Selective Associations in Causality Judgments II: A Strong Causal Relationship May Facilitate Judgments of a Weaker One

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ABSTRACT

Previous research had shown that a strong relationship between a causal factor and an outcome reduces estimates of the relationship between a second causal factor and the same outcome (two causal factors, one outcome). In the present experiment subjects judged the effect of one response (pressing a spacebar) on two outcomes (a ball and/or a box might change color). We used an operant-like procedure in which subjects did problems on the video screen of a computer. The response was involved in various contingencies with the ball and box. In the critical condition one outcome (changes in the color of the box) was highly correlated with the cause (pressing the spacebar) and the other, target, outcome (changing ball color) was only modestly related to the cause. In contrast to earlier work the concurrent strong causal relationship increased the perceived causal relationship between the target outcome and the cause. The present experiment was derived from and its results are partially accounted for by the Rescorla-Wagner model (1972), which is a simple connectionist model.

INTRODUCTION

In classical conditioning experiments animals which are asked to make judgments of the covariation between an outcome and two signals for the occurrence of that outcome often exhibit what are called selective associations. They "decide" that one signal is the cause and discount the other. They show that they have made this decision by showing a strong conditioned response to one stimulus and little or none to the other (e.g., Wagner, Logan, Haberlandt, and Price; 1968).

We (Baker, Mercier, Vallee-Tourangeau, Pam & Frank, unpublished manuscript) have recently demonstrated that if humans are asked to make judgments of the likelihood of an outcome given two possible causes they show a similar tendency. In one of our experiments subjects played a game which had two possible causes (airplanes or landmines) of an outcome (explosions). When one of the causes (the presence of the airplane) was very highly correlated with the outcome it caused a reduction in the judged effectiveness of the other cause which was moderately correlated with the outcome. The presence of a highly correlated causal factor reduced the judgments of the effectiveness of a second cause.This "error" in judgments is very interesting because it is predicted by the Rescorla-Wagner model (1972) which is a simple connectionist model of animal associative learning and which Shanks (1985) and others have suggested can be extended to the human judgment process.

The Rescorla-Wagner model (1972) explains the selective association effects in which a strong causal factor reduces judgments of a weaker one by claiming that there is a limited amount of associative strength to go around and that the causes compete for it. In our earlier studies the strong cause acquires much of the associative strength so the weaker cause gets little. This notion could be contrasted with a cognitive representational view that might claim that the interaction between the judgments occurs at the representational level when the subjects are processing the correlations between the events. We attempted to contrast these two explanations and to extend our results from the discrete trial procedures that we previously used which involved two causes and one outcome to a procedure modeled on free operant techniques and in which one response or causal factor produced two outcomes. According to the Rescorla-Wagner model unlike two causes, two outcomes should not compete with one another yet a simple representational account might predict that if they involve contingencies similar to those used in the earlier experiments they should require a similar amount or level of cognitive processing and thus might be expected produce an interaction that is similar to that found in our earlier experiments.

We modified a procedure that was developed by Wasserman and his colleagues (e.g., Wasserman, Chatlosh, & Neunabar; 1983). Subjects sit at a computer and press the spacebar and then estimate whether this action has an effect on a geometric figure. An outcome involves the figure changing color. The procedure is "free operant". It is not divided into a series of explicit trials as were our earlier multiple causality experiments. The session is divided into 1 second "bins". If one or more responses occurs in any bin it is called an instance of a response and the probability of an outcome is determined by the conditional probability of an outcome given a response. If no response occurs during any second then the outcome is determined by the conditional probability of an outcome given no response.

The contingency or covariation between two events is best described by what is called the delta P rule (dP) (c.f., Allan, 1980). The contingency can be either positive or negative; that is the cause may make the effect more likely to occur or it might make it less likely to occur. The dP rule describes the one way contingency of the cause on the effect and it is simply the difference between the conditional probability that the effect or outcome will occur given that the cause has occurred and the conditional probability that the outcome will occur in the absence of the cause. Delta P varies from -1 to + 1. A dP of 1 represents a perfect positive contingency, a dP of zero represents no relationship between the cause and effect, and a dP of -1 represents a perfect negative contingency.

In our experiment the outcomes involved the center of a square (box) and a circle (ball) changing color. The idea behind the experiment was to see if the presence of an outcome that was highly correlated (dP= 1 or -1) with the response would reduce estimates of a modestly correlated (dP= .5 or -.5) outcome. To this end every subject was asked to do nine problems in a factorial design in which three contingencies of the moderately correlated ball with the outcome (dPs= .5, -.5 and 0 as a control) were paired with three contingencies of the highly contingent box (dPs = 1,-1, and 0). The issue of most interest was whether a highly contingent box would reduce the estimates of the moderately correlated ball.

