of texts

for algorithms in the present volume shows how groups of practitioners have shaped textual resources to formulate texts for algorithms and to use them. As this shows, a more systematic inventory of these acts could be of great interest to History of Science.

1.9 How could History of Science Profit from the Study of Enumerations?

Chapter 10, by Anne Robadey, continues our exploration of enumerations, but this time in the context of modern mathematics. Here, the focus shifts to another reason why enumerations can be of interest for historians of science: Robadey aims to highlight how enumerations attest to cognitive processes at play in scientific activity, and may sometimes be the only records to provide specific pieces of historical information.

Robadey concentrates on a corpus of texts that documents the shaping of Henri Poincaré's famous, specific approach to differential equations between 1878 and 1886, at the beginning of his career as mathematician. Poincaré's approach can be characterized by a set of related features. Let us describe some of them to highlight the points of general interest in Robadey's chapter. Poincaré, like some of his predecessors such as Briot and Bouquet, is interested in the definition of functions by differential equations, rather than in the properties of their solutions once they are expressed explicitly. Unlike his predecessors, however, Poincaré approaches them as curves and not as functions. Accordingly, geometry plays an important part in his work. He is also interested in the curves' global properties, and not only in their local behavior. Lastly, he is interested in the set of curves that are solutions, rather than in specific solutions.

Robadey's main focus in Chap. 10 is on Poincaré's major publication on the topic of curves defined by differential equations (the *Mémoire* "Sur les courbes définies par une équation différentielle," published in two successive parts in 1881 and 1882). More precisely, she focuses on the key Chapter II, which is structured as an enumeration. This distinguishes different types of "cases" for what happens to the curves that are solutions of a differential equation at a given point. Let us call this the "master enumeration." Again, in this case, the enumeration is a textual phenomenon which develops at the level of a whole chapter and is thus undoubtedly multi-phrastic. As in the case of Tablet A 24194 described above, the enumeration is actually a set of embedded enumerations. Robadey describes its material format, which makes use of typographical devices (e.g., italics), or dispositional devices (e.g., arranging titles of cases in a specific way). However, the material format doesn't spatially express the entire structure of the enumeration. This, Robadey notes, causes a problem for the interpretation of the last case, whose exact status in the set of embedded enumerations is not wholly clear.

1.9.1 *The Cognitive Work Carried out in Enumerating*

By highlighting a set of features of the enumeration, Robadey is able to show that in its smallest details its structure reflects Poincaré's mathematical approach to the topic.

A first level of the enumeration counterposes ordinary (and common) points that are easy to deal with, to singular points. The key phenomena Robadey points to occur in relation to the sub-enumeration of the latter, that is, in the treatment of particular cases, which is the main concern of Poincaré's Chapter II. The guiding principle of the master enumeration at that level derives from an analytical inquiry into the situation; the key concepts of this are given by a main theorem. However, in alternative enumerations of the same cases, based on the main theorem, Poincaré's moves reveal that he reads two distinct sets of cases there, each explored using a specific geometric approach to the situation. In fact, Robadey highlights Poincaré's recurring use of enumerations as a tool in his research. She also analyzes how Poincaré combines these two types of tools, analytic and geometric, to develop his analysis of the situation in the framework of the master enumeration. In this way, she illustrates the mathematical work and knowledge required for shaping an enumeration and working with it.

Poincaré does not enumerate to advance *a posteriori* an argument that is already available. The enumeration as text materializes Poincaré's actual process of mathematical research. It reflects the cognitive division of the world that Poincaré performs to work out the situation mathematically. At the same time it serves as a basis on which Poincaré carries out new operations, including new enumerations, which play an important role in his research. In other words, the enumeration offers a basis on which further cognitive operations can be carried out.

Lastly, and perhaps more importantly, the enumeration retains a key feature of Poincaré's research procedure. The previous remarks concern the *structure* of Poincaré's enumeration. Robadey then proceeds to focus on the *organization* of the items and Poincaré's specific *view* of them. Poincaré first analyzes three cases of the sub-enumeration, in the context of which he identifies types of "ordinary singular points." Only then does he turn to cases for which he emphasizes a key point: the differential equations in which they occur are *exceptional* compared to the previous cases. Poincaré thus enumerates in a specific way. He does not give equal weight to all particular cases. Rather, he differentiates between them in terms of importance and, in fact, treats particular case types in a hierarchy of decreasing importance. In addition, the word "importance" has here a specific mathematical meaning and refers to an assessment of the "degree of generality" of the phenomena dealt with.

