The Nature of Reasoning

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Defining and Describing Reason

Jacqueline P. Leighton

Approximately a year ago I began to believe that reasoning was problem solving's poor cousin. In comparison to problem solving, which involves strategically overcoming obstacles in pursuit of a solution, reasoning seemed vague in function. In fact, reasoning has undergone a variety of definitions. As Raymond Nickerson indicates in this volume, reasoning has, on the one hand, been defined narrowly as the process of drawing deductive inferences and, on the other hand, as an aspect of thinking that is involved not only in drawing inferences but in making decisions and solving problems as well. Has reasoning been defined so broadly and redefined so frequently that it has lost its significance? Put another way, could reasoning be legitimately subsumed under problem solving or decision making without any loss? I no longer think so.

The purpose of the present book, *The Nature of Reasoning*, is to provide a comprehensive examination of the significance and distinctiveness of reasoning and, of course, at the same time, to indicate how it mediates other cognitive operations, such as problem solving and decision making. The book organizes in one volume what is known about reasoning, including its structural prerequisites, mechanisms, susceptibility to pragmatic influences and pitfalls, and bases for development. By focusing on factors that are pertinent to reasoning across domains, we present a united and comprehensive analysis of reasoning – an analysis that will inform anyone who is interested in learning about the fundamental factors and critical issues in reasoning research today.

DEFINING AND DESCRIBING REASONING: REASONING AS MEDIATOR

Defining Reasoning. In the present book, reasoning is broadly defined as the process of drawing conclusions. Moreover, these conclusions inform problem-solving and decision-making endeavors because human beings

are goal driven, and the conclusions they draw are ultimately drawn to help them serve and meet their goals.

Describing Reasoning. A prominent theme in the book is that of reasoning as mediator. If we wanted to personify reasoning, it would take on the character of a middleman or middlewoman in a company or enterprise. As a middleman, reasoning works behind the scenes, coordinating ideas, premises, or beliefs in the pursuit of conclusions. These conclusions may sometimes find their way to the surface in the form of observable behavior as when someone exclaims "I have an idea!" or argues "I think your idea is not going to work because. . . ." Other times, the conclusions do not find their way to the surface but, rather, stay beneath the surface and function internally as antecedent conditions that feed into chains of productions for problem solving (Simon, 1999). For example, when a conclusion (e.g., I know that some plants flourish in the presence of sunlight) functions as an antecedent condition to initiate an action (e.g., moving the plant to a sunny spot in the house) that is key to solving a problem (e.g., the plant is dying). In either case, whether conclusions become externally observable or stay beneath the surface to help to initiate problem-solving endeavors, reasoning processes are at work. Unfortunately, these processes may not often be acclaimed because they work behind the scenes and in the shadow of more observable functions such as problem solving and decision making. Despite their covert nature, however, understanding how reasoning processes function is imperative to maximizing our efforts at solving problems and making decisions.

DRAWING CONCLUSIONS: EVALUATING OUR CLAIMS TO TRUTH

In Cervantes' (1605, 1615/1998) *Don Quijote de la Mancha*, some of the disastrous adventures of the self-proclaimed knight and his sidekick Sancho do not result from slips in problem solving. Quijote and Sancho's misfortunes arise from faulty reasoning. For example, upon seeing the huge windmills, Quijote concludes the windmills to be giants and immediately thinks to charge at them with a lowered lance. Despite Sancho's protests, Quijote leads the charge against "the giants" without stopping to evaluate how he concluded *giants* from *windmills*. After the charge, the wounded Quijote blames the disaster on the work of a magician but, in fact, the reader knows this to be untrue.

It could be argued that Quijote's disaster came about from faulty reasoning. Quijote drew a false conclusion from observable evidence – he inferred giants from the windmills at the distance – and this led him to initiate an inappropriate action that was doomed for failure. What we can learn from Don Quijote's adventures is that the conclusions we draw can either steer us to problem-solving disasters or problem-solving successes.

Drawing true conclusions facilitates problem solving. True conclusions facilitate problem solving because they are reliable representations of the external environment. Therefore, true conclusions increase the likelihood that a problem's features are being depicted faithfully so that the best strategy for solving the problem can be selected.

The conclusions we draw underlie the problem-solving initiatives we undertake. Therefore, we want to draw true conclusions so that we can get the most out of our problem-solving efforts. However, verifying the truth of a conclusion is not always easily accomplished. The truth of a conclusion is ultimately decided by its correspondence with reality (e.g., physically checking whether the windmills are indeed large human beings), which can be a little difficult to negotiate in some circumstances. If one draws a conclusion in the middle of an island without any means of verifying its truth, what does one do?

