Précis of *Bayesian Rationality: The Probabilistic Approach to Human Reasoning*

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Logic and the Western conception of mind

- Classic (logicist) view of human rationality: Rationality concerns reasoning according to the formal rules of logic that specify inferential connections that hold with *certainty* between propositions
- Reasoning is governed by unbreakable logic aimed toward specifying relationships that hold with absolute certainty
- Logical inference is truth-preserving
- Commitment to logic as the foundation for thought

The Bayesian probabilistic turn

- Bayesian view of human rationality: Rationality is defined by the ability to reason about *un*certainty; human thought is sensitive to qualitative, probabilistic patterns rather than numeric ones
- Everyday thought involves impressive probabilistic reasoning
- Previous instances of "logical fallacies" or "errors and biases" in reasoning are reinterpreted as natural, rational byproducts of qualitative probabilistic reasoning
- In Bayesian Rationality (BR), probability is determined subjectively in terms of a person's strength of opinion

Rationality and reasoning

- Core objective of rational analysis: Understand the structure of a problem from the point of view of the cognitive system
- Goal is not to measure people's performance on logical/probabilistic problems, but rather to understand human reasoning
- *Monotonicity:* A property of classical logic where adding additional premises can never overturn existing conclusions
    - However, *nonmonotonicity* is the norm in the every day world; almost any conclusion can be overturned if additional information is acquired
    - Nonmonotonic nature of world creates a mismatch with monotonicity of logic, hence we see a Bayesian shift in the sciences

Bayesian Probability models - Mapping BR onto empirical data

1. Conditional Inference
   - Four inference patterns studied extensively: Modus Ponens (MP), Modus Tollens (MT), Denying the Antecedent (DA), and Affirming the Consequent (AC)
   - Bayesian prob. models fit experimental data for these 4 inferences much better than standard logicist models, even after accounting for a possible biconditional interpretation
   - "Errors and biases" are caused by inferential asymmetries (MP drawn more than others), simply consequences of a rational probabilistic model
   - *Negative conclusion bias*: People endorse MT, DA, and AC more when the conclusion contains a negation

- Explained by rarity effect: prob. of an object being in a category is smaller than not being in a category
- Apparent irrational negative conclusion bias is really "high probability conclusion" effect

2. Data Selection and Hypothesis Testing
   - Logicist approach to hypothsis testing is to seek *falsifying* cases
   - But people seem to seek cases that *confirm* the conditional, deemed "confirmation bias"
   - Optimal Data Selection (ODS) model focuses on hypothesis testing being comparative rather than exclusively concentrating on falsification
     - ODS based on *information gain*, or expected information gain
     - Assumes people make decisions in direct proportion w/ information gain, and therefore suggests performance on selection task displays rational behavior as opposed to an irrational confirmation bias
   - Deontic (morally charged) selection tasks are atypical because they aren't rules but rather regulations that should be obeyed, and require a different rational analysis (expected util.)

3. Quantified Syllogistic Inference
   - Logic defines 4 types of quantified premise: All, Some, Some…not, None
   - 64 total syllogisms, 22 of which are logically valid
     - However, people endorse some invalid ones more, and vice versa
   - Probabilistic Heuristic Model (PHM)
     - Probabilistic quantifiers might operate on a continuum beyond the 4 types defined by logic. Logic can't cope with these generalized quantifiers
     - Transforms quantifiers into cond. probabilities by imposing constraints
     - In PHM, people approximate rational analysis by using simple heuristics, which generally identify a probability-valid conclusion
     - 2 types of heuristic: generate (produces candidate conclusions) and test (evaluates plausibility of candidate conclusions)
   - Mental models theory, Mental logic view, and recent memory span measures all support PHM

Take Home Points

- Qualitative patterns are more practical and robust than precise numerical calculations
- Authors suspect that the probabilistic problems faced by the cognitive system are too complex to be solved by direct calculation. Instead, the cognitive system has developed computationally 'cheap' methods for reaching solutions that are good enough
- Probabilistic models don't need to be fully specified at a numerical level, just represent functional relationships through framework for qualitative reasoning
- Rational analysis is simply a small niche embedded within a much larger and complex probabilistic model of the world; it provides a framework into which knowledge about our uncertain world must be integrated
- The mind is a qualitative probabilistic reasoned that deals with uncertainties
- Qualitative > numerical. We get it.