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A Framework for Psychological Causal Induction: Integrating the Power and Covariation Views

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ABSTRACT

We propose a theoretical framework for interpreting the roles of covariation and the idea of power in psychological causal induction. According to this framework, the computation of inference is purely covariation-based, but covariation is computed only on a set of selected dimensions in a set of selected events. Whether or not a dimension has power or efficacy exerts an influence on whether or not that dimension is selected. We present an experiment testing two predictions based on this framework. Our experiment showed a strong bias towards inferring a movement by a human agent (compared to a state) to be the cause of an event. In support of our hypothesis, this bias was found only when the state was not salient and the inference was made within a relatively short time, suggesting that the bias occurred at the selection stage.

INTRODUCTION

Two views have dominated philosophical discussions on causation. According to the first view, which can be traced back to Aristotle's concept of an "efficient cause", causes produce their effects by virtue of their power or efficacy to do so. The idea of power or efficacy has often been associated with the concept of an active agent. Bishop Berkeley, for example, proposed that a person's ideas must be caused, not by either matter or other ideas, which are "inert" or passive, but by some "active" being (such as the person's own self or God, an all-powerful being). Similarly, the philosopher Thomas Reid considered voluntary actions by an agent to be the paradigm example of causation, and suggested that states can be called "causal" only in a loose and metaphorical sense. In the same vein, in their analysis of common-sensical causality, the legal philosophers Hart and Honore (1959) proposed that the concept of causation springs from the primitive notion that movements of our bodies bring about changes in the environment.

In opposition to the above view, David Hume proposed the radical idea that instead of explaining events in terms of causes having the power to produce them, we should simply note that certain events are found to be invariably conjoined with others. Hume's idea was extended by J.S. Mill, who proposed a prescriptive set of methods for causal induction based on the covariation between potential causes and effects. These methods form the basis of the ANOVA model (Kelley 1967, 1973), proposed by Kelley as a descriptive psychological model of causal induction.

Interestingly, although Kelley's covariational model has received some empirical support, there has also been reports of systematic deviations from the model . In particular, people appear to have a bias towards attributing an effect to a person rather than to a situation. This bias is considered so pervasive that it has been termed the "fundamental attribution error" (Ross, 1977). The error is clearly consistent with the idea that events are caused by active agents rather than passive situations. The philosophical debate on the power and covariation views has its psychological parallel. To explain both support for and deviations from Kelley's model, Cheng and Novick (1989, in press) proposed that a distinction ought to be made between the rules of inference computation and the data on which such rules operate. They argued that psychological rules of inference are covariational, and that they operate in an unbiased manner on a set of relevant dimensions in a set of relevant events. Biases reported in the literature, they argued, are due to the selection of relevant events and dimensions characterizing those events, rather than due to the process of inference computation. Cheng and Novick found empirical support for their view.

In the present paper, we propose that within the framework of the above distinction, the power and covariational views of causation can be regarded, not as *competing* explanations of the process of causal induction, but as *complementary* components of the process. More specifically, people may have a bias towards selecting an action as a dimension on which to compute covariation. The computed covariation on the selected dimensions then determines causal inferences. The bias for an action may be particular to actions per se, or may reflect a more general propensity to attend to salient dimensions.

EXPERIMENT TESTING THE INTEGRATION OF POWER AND COVARIATION

We tested two hypotheses within the above framework. If a bias towards attributing an effect to an action is due to a bias towards selecting that dimension for covariation computation, we hypothesize that (1) the bias will be most prominent when there is insufficient time or information for covariation to be computed for other potentially causal dimensions (and as a corollary, the bias may decrease or even disappear when there is sufficient time and information for covariation to be computed for other potential causal dimensions), and (2) the bias for an action may be a specific case of a more general propensity to attend to more salient dimensions.

