

Remarks on Simon's Comments

YOAV SHOHAM

Stanford University

Herbert Simon has commented on my article, to which I have been asked to respond. This sequence of events is slightly misleading: It suggests the familiar article–critique–rebuttal pattern, whereas I believe that, in fact, Simon and I are in substantial agreement about the nature of causation and its formal model. A few points of disagreement do remain, though, and my purpose in these remarks will be to underscore these points and restate my opinions regarding them.

Among the issues that are not in dispute are the elegance of *causal ordering*, and the utility of the notion in tasks such as diagnosis. The concept is as attractive now as it was when it was first introduced in the 1950s (I first encountered it in Lerner, 1965). Also, to the extent that my brief comments on it in my article suggested that the notion of causal ordering is inherently algebraic and precludes a sentential version, I am glad that the record is now set straight.

I disagree, however, that causal ordering is “isomorphic” to my non-monotonic account of causation. I wish it were: A major attraction of causal ordering is its simplicity, which contrasts with my almost embarrassingly complex technical development. In fact, as alluded to in my article, one of the reasons that technical development is preceded by an intuitive exposition is the potential for recapturing the ideas in simpler form.

Isomorphism between structures is defined only relative to specified operations, and it is not clear to me which operations are relevant here. However, such mathematical considerations seem beside the point, and Simon's position seems clear enough. I will take it to be that (a) causal ordering possesses all the desirable properties of causation possessed by the nonmonotonic account; (b) causal ordering does not introduce any undesirable properties; (c) by my own admission, causal ordering is simpler; and, therefore (d) causal ordering is, to use a phrase due to the late Alan Perlis, an improvement on its successor.

In my article I list eight properties that I wish to associate with causation. Of these, Simon agrees with all but two, and expresses partial agreement

Correspondence and requests for reprints should be sent to Yoav Shoham, Department of Computer Science, Stanford University, Stanford, CA 94305-2095.

with one of these two. In fact, I think our approaches differ on both properties, and I consider these two, although not the only points of difference, as best illustrating the difference between causal ordering and the nonmonotonic account of causation.

The first point of disagreement has to do with temporal precedence between cause and effect. I stipulated that causes cannot succeed their effects in time. In order to avoid controversy, I deliberately left open the question of whether they can coincide in time. Simon objected to this assumption, but the reasons he gave only support the argument for possible simultaneity between cause and effect. Although I still view simultaneity between cause and effect as somewhat controversial, I tend to agree with the argument for it, and certainly appreciate de Kleer and Brown's (1984) work on *mythical causality*, as well as Iwasaki and Simon's (1986) discussion of *metastatics*. To be completely fair, I should add that, in my technical development, I disallow simultaneity, although I indicate how restricted forms of simultaneity may be introduced without violating antisymmetry and other properties of causation.

However, causal ordering does more than allow simultaneity: It permits effects to strictly precede their causes. To quote Simon (1991)

We may wish to impose at least the restriction that the effect *not* precede the cause, but the formalism does *not* [italics added] not require this restriction. (p. 296)

To restate my position in this regard, let me quote the following passage from my own article; it refers to Lewis's account which, like causal ordering and unlike Suppes's (1970) account, denies any connection between causation and temporal order:

I sympathize with the desire to maintain as general a theory as possible, but our intuitions about causation seem intimately bound to temporal precedence. Science-fiction stories about "backward causation" are amusing precisely because we have such conflicting intuitions about what such a concept might mean. We should be wary of philosophical theories which flatly contradict human intuition, especially when dealing with concepts which we use regularly in everyday life. . . . At the very least, we can expect a theory of causation to explain why it is difficult for us to imagine backward causation (Shoham, 1990, p. 218).

The other point of divergence between causal ordering and the nonmonotonic account has to do with the relation between "causing" on the one hand, and "enabling" and "preventing" on the other hand. The nonmonotonic account relies on a fundamental foreground-background distinction, in which background assumptions are assumed to hold by default. In the causal rules all the background conditions appear, but in describing a particular situation, they need not be mentioned because their truth is inferred by default. Thus, if information is present that the key was turned and nothing is mentioned about the state of the battery, then it is inferred that

the motor will start, because the battery is assumed, by default, to be alive. Given this distinction, causing is taken to refer to the foreground conditions whereas enabling and preventing refer to the background conditions (in this example, turning the key causes the motor to start, the live battery enables it, the dead battery prevents it).

In causal ordering no such distinction is made. The left-hand side of the causal arrow is a flat conjunction of factors, and as far as I can tell, no mechanism is provided to partition them into two types. In particular, the only way I can see in which to capture the sentence

In the presence of adequate rain, warm weather enables the wheat to grow.
(Simon, 1991, p. 297)

mentioned by Simon, is by $rain \wedge warm \rightarrow grow$, which clearly is not distinguishable from “adequate rain and warm weather cause the wheat to grow.” In other words, the decision of what is an enabling condition and what is a cause lies, as far as I can see, outside the theory of causal ordering.

All this is not to say that the missing properties are *incompatible* with causal ordering: They are not. In fact, if I am right, and causal ordering is not sufficiently strong on its own as an account of causation, it would be interesting to attempt to fortify it with those ingredients; perhaps the result will be a theory with all the properties I listed, and with the elegance of causal ordering.

A final note on the modal logic bashing: It is common to argue that modal logics are more complex than, and hence, inferior to, first-order logic (“estoeric” is perhaps one of the stronger adjectives to be encountered in this connection). Although superficially a radical step, in fact, the use of modal operators is a relatively minor departure from first-order logic, and both accounts of causation in question include much more radical features. In the nonmonotonic account, a more radical step was the adoption of nonmonotonic semantics (which is orthogonal to the use of modal operators). In the case of causal ordering, a more radical departure from first-order logic is the introduction of a new, noncontraposing connective (the causal arrow), reminiscent of relevant and intuitionistic implication. Of course, there is no reason to reject any of these well-defined nonclassical systems, if they turn out to account well for the concept of causation.

REFERENCES

- de Kleer, J., & Brown, J.S. (1984). Qualitative physics based on confluences. *Artificial Intelligence*, 24.
- Iwasaki, Y., & Simon, H.A. (1986). Causality in device behavior. *Artificial Intelligence*, 29.
- Lerner, D. (Ed.). (1965). *Cause and effect*. Toronto: Collier Macmillan.
- Shoham, Y. (1990). Nonmonotonic reasoning and causality. *Cognitive Science*, 14, 213–252.
- Simon, H.A. (1991). Nonmonotonic reasoning and causation: Comment. *Cognitive Science*, 15, 293–300.
- Suppes, P. (1970). *A probabilistic theory of causation*. Amsterdam: North Holland.