METHOD.

SUBJECTS AND APPARATUS

The subjects were 12 female and 6 male volunteers from Concordia University. The stimuli were presented on an IBM PC computer with a color display (color graphics adapter) and consisted of a circle (ball) and a square (box). The box and ball were presented in the center of the screen, side by side, with the ball on the left. The figures were outlines and their colors were from the IBM CGA palettes. The ball was green and the box was brown. On trials in which an "outcome" occurred the centers of the figures changed colors for 100 ms. The center of the ball changed from black to red and the center of the box changed from black to green. On alternating games the palettes were switched substituting the colors cyan, magenta, and white directly for green, red and brown respectively.

PROCEDURE

The subjects signed a consent form and then sat down at the computer and followed the online instructions. There were five screens of instructions. Between the first four screens were demonstrations of the essentials of the task. Following the first screen of instructions the subjects were shown the ball and box. When they pressed the spacebar the ball and box appeared. After 2 s the next page of instructions appeared. Following this page the subjects were shown how a response could make the centers of the ball and box change colors. They pressed the spacebar and the ball and box appeared. When the spacebar was next pressed the centers of the ball and the box changed color for 200 ms. The centers then cleared and 1 s later the next instructions appeared. Following them, the subjects were shown that the objects could change color with no response. They pressed the spacebar and the ball and box reappeared. One second later the centers of the ball and the box changed color for 200 ms and then cleared for 1 s.

The instructions described the task and introduced the above demonstrations. The subjects were explicitly told that it was a good strategy to refrain from responding some of the time in order to see what would happen in the absence of a response. They were also instructed that they should make their judgments on a scale of -100 to +100. The end points represented perfect negative and positive contingencies respectively and the midpoint represented zero contingencies. When the spacebar was pressed the screen cleared and the first problem began with the appearance of the ball and box. Each problem lasted for 180 s. The problems were divided into 1 s bins. If one or more responses occurred in a bin it was defined as a response and then the occurrence of an outcome was determined by the conditional probability of an outcome given a response for each figure. If there were no responses during a bin then it was defined as an occurrence of no response and the outcomes for both figures were determined by the conditional probability of an outcome given no response. The outcomes happened at the end of each bin (i.e., the center of one or both figures changed color for 100 ms).

The ball was the target figure (to be influenced by the box). There were three ball contingencies, a moderately positive contingency (dP = .5), a moderately negative contingency (dP = -.5), and a zero contingency (dP = 0). For the dP = .5 contingency the conditional probability of an outcome given a response was .75 and the conditional probability given no response was .25. For the negative contingency these probabilities were reversed (P(Outcome | Response) = .25; P(Outcome | No Response) = .75). For the zero contingency the probability of an outcome was .5 given a response or no response.

There were also three contingencies for the box: a perfect positive contingency (dP = 1), a perfect negative contingency (dP = -1), and a zero contingency (dP = 0). For the dP = 1 or -1 contingencies the probabilities of an outcome given a response were, of course, either 1 or 0 and the probabilities of a response given no outcome were either 0 or 1. The zero contingency was the same one used for the ball (i.e., probability of an outcome = .5 regardless of whether or not there was a response). All 9 combinations of the ball and box contingencies were given to each subject. Each subject received the contingencies in a different order with each contingency occurring in the first position twice.

Thus in this experiment a moderate positive, a moderate negative or a zero ball contingency was contrasted with either a strong positive, a strong negative or a zero box contingency. If the subjects were to exhibit selective associations as our previous subjects had done then the strong box contingencies would be expected to reduce the estimates of the ball contingencies.

RESULTS.

We analyzed the estimates of the ball and the box contingencies. The results of these analyses indicated that the subjects could discriminate among the contingencies. They discriminated the box contingencies from one another; $F(2,34) = 61.23$; and the ball contingencies did not affect these estimates; $F(2,34) = 0.28$. The subjects discriminated reliably among the three ball contingencies: $F(2,34) = 44.98$. Post hoc tests showed they discriminated each ball contingency from each other; minimum $F(2,34) = 12.02$. There was no reliable effect of the box contingency on the ball estimates; $F(2,34) = 1.62$; but the ball by box interaction was nearly reliable; $F(4,68) = 2.21$; $p < .1$. Thus these data do not extend our earlier results to this paradigm in fact the nearly reliable interaction came about because the estimates of the ball contingency were actually higher (in absolute value) when they were paired with the strong box contingencies (dPs = 1 or -1) than when they were paired with the zero box contingency. In addition to these analyses within the box and ball contingencies we also compared the estimates of the high box contingencies (dPs = 1 and -1) with the moderate ball contingencies (dPs = 5. and -.5) and found that the subjects discriminated between the positive contingencies; $F(1,17) = 26.29$. but that they did not reliably discriminate the -1 contingency from the -.5 contingency; $F(1,17) = 4.18$; $p < .1$.