To test our hypotheses, we presented subjects with animated sequences of events involving a fictional causal relation in which an action by an agent (a human figure's movement) and a state (the figure's shade) jointly cause a bird to chirp. The rule governing the chirping of the bird is: The bird chirps if and only if the figure moves and is dark grey in shade. The bird's chirp therefore covaried equally with an action and a state. An event is defined as an occasion on which the human figure (varying along the three dimensions of movement, size, and shade) and the bird appeared on a simple scene drawn on a black-and-white computer screen, and the bird either chirps, or does not chirp. We created a fictional causal relation to be sure that subjects responded by making a causal inference rather than by retrieving previous knowledge. To assess the role of covariation, we also included a third dimension (the figure's size), a state that did not covary with the effect. We assume that subjects' real-world knowledge would bias them towards interpreting the movement of the human figure as an action which has a high degree of power, and the human figure's size and shade as states which have low degrees of power.

To measure the bias towards attributing an effect to a human movement in an experimental situation, we needed to create conditions under which this bias might be manifested. As mentioned earlier, we predicted that if a bias for a dimension exists, it would most likely be manifested under conditions in which the dimension is more salient than other causally relevant dimensions. It seems to us that the rate at which a value on a dimension changes may be one of the primary determinants of salience. We thought that if a dimension is kept constant across a block of events, it would more likely be perceived as part of the background information, and hence less likely to be selected for covariation computation. Thus, to obtain a bias for inferring a movement as the cause of an effect, for one group of subjects we kept shade (the other causally relevant dimension) constant across a block of events while we let movement vary from one event to the next. However, to test that any preference that exists is for a movement in particular, rather than for more salient information in general, for a second group of subjects we let both movement and shade vary from one event to the next. Because both dimensions were salient for this group, if salience -- rather than bias for an action per se -- is what determines whether a dimension is selected for covariation computation, then there should be no bias in causal inference in this condition.

As mentioned earlier, we also predicted that if a dimensional preference exists, it would be likely to manifest itself most strongly when there is insufficient time or information to compute covariation for other potential dimensions. To measure subjects' causal inferences at various points as they accumulate information on the events, we asked them to answer the question, "What causes the bird to chirp?", after every four events -- our definition of a block. Subjects were told that they could give a specific positive answer, indicate that they did not know the answer, or that they thought there is no possible answer.

Method

Subjects. Thirty-four UCLA students participated in this experiment, 15 in the "change in shade between events" group, and 18 in the "change in shade between blocks of four events" group. One subject was excluded due to experimenter error.

Materials, Design, and Procedure. The human figure varied on three dimensions: movement, shade, and size. Each dimension has two values: The figure could either be still or wave an arm and a leg; be light grey or dark grey in shade; and be big or small. Because there were three dimensions with two values each, there were eight possible types of events defined by the configuration of values along the three dimensions of the figure. The animated sequences of events were presented on a Macintosh Plus microcomputer using the Video Works II software package.

The bird chirped whenever the figure was dark and was waving its arm and leg; it did not chirp otherwise. That is, the chirping of the bird covaried with movement and darkness in combination, but not with size. All subjects were presented the same set of eight events (with repetitions). The rate of change in shade, however, was varied between subjects. This rate was manipulated by arranging the set of eight possible events so that shade changed either from one event to the next or only between blocks of four events. The causally irrelevant dimension of size varied between events for both groups. The eight possible events were presented consecutively, with a star in the middle of a blank screen separating each event from the next. Each set of eight events were divided into two blocks of four. The subject paused after each block to write his or her answer to the question, "What causes the bird to chirp?" The blocks were repeated until the subject decided he or she would not change his or her answer if given more trials. The order of the events was counterbalanced across subjects in each of the two rate-of-change conditions.

Each subject was told to imagine that the computer screen was a window from which he or she saw a sequence of events. They were told that an event would involve a human figure and a bird, and that their task was to "figure out what makes the bird chirp". Nothing was mentioned about the dimensions that would be varied. Subjects were told that there was no "right" or "standard" answer, and that they should answer according to what felt right or natural to them.

