UEcho: A Model of Uncertainty Management in Human Abductive Reasoning

Hongbin Wang[*] **(WANG.190@OSU.EDU)**
Todd R. Johnson[**] **(JOHNSON.25@OSU.EDU)**
Jiajie Zhang[*] **(ZHANG.52@OSU.EDU)**
[*]Department of Psychology
[**]Division of Medical Informatics, Department of Pathology
Center for Cognitive Science
The Ohio State University, Columbus, OH 43210

Introduction

Human beings are, as John Locke put it, most of the time condemned to live in the twilight of uncertainty rather than the midday sun of certainty. Uncertainty management is thus fundamental to human beings at all levels of their interaction with the real world. Abduction, proposed by American philosopher Charles S. Peirce as a distinct type of inference from deduction and induction, is a form of human reasoning that infers causes or explanations from effects. Since in abduction premises do not guarantee the truth of conclusions due to incomplete information, uncertainty management plays an important role in human abductive reasoning.

However, few previous studies directly addressed the connections between the two. For example, Echo (Thagard, 1992), a model of abduction, fails to sufficiently handle various uncertainty aspects. First, Echo does not handle belief acquisition, that is, it does not learn from its experience to adapt to the statistics in the environment. Second, Echo does not handle dynamic belief revision. Echo assumes that all evidence is available at the very beginning, therefore, no belief revision is necessary. This is not a realistic assumption. People usually need to revise their beliefs based on the changing environment.

Our research represents an attempt to explore the essence of uncertainty management in human abductive reasoning. We present a modified Echo model (UEcho), in which we added a learning mechanism for belief acquisition and a dynamic processing mechanism for belief revision. More specifically, we embedded the Rescorla-Wagner learning rule in UEcho, which allows UEcho to reflect some statistics in the environment by updating the strengths of connections based on experience. In order for UEcho to do belief revision, we designed UEcho to accept sequential evidence and operate in a dynamic step-by-step mode. In addition, we added a new parameter to UEcho to differentiate evidence based on different presentation orders.

To evaluate the model, we report an empirical study in which base-rate learning serves as a testbed for belief acquisition and the order effect serves as a testbed for belief revision. Although literature about base rate acquisition and use is quite controversial (see Cosmides & Tooby, 1996 for a review), it has been shown repeatedly that, in some circumstances, people can automatically and accurately acquire and use base rate and frequency information (Hasher & Zacks, 1984). Order effects, on the other hand, are also fairly robust findings in the human reasoning and judgment literature (see Hogarth & Einhorn, 1992 for a review). The order effect refers to the phenomenon that people may obtain different conclusions based on evidence that is identical except for presentation order.

Experimental results show that 1) Subjects can correctly acquire most of the probabilities, and UEcho does reasonably well at simulating subject behavior; 2) Despite accurate base rate acquisition, the order effect occurs under all conditions. More specifically, both UEcho and the experiment show a recency effect: the final decision is more heavily influenced by the direction of the last evidence item.

Conclusions

Abduction is a distinct type of hypothetical reasoning which infers something *may-be*. The empirical work here shows that human abductive reasoning indeed involves uncertainty and thus requires belief operations. Echo, a proposed model of abduction, accounts for many aspects of human abductive reasoning, but does not incorporate uncertainty management. We designed a modified version of Echo (UEcho), which has the potential to handle the uncertainty aspects of abduction. UEcho does a fairly good job modeling belief acquisition and dynamic belief revision, two critical components in human abductive reasoning.

Acknowledgements

This work is funded by Office of Naval Research Grant No. N00014-95-1-0241 and a summer fellowship from the Center for Cognitive Science at The Ohio State University.

References

Cosmides, L, & Tooby, J. (1996). Are humans good intuitive statisticians after all? Rethinking some conclusions from the literature on judgment under uncertainty. *Cognition, 58,* 1-73.

Hasher, L., & Zacks, R.T. (1984). Automatic processing of fundamental information: The case of frequency of occurrence. *American Psychologists, 39(12),* 1372-1388.

Hogarth, R.M. & Einhorn, H.J. (1992). Order effects in belief updating: The belief-adjustment model. *Cognitive Psychology, 24,* 1-55.

Thagard, P. (1992). *Conceptual Revolutions.* Princeton, NJ: Princeton University Press.