The preceding analyses expose a potential problem with this experiment as a test of the hypothesis that strong concurrent contingencies might interact with weak ones. To test the hypothesis it would seem necessary to choose a preparation in which the subjects discriminate the strong from the weak contingencies. While this was true for the positive contingencies the discrimination between the negative contingencies was weak. A small number of subjects appeared to do poorly on the box estimates. To formalize this impression we calculated the correlation between each subject's box estimates and the nominal box contingencies. Generally these correlations were quite high. For 12 of the 18 subjects the correlations were higher than .9.

Because it is crucial that the subjects be sensitive to the box contingencies for them to influence the ball contingencies we decided to eliminate those subjects whose box estimates did not correlate significantly at the 5% level with the nominal contingencies. This rather conservative rule eliminated three subjects (maximum $r(8) = .404$, $p > .25$. Figure 1 shows the mean estimates of the ball contingencies with these three subjects removed. The pattern of the results is very clear. When the subjects experienced a strong positive or negative box contingency the absolute value of the ball estimates was higher. That is they judged the moderate but positive ball contingency to be more positive when it was paired with either a strong positive (dP = 1) or a strong negative (dP = -1) box contingency. They also judged the moderate negative contingency to be more negative when it was paired with either a strong positive or negative box contingency. These impression are confirmed by a statistical analysis of the ball estimates with the three subjects removed, there was a significant effect of the ball contingency; $F(2,28) = 66.68$; and no effect of the box contingency; $F(2,28) = 0.37$; but the interaction was now reliable; $F(4,56) = 3.17$. In order to analyze the interaction and to compare the absolute values of the estimates of the positive and negative dP = .5 contingencies we changed the signs of the estimates of the negative contingencies. This replaces the negative means of the -.5 contingencies with their absolute value but does not effect the variance so that