Results and Discussion

Our results are presented in Table 1 on the next page. In the top half of the table, subjects in the two rate-of-change conditions are classified according to whether they initially judged the cause of the bird's chirp to be (1) movement only, (2) shade only, (3) movement and shade, or (4) other. The bottom half of the table presents an analogous frequency analysis for subjects' final causal judgments.

Both of our hypotheses were confirmed. As can be seen in the first row, there was a strong initial bias towards attributing the bird's chirp to the movement of the human figure in the condition in which its shade was kept constant within blocks of four events. Most of the subjects initially chose the figure's movement to be the cause. Corroborating this finding, the mean number of blocks on which subjects initially considered the cause to include the movement was 1.88, whereas the mean number of blocks on which subjects initially considered the cause to include the shade was 3.88, two blocks (i.e., 8 events) later. In contrast, this bias in initial judgments did not appear in the condition in which shade varied at a faster rate, from event to event, as can be seen in the

Table 1. PERCENTAGE OF TYPES OF INITIAL AND FINAL CAUSAL JUDGMENTS IN THE TWO RATE-OF-CHANGE CONDITIONS.

	Initial causal judgments			
rate of change of shade	movement only	shade only	movement & shade	other
between blocks of 4 events (n=18)	78	0	0	22
between events (n=15)	13	27	47	13
	Final causal judgments			
rate of change of shade	movement only	shade only	movement & shade	other
between blocks of 4 events (n=18)	0	0	89	11
between events (n=15)	13	7	73	7

second row. This pattern of results is consistent with our hypothesis that it is the salience of the dimension (as defined by the rate of change of values on the dimension) that determines selection for covariation computation, rather than whether or not the dimension involves a movement. Because movements are salient, they are more likely to be considered as a potential cause.

Note that although salience has an enormous effect on causal judgments, it is by no means a sufficient criterion for inferring that a dimension is a cause: Very few subjects chose size, which did not covary with the effect, as the cause either initially or finally, even though size changed at the faster rate (from event to event) for both groups of subjects.

Our other prediction was that the bias towards attributing an effect to a movement should decrease or disappear when there is sufficient time to compute information on other dimensions. As we predicted, there was no dimensional bias in subjects' final causal judgments. Most subjects reached the final conclusion that the combination of movement and shade was the cause, a conclusion consistent with the covariation between these dimensions and the effect.

Many real life situations may resemble conditions under which our subjects made their initial judgments, because one may have to form judgments under time and information constraints. The bias towards actions, and towards salient dimensions in general, could therefore be quite widespread.

FURTHER RESEARCH

In the above experiment, we manipulated the salience of shade by manipulating its rate of change. We have interpreted the lack of bias towards attributing an effect to movement when shade changed at a rapid rate to be due to a general propensity to attend to more salient dimensions. However, it seems that increasing the rate of change of shade, besides increasing its salience, may also increase the tendency to perceive the change as an action. This explanation requires further testing.

We have proposed a framework for understanding causal induction. Within this framework, the notion of power plays a role in selecting the relevant sets of dimensions or events, and covariation is then computed on these selected sets. Although our results show support for this framework, it seems to us that this framework is incomplete. Cheng and Novick (1989) discussed the hypothetical case (adapted from Hilton & Slugoski, 1986) of a person whose alarm clock has rung when and only when the sun rises. For this person, the ringing of the alarm clock covaries perfectly with sunrise. This person, however, is unlikely to conclude that the sun causes the alarm clock to ring, or that the alarm clock causes the sun to rise. Cheng and Novick proposed that this is because the person is unlikely on the basis of prior knowledge to select sunrise and the ringing of the alarm clock as dimensions on which to compute covariation. It seems to us that even if that person is to compute covariation on the two dimensions, and moreover succeeds in doing so, he or she is still unlikely to conclude either of the above causal relations. It seems that there may be an influence from a third stage, at which new inferences are evaluated according to its coherence with the rest of a person's knowledge. The evaluation of explanatory coherence (see Thagard, in press) is, of course, not particular to causal induction. Efficacy may play a role at that stage as well as in the initial selection stage.

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