The difficulty of verifying a conclusion's truth does not mean that we are doomed to a life of false conclusions. In the absence of being able to verify a conclusion directly, we can evaluate how our premises (or beliefs) entail the conclusion of interest. In other words, we can learn to scrutinize our claims to truth. Our claims to truth are the processes by which we generate conclusions. Do we generate conclusions that follow necessarily from a given set of premises? Or only very likely from a given set of premises? In the end, we may not be able to control our ability to directly verify a conclusion's truth, but we may be able to control the cohesion or soundness of the reasoning that lead up to it.

Conclusions are commonly described as being generated either deductively or inductively. For example, a conclusion that is derived deductively from a set of premises follows necessarily from its premises; that is, the premises provide conclusive grounds for the conclusion. Moreover, if the conclusion is derived deductively from true premises, then the conclusion is necessarily true (see Copi & Cohen, 1990, for a review of validity and deduction). This is one way to yield true conclusions without checking them against reality: If the premises are true, then the conclusion drawn must be true. Conclusions derived deductively are considered necessary because they contain the same amount of information as that found in the premises leading up to it; necessary conclusions represent information that is already implicitly contained in the premises.

In contrast, a conclusion that is derived inductively from a set of premises does not follow necessarily from its premises, although it might be strongly supported by them. A conclusion that is derived inductively from true premises is likely to be true but it is still not necessarily true (see Copi & Cohen, 1990, for a review of strength and induction). Conclusions derived inductively are considered unnecessary because they contain more information than that found in the premises leading up to it. Unnecessary conclusions represent information that goes beyond the

information already contained in the premises. Although the truth of necessary or unnecessary conclusions must be checked against reality (except when reasoning deductively from true premises), knowing a conclusion's necessity is still informative because it indicates the cohesion of the reasoning that underlies it.

Understanding the difference in the necessity among conclusions can be informative. For example, imagine someone tells you that looking at a computer monitor for too long brings about nearsightedness. How should you evaluate this conclusion? Is it helpful to know that this person derived the conclusion deductively or inductively? Knowing that he or she arrived at the conclusion deductively suggests that the premises, if true, guarantee the truth of the conclusion. It is difficult to deny a necessary conclusion unless its premises are also denied. In contrast, if the conclusion was derived inductively then the conclusion is possible but unnecessary. You might be more critical of the conclusion once you discover that is only a possible conclusion, and you might therefore not change your behavior drastically in light of it. Or you may want to inspect the evidence yourself to determine the strength that it lends to the conclusion. In the end, we want to judge conclusions suitably so that we can capitalize on their information and act accordingly.

The advantage of problem solving is that its outcome can be judged right or wrong, unequivocally, by determining how well it resolves the problem in the first place. In contrast, the outcome of reasoning is not so unequivocally judged because reasoning does not yield a solution but, rather, a conclusion; a conclusion whose origin is not from a problem but from a set of beliefs. To judge a conclusion, then, one must know how it was generated and the truth of the beliefs leading up to it. The standard for judging a conclusion depends on different principles (for a review of these principles see Copi & Cohen, 1990; also Creighton & Smart, 1932). As mentioned previously, a conclusion can be judged according to its necessity and according to its truth. If a conclusion is drawn deductively from true premises, it is a necessary and true conclusion that must be accepted unless its premises are denied. By evaluating our claims to truth – how we generate conclusions – we can be confident about the cohesion of the reasoning that produced the conclusions even when we cannot directly verify these conclusions against reality.

ORGANIZATION OF THE NATURE OF REASONING: AN OVERVIEW

Although we do not normally think about how fundamental reasoning is to our well-being, reasoning is like breathing to the mind. We are constantly doing it but we rarely take notice of it. If it fails, however, we are paralyzed. Imagine being unable to infer conclusions from a conversation? Or being unable to reach a solution to an important life problem? We reason

when we learn, criticize, analyze, judge, infer, evaluate, optimize, apply, discover, imagine, devise, and create – and the list goes on because we draw conclusions during so many of our daily activities. Given that reasoning underlies so many of our intellectual activities, how do we operate, apply, and nurture our reasoning? These questions are addressed in the following chapters.

In Part One, "*The Basics of Reasoning*", Chapter 1, "Defining and Describing Reasoning," examines briefly the importance of reasoning in our daily life, the mediating role reasoning plays in problem solving, and the methods used to evaluate our claims to truth.

