



ABDUCTIVE REASONING AND SPEECH COMPREHENSION

逆证推理与言语理解

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Preface

Suppose that on a public holiday you are standing in the street in a town that has two bakeries. When you meet me, eating a loaf of bread, you draw the conclusion that at least one of the two bakeries is open. Further, seeing from a distance that one of the two bakeries has its lights on, you believe that this particular bakery is open.

When you reach this conclusion, you are doing abduction. Of course, there may be other possibilities, say, the lights are turned on only for the purpose of cleaning and the bakery is closed. However, you are unlikely to draw such a conclusion because it is not the best explanation in the given situation. The process via which we try to arrive at the best explanation is abduction. In fact, abduction is very important not only in our everyday lives, but in scientific discovery. In medical diagnosis, it is also very important. The method used by detectives in detective stories is also characteristic of abduction.

Abduction is first clearly suggested by Peirce, whose abductive theories have undergone great changes from a reasoning mode to a stage in scientific inquiries. In his early writing "Deduction, Induction and Hypothesis" (1878), Peirce describes the three modes of inference as different syllogistic forms in the context of Aristotle's syllogism. Abduction is reserved for the method of reasoning that leads to truly new findings. It is a method, which, for example, licenses the move from an observation such as "the white beans are on the table" to the fresh inference "these beans come from this bag". This "discovery" is made possible by the introduction of a rule that establishes that an inference such as "the beans in this bag are white" is a plausible and possibly correct abduction.

In Peirce's "Lectures on Pragmatism" (1903), abduction, deduction and induction become interacting aspects with different epistemological functions. According to Peirce, abduction constitutes the "first stage" of scientific inquiries (CP 6. 469, CP refers to "Cooperative Principle") and of any interpretive proces-

ses. Abduction is the process of adopting an explanatory hypothesis (CP 5. 145) and covers two operations: the selection and the formation of plausible hypotheses. As a process of finding premises, it is the basis of interpretive reconstruction of causes and intentions, as well as of inventive construction of theories. Deduction determines the necessary consequences, relying on logical provable coherence between premises and conclusion. Induction is aiming at empirical provable coherence between the premises and experience, in order to derive a probable generalization. Yet, induction only classifies the data (CP 3. 516), while abductive reasoning furnishes the reasoner with a problematic theory explaining the causal relation among the facts. From the abductive suggestion, which synthesizes a multitude of predicates, “deduction can draw a prediction which can be tested by induction” (CP 5. 171). Thinking and reasoning is based on abductive, deductive and inductive inferences, aiming at establishing beliefs, habits, rules and codes.

Motivated by the observation of a surprising fact or an anomaly that disappoints an expectation, abductive reasoning is a strategy of solving problems and discovering relevant premises. It is “inference to the best explanation”. Abductive reasoning has the logical form of an inverse *modus ponens* and is “reasoning backwards” from consequent to antecedent. Therefore, Peirce calls it also “retroductive reasoning” (CP 1. 74). From a logical point of view, reasoning backwards is no valid form of inference. It is conjectural, or presumptive thinking, aiming at matching pragmatic standards of plausibility, guided by the reasoner’s “guessing instinct” (CP 7. 46). However, Peirce claims that abduction is logical inference, because it can be represented in “a perfect definite logical form” (CP 5. 188): “The surprising fact, C, is observed; but if A were true, C would be a matter of course, hence, there is reason to suspect that A is true.” (CP 5. 189)

Hanson (1965: 45) differentiates between two aspects in the rational procedure of hypothesis selection, namely firstly, reasons for accepting a hypothesis, and secondly reasons for entertaining a hypothesis in the first place. While the first point highlights the problem of logical coherence the second stresses the pragmatic relevance.

