A COMPARISON OF ELICITATION METHODS FOR PROBABILISTIC REASONING IN MULTIPLE HYPOTHESIS REVISION

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ABSTRACT

This paper presents the results of a field experiment using a case study set in the context of a fraud investigation in which practicing auditors were required to engage in multiple hypothesis probability estimation and revision regarding the perpetrator of the fraud. The experiment examined the effect of two different methods, prior tutoring in probability theory versus a graphical decision aid, of facilitating multiple hypothesis probability estimation and revision. Participants receiving prior tutoring in probability theory complied with the probability axioms of completeness and complementarity but, engaged in frequent violations of Bayes' Theorem. Participants using the graphical decision aids, by construction, did not violate the probability axioms of completeness and complementarity and the patterns of their revisions were qualitatively much more consistent with Bayes' Theorem. Possible explanations of this phenomenon are proposed and discussed, including implications for audit practice and future research.

INTRODUCTION

The evaluation of competing hypotheses is an essential aspect of the audit process. As [2] point out, whether auditors use a complementarity-based strategy or an independent strategy may have implications for audit efficiency and effectiveness. Using a complementarity strategy implies that the auditors recognize that direct evidence about one hypothesis is also indirect evidence about competing hypotheses. If the auditors interpret a particular item of evidence as increasing the probability of a particular hypothesis, and reduce the probability of competing hypotheses accordingly, they may feel it appropriate to eliminate certain of the other hypotheses based on their resulting reduced probabilities.

On the other hand, under the independence, or "one-hypothesis" approach, in a similar scenario they would not be willing to revise the probability of the competing hypotheses downward unless they obtained direct evidence about those hypotheses. This implies a much more exhaustive (i.e., time consuming and expensive) evidence search process. Coupled with the increased cognitive-cost explanation of [8] is the tendency, promoted by professional standards, for auditors to be conservative, as well as the perception that the independence approach is more defensible. The effect of these three influences could translate into a reluctance to dismiss or eliminate a hypothesis until direct evidence about that hypothesis indicates that it is appropriate to do so. This implies a concern with effectiveness that is traded of with efficiency.

Background and Prior Research

The normative model for multiple hypothesis revision (MHR) is Bayes' Theorem, which is based on the Probabilistic Judgment Paradigm (PJP). Numerous previous studies in cognitive psychology [6] [7] have examined the question of how individuals evaluate competing hypotheses regarding the cause of a particular event. The results have appeared to show that individuals consistently violate the axioms of probability, particularly complementarity, and the prescriptions of Bayes' Theorem regarding the

reallocation of probabilities to non-target hypotheses when a change is made to the probability of a target hypothesis. Studies in auditing [1] [5] have essentially shown the same results. The overwhelming violation of the complementarity axiom was supra-additivity. If the evaluator increased the probability of a particular hypothesis, there was no corresponding decrease in the probabilities of competing hypotheses.

Research Questions

The formulation of the specific research questions was guided by previous research findings in probabilistic hypothesis revision [1] [2] [5] [6] [7] and by expectations based on the literature regarding the efficacy of graphical representation [3] [4].

RQ1: Will the participants using the linear scale response mode, but not receiving tutoring, comply with completeness and complementarity in their probability estimations and re-estimations?

RQ2: Will the participants using the linear scale response mode, and receiving tutoring, comply with completeness and complementarity in their probability estimations and re-estimations?

RQ3: Will different response modes be associated with different patterns of belief revision over the eight revisions?

The Experiment

The context of the study was a fraud investigation with five suspects. The participants were 105 practicing auditors from eight Chartered Accounting firms in a major Canadian city. The experimental design was a between-participants 3 X 1 ANOVA. The auditors were required to estimate and revise their subjective probabilities of guilt of five suspects in a fraud investigation. There were eight iterations, the initial situation and seven additional pieces of evidence.

Results

With respect to RQ1, the untutored condition using the linear response scale departed markedly from completeness and complementarity. The overwhelming form of departure was supra-complementarity. With respect to RQ2, the results unequivocally support the contention that the auditor-participants could be taught to make decisions within the constraints of the axioms of probability. With respect to RQ3, the participants who received tutoring in probability theory frequently engaged in the non-Bayesian practice of eliminations and resuscitations. None of the participants in the circle graph or linear scale non-tutored conditions did so.

Additional Analysis

The pattern of revisions was examined for qualitative consistency with Bayesian revision – specifically, to how may other suspects was a change in probability estimation of the target hypothesis distributed? Qualitatively, the participants in the circle graph conditions responded in a manner more consistent with the prescriptions of Bayes Theorem, distributing the change in probability estimation of the target hypothesis to several of the alternative hypotheses.

Discussion and Conclusions

This study examined the nature of multiple hypothesis revision by auditors in a fraud investigation setting. The results of the auditors who used the graphical decision aid indicate that at a qualitative level, their revisions were more consistent with the complementarity concept of axiomatic probability and

recognized the interrelatedness within a set of competing hypotheses. This is consistent with normative standards, and in this context, implies a more efficient multiple hypothesis revision strategy. This may have implications for audit practice. For instance it may be beneficial to provide auditors with training and/or decision aids to promote and reinforce the Bayesian perspective.

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