

Models in the Mind

The Mental Models Theory of Reasoning: Refinements and Extensions. Edited by Walter Schaeken, André Vandierendonck, Walter Schroyens, and Géry d'Ydewalle. Mahwah, New Jersey: Lawrence Erlbaum Associates.

How do people reason about the what follows from certain assumptions? How do they think about implications between statements. According to one theory, people try to use a small number of *mental rules of inference* to construct an argument for or proof of a relevant conclusion from the assumptions (e.g., Rips 1994). According to a competing theory, people construct one or more *mental models* of the situation described in the assumptions and try to determine what conclusion fits with the model or models constructed (e.g., Johnson-Laird 1983, 2006). The present collection offers eleven contributions to the mental models theory.

Specific theories about such reasoning can be tested by asking subjects what follows from certain assumptions. Subjects can also be asked whether a particular stated conclusion follows or is implied by the assumptions. And subjects can be given problems that seem to require such reasoning, such as the familiar the Wason (1966) selection task. In this task, four cards are placed before a subject on the table. The subject is told that the cards have a letter on one side and a number on the other wide. The subject sees only one side of the cards, e.g. "A 3 B 4". The subject is asked to indicate which of the cards need to be turned over in order to determine whether a certain claim about the cards is correct: for example, the claim that, if there is a vowel on one side, there is an even number on the other side. Most subjects get this version of the task wrong. Subjects do better if the situation is a more familiar one, for example, if one side of the card indicates whether or not a particular individual is drinking alcohol, the other side indicates the age of the individual, and the claim to be tested is that if an individual is drinking alcohol, the individual must be 21 or older.

Mental rule theories attempt to explain subjects' reasoning about what follows in various cases by attributing to subjects rules like *modus ponens*: given a conditional of the form, "if p , q ," and a corresponding statement of the antecedent, p , then q follows. Mental rule theories also assume that subjects are able to use such rules to construct arguments with a series of steps. The rule of modus ponens can then be used twice to show that from

the assumptions “If it rains, the street gets wet,” and “if the street gets wet, it is slippery,” the conclusion follows, “If it rains, the street is slippery.”

Subjects might be also supposed have rules about negated statements of the form “not r .” For example, *modus tollens* is the rule that, given a conditional of the form, “if p , q ,” and the denial of the consequent, “not q ,” it follows that “not p .” Subjects with this mental rule can then determine from the assumptions of the previous problem and the further assumption that “the street is not slippery,” it follows that “it did not rain.”

In one sort of mental rule theory, subjects are also assumed to be able to reason from *suppositions* and are able to reject a supposition if it can be seen to imply a false conclusion. In the previous case, instead of using a rule of *modus tollens*, a subject might see that the supposition, “It is raining,” allows the conclusion, “The street is slippery,” which conflicts with the supplied assumption, “The street is not slippery.” Seeing that, the subject can conclude that the supposition is false, which warrants the conclusion, “It is not raining.”

The mental models approach was initially motivated by dissatisfaction with the ability of the mental rule approach to offer a plausible explanation of systematic patterns in experimental results.

Consider the following problem. “The glass is to the right of the plate. The napkin is to the left of the plate. What is the relation between the glass and the napkin?” Subjects tend to answer rather easily that “The glass is to the right of the napkin” (or that “The napkin is to the left of the glass”). A mental rule theory must suppose that subjects have such rules as “If X is to the left of Y , Y is to the right of X ” and “If P is to the right of Q and Q is to the right of R , P is to the right of R .” Subjects would have to use these rules to construct a somewhat complicated proof specifying the relation between glass and napkin.

The mental model approach supposes instead that subjects attempt to construct a model of the situation described by the assumptions. Subjects first imagine the glass to the right of the plate and then add the napkin to the left of the glass. Then they can simply “read off” the relation between glass and napkin from this model. Here, the mental model approach seems to give a better account than the mental rule approach does of the ease with

which subjects get the right answer in this sort of case.

More generally, the mental model approach seems to allow better explanations than the rule based account does of differences in the ease with which subjects can recognize what follows and of their mistakes in various cases. If there is more than one possible model of the assumptions, subjects may construct only one of the models, which can lead them to the wrong conclusion in certain cases. Or subjects may construct two or more models, which will take more time and will typically be harder to assess.

The eleven chapters in the volume under review make a variety of contributions to the mental models approach. Many of the chapters are concerned with reasoning involving conditionals.