Peirce describes the evolution of knowledge in analogy to the Darwinian model of evolution. The “selection” of hypotheses is performed by a partly inborn, partly learned “guessing instinct”, which has developed as a part of the universe and is grown during evolution under the influence of its laws. Therefore, Peirce

states that abduction is “nothing but guessing” (CP 7. 219). In order to make “fair guesses”, abductive inference links the reasoner’s “guessing instinct” with the rational “Principle of Economy”, which is the “leading consideration” in abduction (CP 5. 600). The “Economy of Research” aims at maximal plausibility of the hypothesis and at the maximal efficiency of the process of hypothesis formation and hypothesis testing. Therefore, “the simpler hypothesis in the sense of the more facile and natural, the one that instinct suggests, that must be preferred” (CP 6. 477).

Owing to the great changes of Peircean concept of abduction, much confusion has arisen. Therefore, for the sake of clarity, we redefine abduction as a three-fold relation among observation, explanation and background knowledge (BK) in Chapter 2. We hold that abduction is triggered by an observation needing explanation, which, inevitably, involving BK withdrawal and even BK alteration. Abduction is then divided into selective abduction and creative abduction according to whether abduction has brought about any BK changes. Our focus is creative abduction, which is classified into three categories. To be specific, realizing new meanings, resolving anomalies and inconsistencies, and understanding novelities.

Since BK is very important in abduction, Chapter 3 provides a rather detailed introduction to cognitive contexts, serving as the basis for our later discussion. We hold that cognitive contexts and interpretation are interactive. Cognitive contexts, in which background knowledge is an essential part, enable a reasoner to generate relevant expectations for the very interpretive task. On the other hand, interpretation often leads to some changes in a reasoner’s background knowledge and the changed BK, in turn, will provide him with necessary information and help him to generate relevant expectations when he undertakes a new interpretive task.

Chapter 4 expounds how abduction plays a role in pragmatic inference. Two significant inferential models concerning pragmatic inference, namely cooperative principle and conversational implicature, and relevance theory, are discussed and are compared with the logical form of abduction. On the basis of the great similarities between the theories and the logical form, as well as the great importance the Principle of Economy plays in the models, we draw the conclusion that these two theories embody abduction.

Chapter 5 elaborates how the three categories of abduction play a significant part in linguistic interpretation. Some concrete examples are offered to illustrate our point. We, along with Davidson, maintain that the whole process of interpretation can be identified as an abductive transformation from the prior theories into passing theories. Passing theories just refer to the changed BK, which includes BK revision, BK expansion and BK contraction. Chapter 6 gives a brief summary of the gist of the book.

前 言

逆证推理(abductive reasoning)这一术语是由美国符号学家皮尔斯(Peirce)首次明确提出的。他早年区分了三种不同形式的逻辑推理:演绎(deduction)、归纳(induction)和逆证(abduction)。演绎推理的特点是能够维持真理,即给定前提为真,且推理规则运用无误,结论必然为真。然而,演绎并不能推导出新的发现,因为所有的结论都已经蕴含在前提中了。归纳推理是从个别事实的某些已知特征出发,推导出更多事实或所有同类事实的性质。逆证推理是从已知的某个结果出发,试图确定其相关的解释。

在日常生活中,逆证的例子随处可见。例如,当我们来到一个有两家面包坊的小镇上,看到有人在吃面包,我们会判断出至少有一家面包坊正在营业。如果我们看到一家面包坊灯火通明,我们便会得出这样的结论:这就是那家在营业的面包坊。而在科学理论的发展过程中,逆证更是不可或缺,任何新的理论的产生,往往都是与逆证密切相关的——皮尔斯认为,逆证推理的激发,正是为了解释某种令人吃惊的现象或事实。此外,逆证在医学诊断、侦探推理等领域,都起着非常重要的作用。

皮尔斯的逆证理论经历了一些重大变动。到1903年,皮尔斯认为,演绎、归纳和逆证为科学发展或理解过程中起着不同作用的三个阶段,逆证为其中的第一个阶段。

本书的第2章具体介绍了皮尔斯逆证理论的发展过程。我们认为,正是由于皮尔斯逆证理论本身的变化,催生了逆证这个术语的不同含义。在本章中,我们重新定义了逆证。我们认为,逆证是由某个需要解释的现象所触发的,寻求最佳解释(inference to the best explanation)的推理过程,该过程涉及背景知识的提取和选择,并且往往会导致背景知识的变化。我们认为,逆证的触发机制为任何需要解释的现象,而不一定是令人吃惊的事实。以是否引起背景知识的变化为标准,我们将逆证划分为选择性逆证(selective abduction)和创造性逆证(creative abduction)。创造性逆证在言语理解中扮演着十分重要的角色。

