The New Paradigm and Mental Models

Jean Baratgin
University of Paris VIII, France

Igor Douven
Sciences, normes, décision (CNRS), Paris-Sorbonne University, France

Jonathan St.B. T. Evans
University of Plymouth, UK

Mike Oaksford*
Birkbeck College, University of London, London UK

David Over
University of Durham, UK

Guy Politzer
Institut Jean Nicod, Paris, France

Key Words: P-validity, probability, logic, mental models, New Paradigm, inference

*Corresponding Author:
Mike Oaksford
Department of Psychological Sciences
Birkbeck College, University of London
Malet Street
London, WC1E 7HX, UK

E-mail: mike.oaksford@bbk.ac.uk
Tel: +44 (0) 20 7079 0879

Acknowledgements:

In a recent TICs article, Johnson-Laird, Khemlani, and Goodwin (JKG) [1] argue that mental models theory (MMT) can integrate logical and probabilistic reasoning. We argue that JKG make a radical revision of MMT, but to ill effect.

This can best be seen in what they say about truth and validity (see BOX 1). Formerly [2, p. 651], in MMT *p* v *q* (*p* or *q*) "... is true provided that at least one of its two disjuncts is true; otherwise, it is false." Thus *p* v *q* is true provided that one of three possibilities is true: *p* & not-*q*, not-*p* & *q*, *p* & *q*. But JKG claim, "The disjunction is true provided that each of these three cases [*p* & not-*q*, not-*p* & *q*, *p* & *q*] is possible." But these three cases are always possible for jointly contingent statements: that is why they are rows of the truth table for *p* v *q*. JKG's new definition makes almost every disjunction true! An example of a disjunction that it does not make true is *p* v not-*p*. This tautology fails to be true for JKG because *p* & not-*p* is not possible.

BOX 1 ABOUT HERE

Formerly [2, p. 651] MMT agreed with classical logic that or-introduction—inferring *p* v *q* from *p*—is a valid inference, because *p* v *q* is true when *p* is true. JKG now claim that it is invalid to infer *p* v *q* from *p*. They again refer to the three possible cases saying, "The premise [*p*] does not establish that the second [not-*p* & *q*] and third [*p* & *q*] cases are possible." But again, these cases are always possible for jointly contingent statements *p* and *q*. Note also that, (i) if or-introduction is invalid, *p* and not-(*p* v *q*) are consistent, and that (ii) JKG continue to define consistency between statements as having at least one mental model in common. But clearly *p* and not-(*p* v *q*), which is equivalent to not-*p* & not-*q*, do not have a model in common. JKG must deny that people can ever commit the disjunction fallacy of judging that Pr(*p*) > Pr(*p* v *q*) [3]: responding that Pr(*p*) > Pr(*p* v *q*) is not a fallacy if it is invalid to infer *p* v *q* from *p*. In fact, people generally respect the p-validity of inferring *p* v *q* from *p* by responding that Pr(*p*) ≤ Pr(*p* v *q*) [4,5].

We are puzzled by what JKG say about a valid inference, "In everyday reasoning, its premises should also be true in every case in which its conclusion is true." We have no idea where this use of "should" comes from. We do not know of any normative logic in which the

premises of a valid inference "should" be true when the conclusion is true. Nor do we know of any experimental result supporting this claim about "everyday reasoning".

In addition to these theoretical problems, the evidence JKG present for how MMT integrates logic and probability is weak. In particular, their Figure 4, which apparently demonstrates this integration, only shows that adjustable parameters are needed to fit MMT to data. But this is true for almost any cognitive theory. It does not make them probabilistic theories.

Another main plank in JKG's argument is that MMT provides a better account of syllogistic reasoning than the probability heuristic model (PHM) [6]. However, the meta-analysis [7] they report comparing PHM with MMT used accuracy as a measure but did not allow PHM to predict no valid conclusion (NVC) responses. This move contradicts PHM in which NVC responses are predicted by one of its main heuristics (the *max*-heuristic). When appropriate model comparison methods are used, there is evidence that PHM provides better fits to the data than MMT [8].

According to JKG, MMT provides a better account of non-monotonicity because they generate explanations of an inconsistency. Such explanations can just as well be represented in causal Bayes nets [9,10]. But neither theory *produces* explanations; they only represent them once generated from long term memory for world knowledge.

A further supposed advantage of MMT is that it allows kinematic models that unfold in time. As the representations and processes employed in their example of a kinematic MMT bear absolutely no relationship whatever to the representation/process pair that JKG argue underpins deductive/probabilistic reasoning, this supposed advantage is completely spurious.

In summary, JKG's aim was to clarify the relationship between logic and probability. They certainly do not do this. Their denial that or-introduction (from p to $p \vee q$) is valid in MMT is critical here as many fundamental theorems of probability depend on this inference.

By contrast, the relation between logic and probability in the New Paradigm, with its probability conditional, could not be closer or more precise (see BOX 1).