This indicates that, at the same time as Poincaré is enumerating, he is supervising the items listed from a higher viewpoint, in this case a viewpoint that no longer focuses on points but rather assesses the generality of types of differential equations for which such points occur in comparison to other types. The criteria he uses to do this are not explicit. We shall return to this point below. What is important here,

however, is that conducting the enumeration probably provides an essential basis for carrying out the assessment. Mathematical knowledge is again involved not only in the production, but also in the reading of the cases.

The decreasing importance of the cases is also reflected in how Poincaré handles them: the more “particular” the cases, the less developed his treatment is. Here we encounter a phenomenon about enumerations that Virbel emphasizes in Chap. 6: the enumerated items are not always parallel. This is the case here with respect to the things in the world referred to by the items of the enumerations, whereas in the case of Tablet A 24914 it applied to the text of the items.

Robadey shows how the items’ titles, as well as Poincaré’s incidental remarks on the enumeration in the *mémoire* analyzed, or the quotation of the *mémoire*’s results elsewhere, demonstrate Poincaré’s precise awareness of the distinct degrees of generality of the particular cases. This perception, Robadey argues, is the outcome of a specific reflection on generality. Robadey succeeds in illuminating the main lines of this reflection as revealed and embodied by the enumeration. She advances hypotheses as to where Poincaré may have derived inspiration for this.⁴² The essential issue here, as Robadey emphasizes, is that this is precisely what distinguishes Poincaré’s approach from that of his predecessors on whose writings he relied and whose research he continued.⁴³ However, Poincaré offers no explicit development in relation to these degrees of generality. The reflection on generality is not “thematized,” to use a concept introduced by Cavaillès. Were it not for the structure of the enumerations, there would be nothing in Poincaré’s texts on the topic to testify to specific work on, and understanding of, generality and its degrees of differentiation. It is only by means of a careful analysis of the textual act of enumerating that the historian can approach Poincaré’s reflection on generality, a task that Robadey fulfills excellently in Chap. 10.

1.9.2 Studying the Enumeration as a Key Tool for the History of Science

Studying the enumeration has so far revealed the work done by Poincaré to perform the enumeration and specific aspects of his enumerating practice. This enables Robadey to show very important results. In particular, she establishes the key role of the enumeration as such in Poincaré’s successful research strategy.

Firstly, Robadey shows that the whole *mémoire* actually relies on the enumeration carried out in Chapter II. More precisely, to establish his new results, Poincaré needs to focus on a case which is general enough to be meaningful, but leaves aside particular cases that are both intractable and exceptional. The framework he adopts for this is precisely one he can define on the basis of the enumeration examined above. Consequently, the enumeration’s properties as Robadey described them

⁴² Robadey (2006, pp. 70–82).

⁴³ Robadey (2006, pp. 53–70).

prove *essential* for the success of the next step of Poincaré's program.⁴⁴ Examining the structure and organization of the enumerations, in addition to the use Poincaré makes of them, actually gives Robadey powerful tools for capturing a research method of Poincaré's. In fact, she establishes that Poincaré regularly makes use of the same method in several of his research works.⁴⁵ The method can be formulated as follows: Poincaré focuses on what is essential, and, in order to determine what is essential, he relies on enumerations that list items in decreasing degrees of generality. Nowhere does the method seem as visible as in this particular instance. In other words, describing the method in this context yields important clues about Poincaré's way of performing mathematical activity more generally. It also allows historians to find clues about his way of proceeding even when these clues are hardly visible. The textual features of the enumeration in the *mémoire* analyzed above reflect specificities of Poincaré's mathematical practice and provide ways for the historian to approach its operations. The reasons for this are clear. Poincaré uses the act of enumerating as a research tool in a specific way that leaves clues in the text. The text of the enumeration is produced as the result of an exploration of a specific type, which it materializes. Both the structure of the enumeration and the gradation of the items in terms of generality, yield plentiful information about Poincaré's mathematical work.