The second chapter, "Reasoning and Brain Function" by Anton E. Lawson, identifies the brain structures involved in reasoning. Lawson explores the brain functions that accompany the reasoning processes used when people solve problems in personal settings and during scientific discovery. By examining the reasoning processes in these different circumstances, a model of brain function during reasoning is created. This is a chapter that anchors every other chapter in the book because it identifies the physical nature of reasoning; that is, it reveals the material side of the mental phenomenon we call reasoning.

The third chapter, "Working Memory and Reasoning" by K. J. Gilhooly, discusses the role of working memory in reasoning. This chapter defines working memory and reasoning and then surveys empirical investigations of their interrelations and complementary functions. Gilhooly explains how explicit reasoning processes manifest themselves in working memory by manipulating the temporary contents of working memory. This chapter reminds us that reasoning does not occur in a vacuum but, rather, its function necessitates other processes.

The fourth chapter, "The Role of Prior Belief in Reasoning" by Jonathan St. B. T. Evans and Aidan Feeney, examines the traditional views that psychologists have had about the influence of prior beliefs on deductive reasoning. Evans and Feeney explain that although prior beliefs have traditionally been regarded as a negative influence on deductive reasoning, researchers are now reexamining this view. From this chapter, we learn that the effects of beliefs on reasoning are so pervasive that most researchers have abandoned deductive logic as a descriptive and normative theory of human reasoning. Evans and Feeney highlight the powerful role of knowledge and beliefs in reasoning.

The fifth chapter, "Task Understanding" by Vittorio Girotto, examines the ways in which participants of reasoning experiments might interpret the tasks they are asked to solve. This chapter is significant because it helps us to understand that participants' solutions to reasoning tasks originate from their interpretations. When their solutions do not conform to expected solutions, their interpretations must be considered. Girotto discusses the emergence of linguistic-pragmatics, a recent experimental development

that has made investigators aware of how interpretative processes can influence inferential processes. Moreover, Girotto compares how representational complexity and pragmatic irregularities in reasoning tasks can lead participants to erroneous inferences.

These five chapters present the basics of reasoning and build on each other: Reasoning is a mental phenomenon that is driven by specific sections of the brain. Explicit reasoning processes manipulate information in working memory in order to generate conclusions. The information that is manipulated in working memory often involves prior beliefs along with situation or task variables. Prior beliefs are invoked because participants impose their own interpretation on tasks. In Part Two, the mechanics of reasoning are presented.

The second part of the book, "*The Workings of Reasoning*," focuses on the "mechanics" of reasoning, for example, how reasoning takes form through strategies and knowledge representation, and whether the conclusions drawn from reasoning processes are better described through the lens of mental model theory, mental logic theory, or simple heuristics.

In the sixth chapter, "Strategies and Knowledge Representation," Keith Stenning and Padraic Monaghan, discuss the difference between how knowledge is manipulated (i.e., strategies) and how knowledge is formalized or represented. This is a fascinating chapter because it clarifies the subtle distinction between strategies and knowledge representation. In so doing, the clarification informs the debate about the nature of reasoning processes – whether these processes are better viewed under the lens of mental models or mental rules.

In the seventh chapter, "Mental Models and Reasoning," Philip N. Johnson-Laird presents the theory of mental models, one of the two most prominent theories of reasoning processes today. The chapter begins with an introduction to the theory, and then follows with a review of the empirical evidence that supports Johnson-Laird's theory as an account not only of deduction but also of induction. Johnson-Laird's empirical and theoretical contribution as presented in this chapter is essential to understanding the current debate about the nature of reasoning processes.

The eighth chapter, "Mental-Logic Theory: What it Proposes, and Reasons to Take This Proposal Seriously," by David P. O'Brien, presents the theory of mental logic, the other most prominent theory of reasoning processes today. The chapter begins with a discussion of why mental rules characterize reasoning processes and why mental rules "make sense" as a description of reasoning. O'Brien then addresses one of the major criticisms that has been levied against mental rules and presents arguments showing that this criticism is unfounded when the facts of the theory are considered. The chapter then describes the particulars of the mental logic theory as developed by Martin Braine and David O'Brien and presents empirical evidence that supports the predictions derived from the

theory. O'Brien's presentation of mental logic theory is fundamental to appreciating the debate between the mental models camp and mental rules camp.