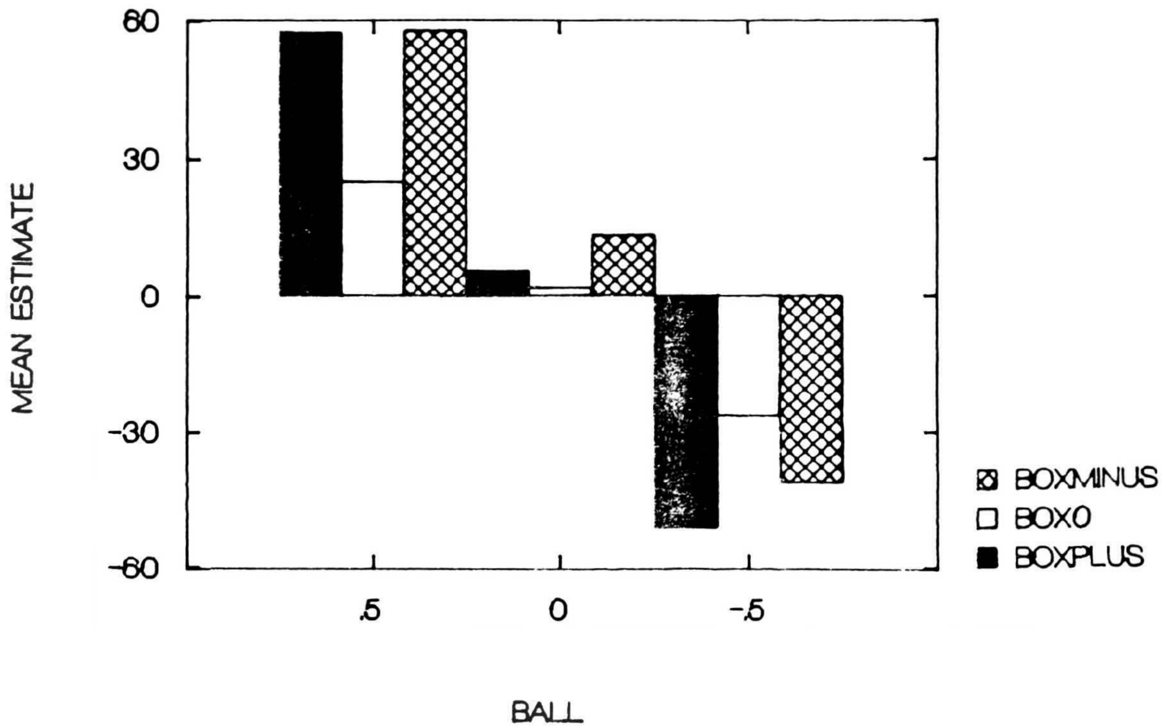

Figure 1: Mean estimates of the ball contingency for the 15 subjects with a high correlation between their box estimates and the nominal box contingencies.

the positive and negative ball contingencies can be directly compared. There was no main effect for ball contingency; $F(3,28) = 0.59$; indicating that the negative contingencies were judged to be as negative as the positive ones were positive. The main effect for Box contingency was now reliable; $F(2,28) = 6.11$; but the interaction was not; $F(2,28) = 0.37$; supporting the observation that the strong box contingencies increased the estimates of the nonzero ball contingencies.

DISCUSSION.

We (Baker et al; unpublished manuscript) have provided evidence that effects analogous to selective associations in animals can occur in human judgments of causality. We found that the presence of an airplane that was highly correlated with explosions reduced the absolute value of judgments of the contingency of landmines that were only moderately correlated with the outcome. This effect was quite robust and was maintained even with major modifications of the game which involved substituting abstract symbols for the airplane and the landmines and changing the instruction sets to ones which did not imply causality at all. Shanks (1986) has also provided evidence that experience with one contingency can reduce estimates of another. Contrary to the above findings, in the present experiment we have found that exposing the subjects to a strong box contingency enhanced rather than reduced ball contingency estimates.

It is of interest to ask why the present results are different. There are other differences between the two preparations. Our earlier selective association effects came from a discrete trials procedure and they are easily modeled by the Rescorla-Wagner (1972) model. But there are other implications of that model and these include the prediction that subjects will judge high density 0 contingencies to more positive than they will judge low density 0 contingency. We have confirmed this prediction using our discrete trial procedure (Baker et al 1989) as has Shanks (e.g., 1985). In general with Wasserman's operant tasks estimates are very accurate and do not show the sort of the density effects that are predicted by the Rescorla-Wagner model (c.f., Wasserman et al 1983). So it is possible that the present preparation is just not sensitive to associative manipulations in the same way that the discrete trial task is. As mentioned earlier the Rescorla-Wagner model provides a framework that explains why this operant task might not be sensitive to associative manipulations. Because the Rescorla-Wagner model explains selective associations as resulting from two causes competing for one effect it would not necessarily predict such an effect here in which two effects have the same cause. Nonetheless, the Rescorla-Wagner model does not easily account for the fact that the present results are in the opposite direction to those of our earlier experiments.

One traditional explanation from the animal literature that might be used to integrate the present results within the traditional associationist framework is that the subjects might generalize between the two figures and/or mistake one outcome for the other. While this is possible, it is really quite unlikely because the subjects clearly understood the tasks and, above and beyond the interaction between the ball contingency and box contingency, they easily discriminated the contingencies from one another.

A second alternative explanation might be that the cognitive load of the perfectly correlated box contingency was low compared to that required for the zero box contingency. Thus when the subjects were concurrently asked to make judgments of the zero box contingency they had less capacity available for making the ball judgments and this suppressed their judgments. The argument is that our results arise not from the strong box contingency facilitating the ball estimates but from the more difficult $dP = 0$ box contingency suppressing the ball estimates. This alternative relies heavily on the additional assumption that the subjects have a zero report bias. If their system is overloaded then they make estimates near zero. This does not seem unreasonable. It must be mentioned, however, that a typical error made in situations in which subjects do not accurately judge contingencies is to go with number of outcomes given a response (Ward & Jenkins, 1965;

Smedslund, 1963) and in the present case this number is quite high because the subjects receive an outcome on 50% of all trials with a response. We also have carried out an indirect test of this explanation. In an unpublished experiment we contrasted the dP=.5 ball contingency with a dP=.8 box contingency. This dP=.8 contingency was quite difficult to do compared to a perfect contingency (thereby increasing the load on the subjects) yet the estimates of the ball contingency in this experiment were very similar to those reported here which used the perfect box contingency. Finally it is our impression from the reports of the subjects that both preparations seem equally difficult.

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