Secondly, the result of Poincaré relying on the enumeration to define the framework of the general case in which he operates is that his approach embodies rigorous general reasoning. This type of reasoning, Robadey stresses, must be distinguished from what Thomas Hawkins has described as the usual "generic reasoning," which mathematicians such as Cauchy and Weierstrass reacted against.⁴⁶ The enumeration carried out in his Chapter II enables Poincaré to define with great precision the framework he adopts for developing his reasoning. As we have seen, such enumerations and the method of approach they derive from are, in fact, a distinctive and recurring feature of Poincaré's mathematical practice. They are always correlated in a similar way with the use he makes of the enumeration: in distinct mathematical explorations, Poincaré focuses first—and sometimes only—on the essential, which should again be understood as the most general. The enumeration provides the basis for the definition of what is essential.

Lastly, Robadey emphasizes that this way of dealing with particular cases is not only specific to Poincaré, in contrast to his predecessors, but also characterizes Poincaré's approach to differential equations from his earliest writings in 1878 and 1879.⁴⁷ Shaping this approach carried out using the enumeration may well have been a key condition that allowed Poincaré to develop a wholly new and successful approach to differential equations. This leads Robadey to suggest a new periodization for this chapter of the history of differential equations. It awards a decisive role

⁴⁴ Robadey (2006, pp. 84–91).

⁴⁵ Robadey (2006, pp. 91–97).

⁴⁶ See the discussion by (Hawkins 1977b; Hawkins 1977a), as analyzed in (Robadey 2006, pp. 77–82).

⁴⁷ Robadey (2006, pp. 61–70).

to enumerations. These results illustrate clearly how the study of enumerations can provide valuable historical information.

In conclusion, identifying and studying Poincaré's enumeration in Chapter II of his *mémoire* enables Robadey to address key questions: the part played by the shaping of the master enumeration in Poincaré's further work in the *mémoire* under consideration; more generally, the correlation between the novelty of Poincaré's approach with respect to differential equations and the specific approach that enumerations represent; and lastly, a new periodization of the research done on differential equations. Robadey offers a detailed treatment of these questions, illustrating how History of Science could gain immensely from focusing on what our sources document indirectly.

This brings us to the conclusion of Part II. We shall conclude this introduction by outlining the research program inspired by the explorations conducted in this book.

In the case of enumerations, we have considered a textual object and the textual "meta-act" carried out with it, i.e., an act that operates on the text itself and leaves marks of the operations in the text. The results shown by research focused on enumerations could have been anticipated: we have seen evidence of the work carried out by actors using their own texts. This led us to focus not on what actors asserted, but rather on what they did with their own inscriptions. Actors have not merely used writings to set forth results or theories; in the course of their intellectual activities they have struggled with texts and inscriptions. As we have seen in the case of enumerations, concentrating more generally on textual objects and textual acts specific to the level of texts seems to be a way of finding traces of this other facet of actors' engagement with texts. Many textual objects appear equally promising and we intend to explore them in the future. They include titles and definitions, parentheses and parenthetical clauses, footnotes, and quotations, as well as sections actors distinguish in their texts and use to structure their texts.

However, these are not the only benefits that can be expected from such an inquiry. We have seen how reading what our sources document without asserting it proved essential for capturing historical facts not documented in any other way. *How*, and not only *what*, do texts document? This is a key question that our endeavor highlights.

One last important issue emerged from our investigations, and seems promising for the future. As we have seen, specific aspects of carrying out textual acts allowed historians to identify features of the contexts in which these acts were performed. The term "context" has been used here in relation to several layers of phenomena. In some cases it referred to the "immediate" context of production of a text, i.e., its producers, their illocutionary aim and their intended readership. It also included institutions, which we encountered through the rules governing the performance of certain acts. Last, but not least, the scholarly cultures in which textual acts were carried out were shown to leave their mark on the texts and to be rendered perceptible using textual studies. The information on the context that a careful examination of sources provides is highly meaningful for ancient historians, who usually work with only a small number of documents. However, several chapters in the book

indicate that the development of approach methods useful for ancient history can also provide information on features of modern science that are not documented by sources.

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