Maxwell J. Roberts, in Chapter 9, "Heuristics and Reasoning: Making Deduction Simple," presents a new theoretical twist in the debate between mental model theory and mental logic theory. Roberts discusses the idea that heuristics characterize most of the reasoning that people do on a daily basis. He argues that heuristics or simple rules of thumb characterize reasoning because other processes such as models or rules would take too long and would be too costly to apply. This chapter presents a new, and increasingly strong, third voice in the debate over whether mental models or mental rules characterize reasoning processes.

Chapter 10, "Cognitive Heuristics: Reasoning the Fast and Frugal Way," by Barnaby Marsh, Peter M. Todd, and Gerd Gigerenzer, presents the operations of a specific set of heuristics – fast and frugal heuristics. These heuristics, such as the recognition heuristic, are shown to provide good solutions for many kinds of problems without the need to expend too much time or effort or even too much knowledge of what is being reasoned about. Marsh, Todd, and Gigerenzer underscore the third voice in the debate over whether mental models or mental rules characterize reasoning. These investigators present the possibility of accounting for reasoning without using elaborate models of behavior.

These five chapters present the mechanics of reasoning – the difference between strategies and knowledge representation, and the different theories that have been proposed to account for the reasoning processes that generate our conclusions. These chapters describe what is currently known about reasoning as it occurs on a daily basis. Finally, Part Three of the book focuses on the improvement and development of reasoning.

Part Three, "*The Bases of Reasoning*," focuses on reasoning from an ontological perspective, exploring how reasoning can be assessed, how it develops, how it has evolved, how it manifests itself uniquely in human beings, and how we can nurture it through instruction.

The eleventh chapter, "The Assessment of Logical Reasoning, which I wrote, explores the fairness of evaluating or assessing reasoning without first measuring how well participants understand the domain of the task. In this chapter, I argue that making judgments and building theories about human reasoning using logical tasks that require at least some knowledge about formal logic – even if only to interpret the logical terms in the task in a specified and formal manner – may result in biased theories about how people actually reason.

In Chapter 12, "The Development of Deductive Reasoning," Henry Markovits discusses the pervasiveness of deductive reasoning in daily life and the importance of understanding how this form of reasoning

manifests itself and develops in children and adults. In his review of empirical studies, Markovits demonstrates that there is disagreement about the deductive reasoning skills children and adults are believed to possess. The chapter ends with an examination of how Johnson-Laird's theory of mental models may be adapted within a developmental framework and used to explain some of the contradictory results in the literature. This chapter helps us to understand the early stages of what it means to reason well and why it is a challenging pursuit.

The thirteenth chapter, "The Evolution of Reasoning," by Denise D. Cummins, traces our reasoning pedigree. Cummins examines the evolutionary forces that have shaped the processes through which we reason and the environmental variables that invoke those processes. The chapter explores the adaptive value of deontic reasoning and its legacy to understanding higher cognition in general, including the errors that participants make on abstract reasoning tasks. It is clear in this chapter that human reasoning cannot be understood fully by ignoring the ecological variables of our past.

Chapter 14, "Individual Differences in Thinking, Reasoning, and Decision Making," by Keith E. Stanovich, Walter C. Sá, and Richard F. West, explores the variables that distinguish reasoning performance among individuals, and provides a basis for using these variables as keys to understanding the nature of reasoning. For instance, Stanovich, Sá, and West offer a fascinating analysis of how cognitive ability and thinking dispositions are associated to performance on standard reasoning tasks. In addition, the chapter presents the implications of individual differences for generating normative standards of reasoning and evaluating the rationality of human performance.

The fifteenth chapter, "Teaching Reasoning," by Raymon S. Nickerson, presents a discussion of what good reasoning entails and the variables that facilitate it. For example, Nickerson surveys the cognitive qualities that encourage good reasoning and how instruction can nurture these qualities. In addition, the chapter addresses the issue of whether good reasoning is situation-specific or whether it can be transferred across domains. This chapter is vital to anyone who is interested in improving his or her reasoning and fostering sound reasoning in others.

Finally, in Chapter 16, "What Do We Know about the Nature of Reasoning," Robert J. Sternberg, concludes the book and, in so doing, presents a unified look at the nature of reasoning, including what we know, how we know it, and what is still left to investigate and learn.

These final six chapters explore some of the major issues that border our understanding of reasoning, such as how we can assess it, how it develops, how it evolved, how it is manifested in different people, how we can teach it, and finally how we can put it all together to understand its nature.

CONCLUSION

Reasoning, the mediator leaves its mark on almost everything we do and think. This is because almost everything we do and think involves drawing conclusions. When we learn, criticize, analyze, judge, infer, evaluate, optimize, apply, discover, imagine, devise, and create, we draw conclusions from information and from our beliefs.

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