由于背景知识在逆证过程中起着非常关键的作用,我们在第3章具体介绍了关于认知语境的一些基本理论,并指出认知语境与理解过程是互动的:认知语境使得理解的预期成为可能,理解同时又会影响认知语境的构成,具体体现为背景知识的更改和扩充。

在第4章中,我们介绍了两种重要的语用推理模式,即格赖斯(Grice)的会话含义理论以及斯珀伯和威尔逊(Sperber & Wilson)的关联理论。我们认为,前者的推理过程带有很多的逆证特征。而关联理论认为,语用推理是对最佳关联的追求,其核心关联原则也可以从逆证推理的角度,利用逆证推理的逻辑表达式进行分解。据此我们提出,这两个理论从本质上来说,都可以看作逆证推理。此外,经济原则在这两个理论及皮尔斯的逆证理论中都起着非常重要的作用,这也进一步证明了我们的上述观点。

在第5章中,我们具体介绍了三种类型的创造性逆证在言语理解中的作用。我们力图用一些具体的例子证明,我们可以通过使用创造性逆证使某个词和句子的意思具体化和丰富化,能够解决一些异常或不一致的语言现象,还能够理解一些新的概念。我们认为,可以将理解看作背景知识逆证的转变过程(abductive transformation),其结果往往导致背景知识的更改、扩充或紧缩。第6章总结了全书。

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Chapter 1 Introduction

Human conceptual activity has a “requirement for understanding” at its core. As our senses continually gather data, we are driven to categorize, compress and store them. When confronted by a novel group of stimuli, we try to explain how those stimuli have arrived at our senses, where and how they have originated, why they have happened to be grouped together, and so on. This process of constructing explanations can be described by the general term interpretation. This term applies both to tasks colloquially described as comprehension, such as reading, and to other tasks often considered as separate activities, such as categorization and visual perception. In all of these cases, the interpretation process generates an explanation, a representation that depicts, describes, models or “stands for” the data that have been observed.

There have been increasing interests from a number of fields in the study of the mental mechanisms that make it possible for people to understand language. Many scholars and researchers have devoted themselves to the study of interpretation, especially natural language understanding.

This book is an endeavor to characterize the cognitive role of abduction in linguistic communication. It tries to produce a theory capable of capturing the basic characteristics of communicative interpretation, based on the relevant ideas put forward by Peirce (1958) and Davidson (1986). It is meant to prove that the process of interpreting discourse can be viewed as the process of providing the best explanation. Since abductive inference is inference to the best explanation, interpretation may be seen as basically abductive. This book also wants to show that both Cooperative Principle and Relevance Theory embody abduction^[1], or that both of them are abductive in essence.

1.1 Position and general orientation

Abduction plays an important role in various kinds of interpretation. In visual interpretation, abduction is important, for perception, according to Peirce, is a kind of abduction. In ordinary life, when we observe our surroundings, we are actually doing visual abduction. When it comes to scientific discovery, it is obvious that abduction is critical (McMullin, 1992; Magnani, 2001). Abduction is also critical in understanding the abnormal usage of language, when what we expect is in contradiction with the actual use.

Nonetheless, the role of abduction is not fully realized to be paid attention to as far as pragmatics is concerned. Various theories have been put forward successively to make pragmatics an ever-progressing discipline. Some theories were proposed to be complementary to others and some intended to undo precedent theories and to suggest new ways of tackling problems. The most influential interpretive theories include such theories as Speech Act theory, Cooperative Principle and Relevance Theory. The latter two are of particular importance from an inferential viewpoint. Ever since Grice (1975), utterance interpretation has been generally understood to be inferential in nature. However, neither Conversational Implicature nor Relevance Theory expounds on the epistemic changes caused by the interpretation. In my opinion, interpretation can be seen as withdrawal from or alteration of one's background knowledge. In other words, interpretation is only a transformation from one's previous knowledge into current knowledge, or in Davidson's terms, from one's "prior theories" into "passing theories".

It is clear that a discourse understanding model should be characteristic of the integration of information from various sources: linguistic, social, psychological, contextual, epistemic, and so on. Such a process requires a cognitive definition. Specifically, it needs to be dynamic rather than static, flexible rather than rigidly fixed, to cope with the diversity of information, the frequently changing context of communication, and the complexity of cognitive activities. As a result, the present research expects to show that the study of natural language understanding

is in the province of cognitive psychology, which describes the human cognitive abilities allowing different types of information, both linguistic and non-linguistic, to be processed. What this research intends to show is that a reasoner, in order to interpret a discourse, must appeal to his repertoire of knowledge representation and select and integrate parts of such knowledge as demanded.

The focus of this book is thus how interpretation can be seen as abduction and what changes it may lead to in a reasoner's knowledge representation. Since the concept "abduction" has undergone a lot of changes in Peirce's theory and later scholars and researchers have suggested numerous definitions and explanations, there are entanglements with the abundant confusions surrounding diversified uses of the term. As a result, we should make it clear that our discussion of abduction is mainly as inference to the best explanation and the product of the abductive reasoning as epistemic changes, although different usage of the concept abduction has been introduced as well. The aims of this book are as follows:

- a. To clarify the concept of abduction;
- b. To show that abduction is really important in many fields, especially natural language understanding;
- c. To verify that interpretation can be seen as abduction;
- d. To prove that Grice's Cooperative Principle and Sperber & Wilson's Relevance Theory are abductive in nature;
- e. To show that abduction can be identified as epistemic change.

To summarize, the long-term objective of this present research is to establish a theoretical model accounting for a reasoner's interpretation processes, which might be generally applicable to different types of communication.

1.2 Abduction: background and issues

Abduction is very evident in many fields, yet it is neglected for thousands of years. In the last five decades, there can be noticed an increasing interest of the scientific community regarding non-deductive, pragmatic reasoning. Disciplines such as Philosophy of Science, Sociology, Psychology, Linguistics, Literary Criticism, Semiotics, and particularly Artificial Intelligence have pursued using

abductive inference to reformulate some of their specific problems of research. For scientists, and particularly for semioticians, the research on abductive inference provides the unique opportunity of approaching interdisciplinarity under a single aspect.

Over the last twenty years, abduction has attracted more and more attention in the field of Artificial Intelligence in that studies have shown how abductive reasoning can be used to address a great variety of problems, including updates in databases, belief revision, planning, diagnosis, natural language understanding, and, more generally, problems requiring reasoning with incomplete information.

1.2.1 Roots of abduction

The word abduction derives from the Latin word “abducere”:

abducere=ab + ducere (ab=from, off; ducere=to lead, to take)

The term “abduction” was introduced by the philosopher Charles Sanders Peirce to describe an inference pattern sometimes called “hypothesis” or “inference to the best explanation”. Peirce was the first person to distinguish it as a fundamental form of logical inference alongside deduction and induction. Abduction (or abductive reasoning; abductive inference) accepts a conclusion on the grounds that it explains the available evidence. Peirce used the example of arriving at a Turkish seaport and observing a man on horseback surrounded by horsemen holding a canopy over his head. He inferred that this was the governor of the province since he could think of no other figure that would be so greatly honored.

However, this mode of reasoning appears to have its origins in a syllogistic form of reasoning discussed by Aristotle in the *Prior Analytics* (Book II, Chapter 25), known as *apagoge* (Codognet, 1997). This syllogism looks for premises that would make a given conclusion more desirable. Crombie A. C. (1953) proposed to place the origin of the experimental method in science in the 13th century, especially in the work of the scientist and philosopher Robert Grosseteste. Grosseteste stated that there is “a double path from already existing knowledge to new knowledge, that is, from the simple to the complex and conversely”, that is to say, going from principles to effects, and vice versa. Grosseteste considered that for natural sciences, one has to distinguish a possible cause or explanation