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Cognitive bias mitigation: Reducing the frequency of conjunction effects in explanations

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Abstract
An enormous amount of research has been conducted that documents judgment and decision-making biases when dealing with situations involving uncertainty. One such documented bias is that when asked to explain why events occurred, people rated a conjunction of two explanations as being more likely to have influenced the outcome than the explanations' individual components (the "conjunction effect"), a statistical impossibility given that a conjunction of two events cannot be more likely than their individual component events (Leddo, Abelson and Gross, 1984; Leddo *et al*., 2020). This raises the question as to whether cognitive biases can be mitigated. In the Leddo *et al*. (2020) study, participants who were asked to rate the likelihood that events were true given an outcome showed fewer instances of conjunction biases than those rating the likelihood that those same events were explanations for the same outcomes. This suggests that applying a "truth standard" to explanations may help mitigate the conjunction effect as it pertains to explanations. In the present study, 34 high school students were given questionnaires containing ten scenarios depicting realistic events followed by an outcome. Each outcome was followed by two individual explanations and a conjoint explanation. Participants were asked to rate the likelihood that these explained the scenario outcome. The control condition contained only those instructions. The mitigation condition contained additional instructions asking participants to consider how sure they were that they were right in their ratings. Results showed that control condition participants showed conjunction effects in 93% of their scenario ratings while mitigation condition participants showed conjunction effects in 76% of their scenario ratings. This difference was statistically significant. This suggests that by self-monitoring, people can achieve at least partial cognitive bias mitigation.

Keywords: cognitive biases, explanations, conjunction effect, judgment and decision making, bias mitigation

Introduction

An enormous amount of research has been done that examines human biases in judgment and decision making (Kahneman, Slovic, and Tversky, 1982) [7]. Examples of such biases include the availability heuristic, where events associated with a salient or easily retrievable memory are judged to have higher likelihood of occurring than those not associated with such a memory; the representativeness heuristic, where events that are similar to a categorical prototype are judged to be more likely than those that are not; the hindsight bias, where people upwardly revise their perceived ability to have predicted a past event once they learn the outcome of the event; the confirmation bias, where people tend to overweight evidence that confirms a favored hypothesis rather than disconfirms one (see also Leddo *et al*., 2018) [10].

One of the factors that many of the documented biases have in common is that they demonstrate people's weaknesses in making probabilistic judgments when dealing with situations involving uncertainty. Typically, people judge events to be more likely than they really are. A good example of this occurs in people's judgments of causal factors that are potential explanations for events. Leddo and his colleagues (Leddo, Abelson and Gross, 1984; Abelson, Leddo, and Gross, 1987) [1, 9] found that people judged conjunctions of two reasons as explanations for events as more likely than single reasons (termed "the conjunction effect"), even though it is mathematically impossible for a conjunction of events to be more likely than the likelihood of the component events. An explanation for the conjunction effect is the schematic notion that multiple reasons are more compelling that single reasons since most events result from multiple rather than single causes.

Given that cognitive biases are so prevalent, the natural question arises as to whether these biases can be mitigated. Numerous studies have been conducted examining this question, and many have found virtually no or limited effects. One of the earliest successful attempts at cognitive bias mitigation was to provide people with statistical training (Fong *et al*., 1986, see also Clegg *et al*., 2014; Moorewedge *et al*., 2015; Kucera, 2017) [6, 3, 8]. People trained in statistics show fewer cognitive biases when reasoning under conditions of uncertainty.

Another approach to cognitive bias mitigation involves incentivizing people to perform better in judgment tasks (Stapel *et al*., 1998; Camerer *et al*., 1999) [14, 2]. Yet another method of cognitive bias mitigation involves manipulating the decision-making environment (Clemen & Reilly, 2001; Dawes *et al*., 1989; Soll & Larrick, 2009) [4, 5, 13].

A different approach to cognitive bias mitigation was taken by Leddo *et al*. (2020) [11]. Here, the type of task a person was asked to perform was shown to affect the presence or absence of conjunction biases. Specifically, people who were asked to explain events showed strong conjunction biases, while those asked to perform inferences (rate the likelihood that single or conjoint events were true) showed substantially fewer instances of the conjunction bias, and those who were asked to make predictions (rate the likelihood that single or conjoint events would occur in the future) showed the fewest instances of the conjunction bias.

One thing that the above-referenced interventions have in common is that they all involve external manipulation of the decision maker, whether it is changing the task, imposing a different decision-making structure, providing incentives, or changing the decision-making environment. Since such external interventions may not always be available to support people's decision making, the question arises as to what intervention an untrained person could impose on himself or herself that might mitigate cognitive biases.

An answer to this question is suggested by the work of Leddo *et al*. (2020) [11]. As noted, when people are asked to make inferences, i.e., determine the truth of an event, they are less likely to demonstrate a conjunction bias. This suggests that if people apply a "truth standard" to their judgments, it is possible that other cognitive biases might be mitigated. Addressing that research question is the focus of the present research. Given that conjunction biases are very prevalent when people rate explanations, it was hypothesized that conjunction biases could be mitigated, if people applied a "truth standard" to their explanations, i.e., consider whether the explanations they are evaluating are also true. This hypothesis was tested in an experiment that replicated the format of Leddo, Abelson and Gross (1984) [1] and Leddo *et al*. (2020) [11] in which participants are asked to rate the likelihood of potential explanations for events described in scenarios. Two variations of each scenario were created: one that replicated the formats used in the previous research of Leddo and his colleagues and one that included instructions for participants to consider how sure that were that they were right.

