Complexity provides a better explanation than probability for confidence in syllogistic inferences

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Abstract: Bayesian rationality is an important contribution to syllogistic inference, but it has limitations. The claim that confidence in a conclusion is a function of informativeness of the max-premise is anomalous because this is the least probable premise. A more plausible account is that confidence is inversely related to complexity. Bayesian rationality should be supplemented with principles based on cognitive complexity.

The Bayesian account of reasoning proposed by Oaksford & Chater (O&C) in *Bayesian Rationality* (Oaksford & Chater 2007, henceforth BR) extends the historic trend away from regarding logic as the science of thought, and toward seeing reasoning as adaptation to the environment. Piaget, who is cited on page 4 of the book as wholeheartedly adopting a logicist conception of the mind, was in fact part of this trend, and he expressly repudiated logicism (Piaget 1957, p. 1). The Bayesian account arguably has potential to revolutionise our understanding of reasoning, but it has limitations. I want to draw attention to some issues that are additional to those that have been identified in the literature.

The heuristics proposed by the Probability Heuristics Model (PHM), that is, min, max, and attachment, operate on an implicit ranking of the informativeness of the four premise moods (All, Some, Some not, None). According to the min-heuristic, individuals tend to draw conclusions that match the mood of the least informative premise, which by information theory is also the most probable proposition in a set of premises. The validity of the min-heuristic is that it reflects constraints between the mood of the min-premise and the mood of the valid conclusion (see Tables 7.2 and 7.3 in BR). Thus, PHM implies that reasoning depends on knowledge of constraints contained in world knowledge. PHM accounts for approximately the same proportion of variance in problem forms as Mental Models theory and Relational Complexity theory (Halford et al. 2007). PHM goes beyond these theories in dealing with premises "Most" and "Few," but it only predicts mood of the conclusion, not actual conclusions, and it depends on estimated parameters.

There is also a significant anomaly. The max-heuristic determines confidence in the conclusion in proportion to the informativeness of the max-premise, but the most informative premise is the least probable. There does not appear to be an explicit explanation for confidence being inversely related to probability, whereas selection of conclusions, by the min-heuristic, is directly related to probability. An alternative hypothesis is that high confidence is associated with lowest complexity, because the least probable forms according to PHM are also the least complex according to complexity metrics, including number of mental models, and the relational complexity metric. The simplest syllogisms according to the Relational Complexity metric (Halford et al. 2007), those based on binary or ternary relations, have at least one A (All) premise, or at least one I (Some) premise. A (All) premises are the most informative (least probable) and I (Some) premises are second most informative in PHM. Thus, the most informative, and least probable, syllogisms are of low complexity, which is a more plausible basis for confidence than low probability. Therefore, PHM might work better if it incorporated other principles that have been established in cognitive science, including those that define cognitive complexity of reasoning tasks.