(796) WORDS

References

1. Johnson-Laird, P. N., Khemlani, S. S., & Goodwin, G. P. (2015). Logic, probability, and human reasoning. *Trends in Cognitive Sciences*, *19*, 201-214. doi:10.1016/j.tics.2015.02.006
2. Johnson-Laird, P. N., & Byrne, R. J. (2002). Conditionals: A theory of meaning, pragmatics, and inference. *Psychological Review*, *109*, 646-678. doi:10.1037/0033-295X.109.4.646
3. Bar-Hillel, M., & Neter, E. (1993). How alike is it versus how likely is it: A disjunction fallacy in probability judgments. *Journal of Personality and Social Psychology*, *65*, 1119-1131. doi:10.1037/0022-3514.65.6.1119
4. Cruz, N., Baratgin, J., Oaksford, M., & Over, D. E. (2015). Bayesian reasoning with ifs and ands and ors. *Frontiers in Psychology. 6*:192. doi: 10.3389/fpsyg.2015.00192
5. Politzer, G. & Baratgin, J. (in press). Deductive schemas with uncertain premises using qualitative probability expressions. *Thinking & Reasoning*.
6. Chater, N., & Oaksford, M. (1999). The probability heuristics model of syllogistic reasoning. *Cognitive Psychology*, *38*, 191-258. doi:10.1006/cogp.1998.0696
7. Khemlani, S., & Johnson-Laird, P. N. (2012). Theories of the syllogism: A meta-analysis. *Psychological Bulletin*, *138*(3), 427-457. doi:10.1037/a0026841
8. Copeland, D. E. (2006). Theories of categorical reasoning and extended syllogisms. *Thinking & Reasoning*, *12*(4), 379-412. doi:10.1080/13546780500384772
9. Chater, N., & Oaksford, M. (2006). Mental mechanisms: Speculations on human causal learning and reasoning. In K. Fiedler, & P. Juslin (Eds.), *Information sampling and adaptive cognition* (pp. 210-236). New York, NY, US: Cambridge University Press.

10. Oaksford, M., & Chater, N. (2013). Dynamic inference and everyday conditional reasoning in the new paradigm. *Thinking & Reasoning*, *19*, 346-379. doi:10.1080/13546783.2013.808163

Box 1: The validity of arguments (199 WORDS + 1 Figure)

The New Paradigm defines validity as probabilistic validity (p-validity), where an inference is p-valid precisely if the uncertainty of its conclusion (i.e., one minus the probability of the conclusion) cannot be greater than the sum of the uncertainties of its premises [1]. Probability theory ultimately depends on classical logic, and all classically valid inferences are p-valid. P-validity is also monotonic: adding premises to an inference cannot decrease the total uncertainty of the premises.

JKG fail to distinguish between the logical concept of p-validity and the special use of this term in work on syllogisms [2], which made additional extra-logical independence assumptions. For the logical concept, syllogisms are p-valid precisely if they are classically valid deductions.

The New Paradigm introduces a probability conditional, "$\rightarrow$", that is undefinable in classical logic. Its p-valid rules of inference are a proper subset of the rules of inference for the material conditional, "$\supset$". The latter license inferring $(p \,\&\, q) \supset r$ from $p \supset r$; the former does not license inferring $(p \,\&\, q) \rightarrow r$ from $p \rightarrow r$. In this sense, $\rightarrow$ is non-monotonic. Figure 1 instantiates this inference schema and provides a test of which represents the natural language "if."

FIGURE 1 HERE

References

1. Adams, E. W. (1998). *A primer of probability logic*. Stanford, CA: CSLI Publications.
2. Chater, N., & Oaksford, M. (1999). The probability heuristics model of syllogistic reasoning. *Cognitive Psychology*, *38*, 191-258. doi:10.1006/cogp.1998.0696

Figure 1

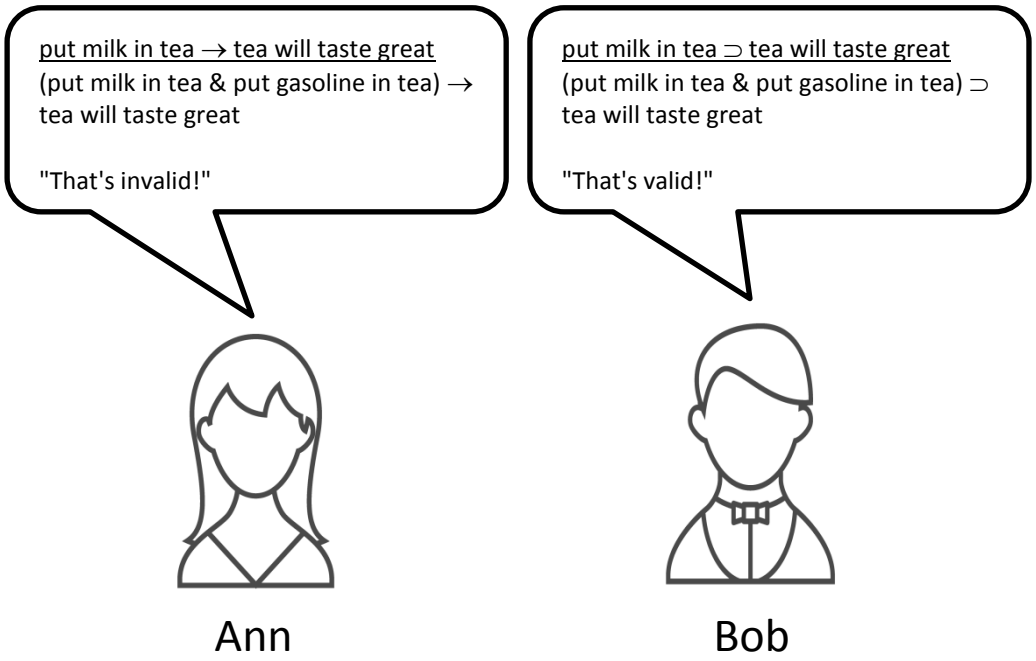

Figure 1: Are people like Ann, interpreting "if" as $\rightarrow$, or are they rather like Bob, interpreting "if" as $\supset$? Ask them to evaluate the argument mentioned in the box and see whether, like Ann, they reject it as invalid or, like Bob, accept it as valid.