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Belief Revision in Causal Learning

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Confidence in Causal Inferences

When a causal model is induced from observations, inferences *deduced* from that model are usually probabilistic and their uncertainty is influenced by the observer's former experience with the model. Thüring, Drewitz and Urbas (2006) tested this assumption in a trial-by-trial-experiment. Participants were presented data (D) about an event in question (Z) and had to predict whether the event would occur or not. In each trial, they rated the certainty of their inference and got feedback on the correctness of predicting Z or -Z.
The task could be solved by forming conditional rules to represent the underlying causal relationship between D and Z. In a *mono causal model*, for instance, a single factor A could be derived from D as a unique cause for Z. The two corresponding rules were: *R1: A → Z* and *R2: -A → -Z.*
In addition, two more complex models were learned: the *'or' model* (A *or* B cause Z) and the *'and' model* (A *and* C together cause Z). In the experiment, the validity of the models was varied, i.e., in some trials participants received the feedback that their prediction, although consistent with the given data and their model, was wrong. As a consequence, confidence in predictions subsequently decreased.

Predicting Confidence Judgments

In this paper, we address the issue of how the change of confidence ratings reported in Thüring et al. (2006) can be formally modeled. Since our participants' confidence in an inference was heavily affected by their experience from previous trials, we selected the Belief Revision Model (BRM) by Catena, Maldonado and Cándido (1998) to predict their confidence. The BRM uses frequency information of a 2x2 contingency table (see Fig. 1) for its estimations, but in contrast to other covariation based theories, it also accounts for the influence of the type of the latest trial as represented by the cells of the contingency table. The estimation of a judgment in trial n (J_n) is calculated by two serial algorithms:

(1) $NE = \frac{w_a a + w_b b + w_c c + w_d d}{a + b + c + d}$ **(2)** $J_n = J_{n-1} + \beta(NE - J_{n-1})$

First, new evidence *(NE)* gained since the latest judgment is taken into account by accumulating and weighing the information in all cells according to the standard order $w_a > w_b \geq w_c > w_d$. Second, the actual judgment is calculated from a function accounting for the actualization rate (β) and the difference between *NE* and the previous judgment (J_{n-1}). To apply the BRM for predicting confidence judgments, the terms of the rules of a causal model must be related to the contingency table (see Fig. 1). Now, each learning trial can be unequivocally assigned to one of the cells. For example, any occurrence of Z together with A or B increases the frequency represented by cell a for the *'or' model* and thus augmenting the impact of this cell on the actual judgment.

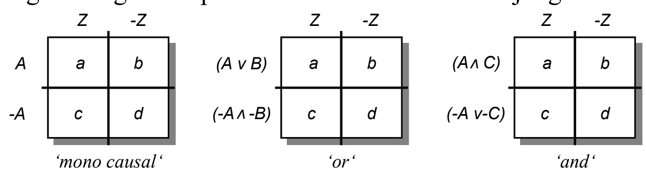

Figure 1: Contingency tables for three causal models.

Results and Discussion

All correlations between estimated and empirical judgments are highly significant ($p<.001$; *mono causal model*: r=.88; *'and' model*: r=.84; *'or' model*: r=.90). This can also be illustrated by comparisons per trial (e.g., see Fig. 2 for the *'or' model*). For the *mono causal model* and the *'or' model*, the high correlation is accomplished by using weights according to the standard order $w_a > w \geq_b w_c > w_d$. For the *'and' model*, it is achieved by assigning the highest weight to cell d and the lowest one to cell a: $w_d > w_b \geq w_c > w_a$. In summary, the BRM proved as an excellent base for predicting confidence judgments during inductive learning, but more research is needed to find and understand adequate weighing procedures for causal models of different or more elaborated structures.

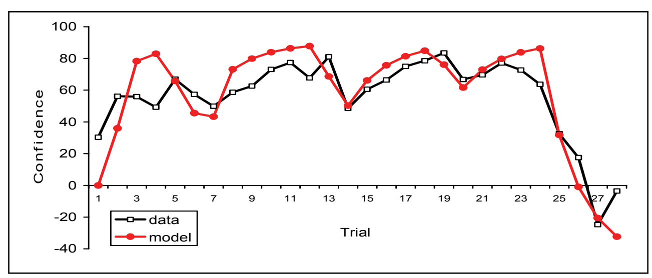

Figure 2: Estimations and mean ratings for the *'or' model*.

References

Catena, A., Maldonado, A. & Cándido, A. (1998). The effect of the frequency of judgment and the type of trial on covariation learning. *Journal of Experimental Psychology: Human Perception and Performance*, 24, 481-495.

Thüring, M., Drewitz, U., Urbas, L. (2006). Inductive Learning, Uncertainty and the Acquisition of Causal Models. In R. S. & N. Miyake (Eds.): *Proceedings of the 28th Conference of the Cognitive Science Society*. NJ: LEA.