Causal chain

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Let's focus on a causal chain as depicted in Fig. 1, and let's assume that we are dealing with continuous time. Typically, in a causal chain the actual cause of the activation of the last node (the effect) seems to be obvious : the chronologically first activated node of an activated path is considered as the actual cause. It is indeed responsible for the activation of all of its descendant. In that context, the difference-making (DM) account of causation in its counterfactual sense predicts well that the first node is the actual cause, since it hadn't occurred, the effect at the very end of the chain wouldn't have happened. The physical causal process (PCP) account agree with that and states that the first node is the actual cause because : a) it possesses a certain conserved quantity for a spatio-temporal region (the "world-line" of the object); b) it exchanges this quantity by interacting with an other object, without crossing its world-line with any previous one.

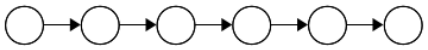

Figure 1

But this agreement between DM and PCP could be threatened, I think, even for a simple causal chain like that, if we precisely depart from the ideal case to take into account the physical and temporal reality of the world. Indeed, we can find cases where the first node to be activated in a causal chain is node obviously judged as the most important one for an effect to occur. In a causal chain, whether we attribute causality to a specific node rather than an other, crucially depends upon (at least) four factors:

1. The probability of self-activation of each node. We can model that by exogenous variables;
2. The conditional probability of the activation of each node given the activation of its parent;
3. The regularity of the activation time between a parent and its child;
4. The presence or not of breaks in the chain and (temporally) posterior activation of (spatially or causally) anterior node.

The importance of (4) depends on (1)-(3) and maybe more specifically on (3): the less noisy (or the more uniform) the activation time between parents and children is, the less posterior activations and breaks will have an impact on the causal judgments.

To give an example, let's consider the dynamics we have implemented in *chain1.py* [TO SHOW DURING THE MEETING. It will be downloaded later...]

An other example could be find in a more concrete case represented by three billiard balls A, B and E. Let's say that E is at rest first, and that A moves linearly toward E with a certain velocity. After few seconds B appears on the same path as A and moves linearly toward E as well with a certain velocity. Let's say that B's velocity is the same as A's one or lower than it, such that B cannot reach A on its path. At the end A hits E with a certain strength and E moves with a certain speed. In that context, A is surely considered as the unique cause of E being moved. But what about if B reaches A before A hits E, such that B moves A toward E more quickly and makes A hit E more strongly ? And what happens if we increase the velocity of B, keeping fixed that of A ? It is far from impossible that the more violently B hits A (before A hits E), the more B will be judged to cause E. In this case, the probability raising (PR) account of causation wouldn't give us a fine explanation because that B moves toward A and hits it doesn't raise the probability that E be hit. The DM account doesn't seem to do better, because the effect would have occurred as well, hadn't B hit A.

This special case of causal chain seems to be not very well studied, at least tested experimentally. We can cite however [1] who presented to participants the case above where B reaches A which then hits E. It is labelled "clip 31" in their experiment[1]. The results show that participants judge both A and B as equally causally responsible. But the authors didn't study the impact of the difference between A's and B's velocity on the causal judgments. It would be interesting to see how their counterfactual account of causation (making distinction between *whether-cause* and *how-cause* could deal with a more fine-grained analysis of the role of A and B in the causal chain. Actually, it is an interesting case because it reveals, according to me, a feature that DM account would have trouble dealing with : the propensity for a cause to support, to reinforce the role of an other cause. It would be not easy for DM account to grasp this notion because it relies precisely much more on the notion of *quantity* or *momentum* than on that of *counterfactual*.

Accordingly, we would like to find a measure of the causal strength, understood as the degree to which an event B transfer to an other event A a part of its energy. We also would like that this measure somehow depend on conditional probabilities and the intrinsic variability of each variable (captured by exogenous variable in a structural causal model). The measures of *causal power* put forward so far by Cheng, Good, Glymour, Korb and others in Bayesian Nets are very inspiring. Yet these measures apply to causal networks in general as a tool for inference, not specifically to actual causation where the (presumed) cause(s) and effect(s) are already known. Maybe we could see how to combine such measures with the *Conserved Quantity* theory argued by the PCP account of causation or just to search for an already existing attempt.

Remarks

- Maybe we could think about a complementary interpretation of the notion of quantity that wouldn't be restricted to the physical concept only. Indeed, could the Shannon notion of *quantity of information* or *entropy* be somehow used to account for actual causation ? This mathematical concept is sometimes used as an inferential tool in

[1] http://web.mit.edu/tger/www/demos/contrasts.html

causal networks. Would it be possible or relevant to use it in the domain of actual causation as well ? And maybe more importantly, would it model a psychological reality ? In other words : does a perceived *quantity of information* play in itself any role in our causal judgments ? Does this hypothesis make even any sense ?

- DM and PCP account of causation are probably not exclusive and surely play complementary roles in different contexts. But little work has been done, it seems, to understand the difference between both accounts in term of task complexity and level of abstraction. It is highly probable that DM models of causal judgments perform poorly in stressful situation where people has to make causal judgments with time pressure or other type of pressure.

References

[1] Gerstenberg T., Goodman N., Lagnado D., and Tenenbaum J. How, whether, why: Causal judgments as counterfactual contrasts. 01 2015.