Method

Participants

Participants were 34 high school students recruited from schools in Montgomery County, Maryland and Fairfax County, Virginia in the United States. Participants were not paid for their participation in the study.

Materials

Two versions of a questionnaire were created. Each questionnaire contained ten everyday-type scenarios that would be recognizable to high school students. The scenarios each ended in an outcome. Following the outcome was a list of potential reasons, either single or a conjunction of two for why the outcome occurred. The instructions for the explanation questionnaire were: "What is the probability that the following are among the reasons why <outcome>?" The scenarios and potential explanations were identical to those used in Leddo *et al*. (2020) [11].

An example of a scenario is as follows: "Jodie's parents are allowing Jodie to redecorate her room before school starts in fall. She painted her walls and bought new furniture to decorate her room in. Jodie also buys two types of wallpaper to put on one of the walls. One of the wallpapers has polka dots and the other has a floral pattern. Jodie decides to use the floral pattern instead of the polka dot wallpaper." Explanations for this scenario, both single and conjunctive, were: 1) the floral wallpaper matches the paint color; 2) Jodie likes how the floral wallpaper looks on the wall; 3) the floral wallpaper matches the paint color and Jodie likes how the floral wallpaper looks on the wall.

The conjunction effect mitigation version of the questionnaire was nearly identical to the control condition questionnaire. The sole difference between them was that after the question, "What is the probability that the following are among the reasons why <outcome>?", the additional instruction, "When you come up with your answer, ask yourself how sure you that you are right and could something else be the answer.", was included. This additional instruction was intended as the independent variable to mitigate the conjunction effect.

Procedure

Participants were randomly assigned to a specific version of the questionnaire with 17 given each questionnaire version. Participants were given as much time as they wanted to complete the questionnaire. The experimenter did not observe the specific answers the participant was giving per question so as not to bias the participants.

Results

The probability ratings for each of the 34 participants were evaluated by scenario to see if there were any conjunction effects. A conjunction effect was defined as a case in which a participant gave a probability rating to a conjunction of two events that was higher than the probability of either individual event. This follows as it is mathematically impossible for the conjunction of two events to have a higher probability than either of the individual events. A probability rating for a conjunction of two events that was equal to the lower of the two individual events was not considered a conjunction effect. This is because the probability of a conjunction of events is given by the formula $p(A \text{ and } B) = p(A) * p(B|A)$. Therefore, if $p(B|A)$, the probability of B given A, is judged to be 100% by the participant (namely that B always occurs whenever A occurs), then $p(A \text{ and } B) = p(A)$. Since we did not explicitly ask participants to rate $p(B|A)$, we had no empirical basis to assume that the participants did not deem it to be 100%.

For each participant across 10 scenarios, the number of scenarios for which the conjunction effect did and did not occur were tabulated. Therefore, the maximum possible instances of conjunction effect per participant is 10. Across the 17 participants per questionnaire version, the maximum number of possible conjunction effects is 170 per version. Table 1 below shows the total number of times the conjunction effect was present and absent across all 17 participants per condition and all scenarios per questionnaire.

Table 1: Frequency of Conjunction Effects Broken Down by Condition

	Present	Absent
Control condition	158	12
Mitigation condition	129	41

A visual inspection of the data shows that the frequency of conjunction effects follows the predicted direction. Conjunction effects for the control condition occurred in 93% of the ratings, and, for the mitigation condition, 76% of the ratings showed conjunction effects. The difference between these proportions was statistically significant, $z = 4.36$, $p < .001$.

An examination of participant probably ratings at the individual level reveals some interesting anecdotal trends. All control condition participants showed at least one instance of a conjunction effect. Ten of the 17 participants (59%) showed conjunction effects for all of their conjoint explanation ratings with a conjunction effect range of 70% to 100% in conjoint-explanation ratings.

In the mitigation condition, one participant showed no instance of conjunction effects, one showed conjunction effects in only three out of the ten scenario ratings and one showed conjunction effects in only five out of ten scenarios. Only four of 17 participants (24%) showed conjunction effects in all ten scenarios. The percentage of participants who showed conjunction effects in all ten scenarios was statistically lower for the mitigation condition than it was for the control condition, $z = 2.07$, $p < .05$.

Discussion

The present experiment showed that when people were instructed to ask themselves how sure they were that their judgments were right, the frequency of conjunction effects was reduced. Those receiving no such instructions showed conjunction effects 93% of the time, while those receiving the mitigation instructions showed conjunction effects 76% of the time, an 18% reduction compared to the control condition. While this difference was statistically significant, the result remained that people continued to show conjunction effects the majority of the time, suggesting that the conjunction effect is stubborn and resistant to elimination.

Such a finding is consistent with the results found by other researchers, namely that cognitive bias mitigation efforts can work, but their effects are limited. Still, the present study found that while the majority of control condition participants exhibited conjunction effects on all of their ratings, the majority of mitigation condition participants did not exhibit conjunction effects on all of their ratings. This suggests that under the right conditions, most people can avoid biased reasoning at least some of the time. Such a finding is hopeful, but more research is needed to better understand how people can overcome their decision-making biases.

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