Reasoning with Probabilistic Factual and Counterfactual Conditionals

William Jimenez-Leal[a] (W.Jimenez@warwick.ac.uk)
Nick Chater[b] (N.Chater@ucl.ac.uk)
[a]Department of Psychology, University of Warwick, Coventry, CV5 7AL, England, UK
[b]Department of Psychology, University College London, Gower Street - London - WC1E 6BT UK

Keywords: counterfactual reasoning; causal reasoning; conditionals.

Introduction

Counterfactual reasoning is pervasive in our mental lives and usually takes the form of conditional sentences about what could/should/might have been. Its cognitive dimension has usually been studied acknowledging this double nature of being a conditional sentence and an imagined alternative to reality (Byrne, 2002). Recent research has shown that some counterfactual inferences rely on the construction of causal models (Sloman & Lagnado, 2005) and that these inferences do not differ in nature from reasoning about factual possibilities. Consequently, the difference between 'factual' and counterfactual reasoning is just a matter of time perspective.

Causal models can represent the inherent element of uncertainty present in causal relationships by using probabilities (Pearl, 2000). Sloman & Lagnado (2005) show how factual and counterfactual inferences are based on causal models for both deterministic and probabilistic situations.

The Mental Models Theory (MMT) has also emphasized the link between factual and counterfactual information in reasoning, but in a different fashion. According to MMT, when reasoning with counterfactual conditionals, people form models of the situation that include both the factual and the counterfactual information, as the utterance of a counterfactual conditional usually implies that a certain state of affairs is not actually the case (Byrne, 2002). This initial enriched model explains the facilitation of certain inferences with counterfactual conditionals (Byrne, 2002). MMT has not been extended to the case of probabilistic counterfactuals but predictions about this kind of counterfactual can surely be derived from the MMT approach to probabilistic reasoning.

Johnson-Laird et al. (1999) proposed that the probability estimate for a given statement relies on the judgment of the ratio between the frequencies of models that make the statement true and the total frequency of cases available. Consequently, as the initial representation of counterfactual conditionals includes a model of the factual situation, it is determined by the probability of the indicative conditional. The initial representation of the indicative conditional equals the conjunctive probability (P(pq)), as the initial models only represents the conjunction of the antecedent and the consequent. The full fleshed-out representation has a probability of 1 – P(p~q), since the MMT assumes the material interpretation of the conditional (Johnson-Laird et al. (1999)). MMT then predicts that probability estimates attributed to a counterfactual will either be zero (because the initial model already includes a representation of what actually happened) or people would consider the question as if it were a case of an indicative conditional. In the latter case, the probability will be either the conjunctive probability or the probability of the material conditional.

The following experiment tests the MMT hypothesis against the idea that counterfactual inferences are determined by the conditional probability of the antecedent given the consequent as represented in a causal model (Evans et al, 2001; Sloman & Lagnado, 2005).

Method

60 participants took part in an internet-based experiment. Their task was to rate from 1 to 100, 16 conditional statements distributed into 4 scenarios where the presence of negations was counterbalanced using a Latin square design. Half of the participants were aleatorily allocated to either the factual or counterfactual condition. Each conditional was presented with a contingency table where the absolute frequency of cases was modified, keeping the constant $P(q \mid p)$, P(~p) and systematically altering P(pq).

Results and discussion

A 4 (polarity) x 4(scenario) X 2(condition) mixed Anova only showed a main effect of condition ($F(2,58)=11.1$, $p<.05$, $\eta=.25$) with higher mean probability estimates for counterfactual conditionals, possibly explained by a hindsight bias.

Participants' ratings were then analyzed with a multiple regression, with $P(q \mid p)$, P(pq) and 1-P(p~q), as calculated from the contingency tables, as predictors. The only significant predictor of the ratings was the conditional probability for both causal and counterfactual conditionals ($b = .24$, $t(1)=2.5$ $p<0.5$), thus supporting the conditional probability hypothesis against the MMT hypothesis.

References

Byrne, R.(2002) Mental models and counterfactual thoughts about what might have been. *Trends in Cognitive Sciences*. 6, 10, 426-431.

Evans, J, Handley, S & Over, D. (2003) Conditionals and conditional probability. *Journal Of Experimental Psychology-learning Memory And Cognition* 29(2) 321-335.

Johnson-Laird, P. N., Legrenzi, P., Girotto, V., Legrenzi, M. S., & Caverni, J. P. (1999). Naive probability: A mental model theory of extensional reasoning. *Psychological Review*,106, 62-88.

Pearl, J. (2000). Causality. Cambridge: Cambridge University Press.

Sloman, S, & Lagnado, D. (2005). Do we 'do'? *Cognitive Science*, 29, 5-39.