Studies have shown, for example, that subjects easily determine that “the book is on the table” follows from “if the napkin is on the floor, the book is on the table,” and “the napkin is on the floor” (an instance of *modus ponens*: Q follows from *if P, Q and P*); subjects have more trouble recognizing that “The napkin is not on the floor” follows from “if the napkin is on the floor, the book is on the table,” and “the book is not on the table” (an instance of *modus tollens*: *not-P* follows from *if P, Q and not-Q*; and subjects sometimes wrongly suppose that “the napkin is on the floor” follows from “if the napkin is on the floor, the book is on the table,” and “the book is on the table” (*fallacy of affirming the consequent*: P does not follow from *if P, Q and Q*).

Johnson-Laird and Byrne (1991) propose that faced with such problems subjects tend initially to consider only a single mental model, which might be represented as follows:

P Q
...

Here only one possibility is explicitly represented and the “...” represent that additional models are possible. Fully competent subjects will be aware that these additional models hold when P does not hold, but they do not normally initially represent those additional models.

Modus ponens requires looking only at that model, so it is predicted to be

easily recognized. Recognizing that affirming the consequent is a fallacy and that modus tolens is valid are predicted to be more difficult and (in the absence of special features of the example) will typically take longer because the full set of possible models must be constructed:

P	Q
$not-P$	Q
$not-P$	$not-Q$

If all these models are consulted, it can be seen that there is only one case in which $not-Q$ holds, and $not-P$ holds in that case, so *modus tolens* is valid. But there are two cases in which Q holds, one in which P holds and one in which $not-P$ holds. Since P does not hold in all cases in which Q holds, *affirming the consequent is a fallacy*. According to Byrne and Johnson-Laird, it is because such additional models must be considered that subjects have trouble recognizing instances of *modus tolens* as valid and instances of *affirming the consequent* as invalid.

The present volume consists in eleven rich chapters aimed at extending and further specifying the mental models approach, taking up a variety of issues, reporting on many experimental studies, too numerous to mention here. Issues discussed include the following. How do background knowledge and pragmatic aspects of what is said affect model construction? What if the assumptions and potential conclusions are understood not to be true? What differences are there in how speakers interpret conditional statements? How might the mental models approach figure in a developmental account of the understanding of conditional statements? What about conditionals using other connectives besides “if”—connectives like “only if,” “whether,” “although,” “suppose,” “whenever,” “because,” and “cause”? How might mental models represent temporal relations? How might the mental models approach handle reasoning about “extensional probability”? How might mental models represent argumentative contexts when people disagree? Does the mental models approach fit with what is known about when people can be trained to do better at reasoning about what follows from what? Does it suggest ways of improving such training?

A listing of the authors and chapters provides some indication of the range of authors and issues discussed.

“Memory Retrieval and Content Effects in Conditional Reasoning: A Developmental Mental Models Account,” by Pierre Barrouillet and Nelly Grosset.

“Representation, Pragmatics, and Process in Model-Based Reasoning,” by Simon Handley and Aidan Feeney.

“*Whether, Although, and Other Conditionals*” by Ruth Byrne.

“Rethinking the Model Theory of Conditionals,” by Jonathan St. B. T. Evans, David E. Over and Simon J. Handley.

“Mental Models and Falsification: It Depends on the Task,” by Maxwell J. Roberts.

“Modeling Something That Is Believed to Be False: The Competition of Scripts and Models in Linear Reasoning,” by Vicky Dierckx and André Vandierendonck.

“The Mental Models Theory of Relational Reasoning: Premises’ Relevance, Conclusions’ Phrasing, and Cognitive Economy,” by Walter Schaeken, Jean-Baptiste Van der Henst, and Waltere Schroyens.

“Extensional Reasoning about Chances,” by Vittorio Girotto and Michel Gonzalez.

“Models of Cause and Effect,” by P. N. Johnson-Laird and Eugenia Goldvarg-Steingold.

“A Mental Model Theory of Informal Argument,” by David W. Green.

“Training Effects in Deductive REasoning: A Theory-Based Review,” by Karl Christoph Klauer and Thorsten Meiser.

Evans, Over, and Handley remark that, “If the value of a theory is to be judged by the amount of research it stimulates, then the mental model theory of reasoning proposed by Johnson-Laird and Byrne must be considered very successful indeed” (63). The present volume provides additional evidence of the stimulation and success.

Gilbert Harman
Department of Philosophy
Princeton University
Princeton, NJ 08544
E-mail: harman@princeton.edu

Sanjeev Kulkarni
Department of Electrical Engineering
Princeton University
Princeton, NJ 08544
E-mail: kulkarni@princeton.edu

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Rips, L. J. (1994). *The Psychology of Proof*. New York: MIT Press.

Wason, P. C. (1966). "Reasoning." In Foss, B. M. *New Horizons in Psychology*. Harmondsworth: Penguin.