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Probabilistic conditional reasoning: Disentangling form and content with the dual-source model ☆

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ABSTRACT

The present research examines descriptive models of probabilistic conditional reasoning, that is of reasoning from uncertain conditionals with contents about which reasoners have rich background knowledge. According to our dual-source model, two types of information shape such reasoning: knowledge-based information elicited by the contents of the material and content-independent information derived from the form of inferences. Two experiments implemented manipulations that selectively influenced the model parameters for the knowledge-based information, the relative weight given to form-based versus knowledge-based information, and the parameters for the form-based information, validating the psychological interpretation of these parameters. We apply the model to classical suppression effects dissecting them into effects on background knowledge and effects on form-based processes (Exp. 3) and we use it to reanalyse previous studies manipulating reasoning instructions. In a model-comparison exercise, based on data of seven studies, the dual-source model outperformed three Bayesian competitor models. Overall, our results support the view that people make use of background knowledge in line with current Bayesian models, but they also suggest that the form of the conditional argument, irrespective of its content, plays a substantive, yet smaller, role.

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1. Introduction

It is difficult to overstate the influence Bayesian approaches have had on the development of theories in cognitive psychology in the last few decades. Across diverse domains – ranging from low-level phenomena such as perception to high-level phenomena such as argumentation – Bayesian models often provide an unprecedented level of explanatory power (Chater, Oaksford, Hahn, & Heit, 2010). A core assumption of such models is that subjective degrees of belief can be modeled as probabilities obeying the axioms of probability theory.

In the field of reasoning, people evaluating an argument have traditionally been asked to assume that the stated premises hold true and to ignore any background knowledge elicited by the contents of the premises. In tune with these instructions, theoretical accounts have often assumed that reasoning is performed on relatively abstract representations of the argument form (e.g., Johnson-Laird, 1983; Johnson-Laird & Byrne, 1991; Rips, 1994). The advent of Bayesian and related probabilistic approaches has led to what has been called the *new paradigm* (Over, 2009). In the new paradigm, the reasoning problems are typically couched in everyday, real-world contents, and reasoners are not instructed to disregard what they know about the contents.

Using such contents, it turned out that it is easy to construct arguments that are logically valid, but yield a conclusion that most people reject as highly improbable. Conversely, it was found easy to construct arguments that are logically invalid, but yield a conclusion that most people accept as highly probable (in the context of conditional reasoning see Byrne, 1991; Nickerson, 2015, chap. 14; Singmann & Klauer, 2011). These and related findings have led many theorists to make a strong case that human reasoning is guided not by logic, but by probability. For example, Chater and Oaksford (2001) state that "we see probability theory as a wholesale replacement for logic as a computational level theory of what inferences people should draw." (p. 208). Prominent Bayesian models assume that reasoning amounts to the assessment of probabilities of conclusions based on what the reasoners know about the contents of conclusions and premises; reasoning is thus conceptualized as probabilistic and content-driven (e.g., Baratgin & Politzer, 2006; Cruz, Baratgin, Oaksford, & Over, 2015; Oaksford & Chater, 2007; Pfeifer & Kleiter, 2010).

The focus of the current work is on a model that integrates these two seemingly irreconcilable positions within the new paradigm. We will show that there are content-independent effects of different argument forms that are not adequately captured by Bayesian models. Hence, we propose that reasoning is influenced by two different and independent cognitive processes – a probabilistic process in line with extant Bayesian models, which we call *knowledge-based*, and a content-independent process driven by the form of the argument, which we call *form-based*. In this view, reasoners' evaluations actually reflect a mixture of form-based and knowledge-based information. These assumptions are explicated formally in our *dual-source model* (DSM; Klauer, Beller, & Hütter, 2010) elaborated on below.

1.1. Probabilistic conditional reasoning

A conditional rule links two propositions, an antecedent p and a consequent q, in the form "if p then q". Inference tasks in conditional reasoning (for an overview, see Nickerson, 2015) typically present the conditional rule as major premise and one of p, q, or their negations as minor premise. Reasoners are asked to assess a proposed conclusion on the basis of this information. According to classical logic, two of the usually studied inferences are valid; the truth of the premises entails the truth of the conclusion:

Modus ponens (MP): Given "if p then q" and "p", it follows that "q".
Modus tollens (MT): Given "if p then q" and "not q", it follows that "not p".

The two so-called reasoning fallacies are invalid; the truth of the premises does not entail the truth of the conclusion: