Causal Inference from Descriptions of Experimental and Non-experimental Research: Public Understanding of Correlation-Versus-Causation

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Background:

Humans are cognitive misers who fall prey to a variety of thinking biases,[1,2] including a bias toward seeing patterns between events and a tendency to search for causes of events. One consequence of human cognitive biases is the conflation of correlation with causation.[3,4] The distinction between correlation and causation is emphasized in various college courses; however, previous research from our lab suggests that college students frequently incorrectly infer cause and effect relationships from correlational data. These incorrect inferences are made more often when the direction of the causal relationship seems intuitive, a bias that may be perpetuated by incorrect media and scholarly representation of correlational findings.[5] Personal experiences and vivid testimonials also perpetuate this bias. [6,7] We designed three studies to investigate the inferences general community members draw from hypothetical descriptions of experimental and non-experimental research on human behavior.

Participants:

Participants were recruited from restaurants and cafés in three Midwestern communities. Participant demographics are below.

Demographic Variable	*Study 1 (N = 117)*	*Study 2 (N = 104)*	*Study 3 (N = 100)*
Participant Sex (% Male)	42%	42%	40%
Participant Age			
Mean	45.72	46.66	39.48
Range	19-80	18-73	19-72
Highest Educational Attainment			
High School Degree or Less	15%	18%	13%
Some College or Associate's Degree	36%	43%	46%
Bachelor's Degree or More	49%	39%	41%

Procedure:

Each study was a 2 x 2 between-subjects design. Participants read one of four versions of a hypothetical research vignette. The two independent variables in each study were (1) whether the research vignette described an experimental design or a non-experimental design and (2) whether the research vignette described a positive relationship between the variables or interest or a negative relationship between the variables of interest. After reading the vignette, participants selected which of six inferences they could draw from the results of the research. The layout of information participants in Study 2 received is presented below. The layout for Studies 1 & 3 is identical; see handouts. Study 1 participants read about video games and aggressiveness; Study 2 participants read about self-esteem and academic performance; Study 3 participants read about pornography consumption and marital satisfaction.

Vignette For Study 2:

Study 2: Self-Esteem and Academic Performance

All participants read:
Educational researchers are interested in the association between students' self-esteem and their academic performance. To study this association, they go into local high schools and...

Manipulation 1: Experimental vs. Non-experimental

Self-esteem manipulated:
...collect a representative sample of 500 students. Half of the students are randomly assigned to receive self-esteem enhancing messages from their principal once a week for two months; the other half of students serves as the control group and receives no intervention.

Self-esteem measured:
...survey a representative sample of 500 students. The students complete a validated self-esteem inventory.

All participants read:
After two months, the students complete an academic achievement test appropriate for their grade level.

Manipulation 2: Positive vs. negative association

Self-esteem manipulated		Self-esteem measured	
Positive association: The psychologists' statistical analysis reveals a significant positive (i.e., direct) relationship...	Negative association: The psychologists' statistical analysis reveals a significant negative (i.e., inverse) relationship...	Positive association: The psychologists' statistical analysis reveals a significant positive (i.e., direct) relationship...	Negative association: The psychologists' statistical analysis reveals a significant negative (i.e., inverse) relationship...

All participants read:
...between students' self-esteem and their performance on the academic achievement test. Which of the following is an appropriate inference for the researchers to make on the basis of these data? Check all that apply.

__Achieving academically causes an increase in students' self-esteem.
__Achieving academically causes a decrease in students' self-esteem.
__Increasing self-esteem causes an increase in students' academic achievement.
__Increasing self-esteem causes a decrease in students' academic achievement.
__Students who have higher self-esteem tend to do better on academic achievement tests (compared to students who have lower self-esteem).
__Students who have higher self-esteem tend to do worse on academic achievement tests (compared to students who have lower self-esteem).

Results:

The table below shows the percent of participants who selected each inference about academic achievement and self-esteem. Correct inferences are highlighted with boxes.

- The first thing we assessed was the rate at which participants who were exposed to an experimental vignette (self-esteem manipulated) drew correct causal inferences. For participants who received a positive association, 82% correctly inferred correctly that increasing self-esteem causes an increase in achievement. For participants who were told the association was negative, only 38% correctly inferred that increasing self-esteem causes a decrease in achievement. Thus, twice as many participants correctly inferred causation when the influence of self-esteem was presented as positive (82%) than when it was presented as negative (38%).

- Next, we assessed the rate at which participants drew causal inferences from non-causal data. The frequency with which various causal statements were selected by those who were exposed to the non-experimental vignettes was not systematically different from the frequency with which causal statements were selected by those exposed to non-experimental vignettes. In other words, participants who read about non-experimental research were just as likely to select causal inferences as were participants who read about experimental research. In the non-experimental vignette describing a positive association between self-esteem and achievement, 70% of participants incorrectly inferred that increasing self-esteem causes an increase in achievement, just as 82% of those who had read the experimental vignette correctly inferred that self-esteem causes an increase in achievement. Among those who read about a non-experimental vignette describing a negative association, 24% incorrectly inferred that increasing self-esteem causes a decrease in achievement, similar to the 38% of participants in the experimental condition who correctly inferred that self-esteem causes a decrease in achievement.

Study 2: Self-esteem and Academic Achievement

	Self-esteem Manipulated		*Self-esteem Measured*	
	↑ Self-esteem ↑ Achievement	↑ Self-esteem ↓ Achievement	↑ Self-esteem ↑ Achievement	↑ Self-esteem ↓ Achievement
Achieving academically causes an increase in students' self-esteem.	67%	24%	74%	56%
Achieving academically causes a decrease in students' self-esteem.	4%	0%	0%	32%
Increasing self-esteem causes an increase in students' academic achievement.	**82%**	21%	70%	56%
Increasing self-esteem causes a decrease in students' academic achievement.	7%	**38%**	0%	24%
Students who have higher self-esteem tend to do better on academic achievement tests.	**78%**	28%	**83%**	52%
Students who have higher self-esteem tend to do worse on academic achievement tests.	7%	**38%**	0%	**36%**

- In the non-experimental vignettes, the causal arrow is bidirectional. Self-esteem might influence achievement; achievement might influence self-esteem. Participants, then, should be just as likely (or unlikely) to infer causality in the two directions. Indeed, participants presented with a non-experimental positive association were as likely to incorrectly infer that self-esteem increases achievement (70%) as they were to incorrectly infer that achievement increases self-esteem (74%). Participants receiving a non-experimental negative association were less likely to make incorrect inferences about negative causal effects of self-esteem on achievement (24%) and of achievement on self-esteem (32%). Instead, they flipped the direction of the effect and incorrectly concluded that self-esteem causes an *increase* in achievement (56%) and that achievement causes an *increase* in self-esteem (56%). Similarly, for participants receiving the negative association, their notion about how self-esteem and achievement go together biased their interpretation of the association. When provided with inferences that merely restate the association, only 37% selected the correct restatements (compared to 82% of participants who had received the positive association).

In addition, participants who received the vignettes depicting the negative association were just as likely to select an incorrect restatement that described the association as positive (39%). Clearly participants' beliefs about the relationship between the variables holds weight, even in the face of contrary findings.

Discussion:

Participants' pattern of inferences in the three studies was consistent. First, across studies participants drew causal inferences from non-causal data just as often as they did from causal data. Second, they were more likely to infer directions of causality (positive versus negative effects) that coincided with common-sense notions about the topic. Third, participants favored certain causal paths over others. For example, as shown in the Study 1 handouts, participants were more likely to infer that video game playing causes an increase in aggressiveness than to infer that aggressiveness causes an increase in video game playing. Finally, participants consistently chose the restatement of the probabilistic association they read about when the direction of the association coincided with their intuitive notions about how the two variables are related.

Despite that most participants favored statements that coincided with their preconceived notions, not all participants selected the inferences that were intuitive and correct on the basis of the vignette. Perhaps these participants who were unwilling to select the restatement of the association represent the percent of people who do not understand that the associations are probabilistic rather than deterministic. They may think that saying "students who have higher self-esteem tend to do better on academic achievement tests" is synonymous to saying that "any student who has high self-esteem will do better on academic achievement tests." Future research may want to identify the mindware gaps that explain why some people view exceptions to a trend as refuting that trend.

Our findings raise concern about the tendency of media reports to conflate correlation and causation. If the average reader of research findings is prone to conflate correlation with causation, then those delivering the news must do their best not to mislead the already susceptible reader. Many media headlines advertise the "effects" or "consequences" of one variable on another when the research cited is non-experimental. These causal claims about correlational data often occur in domains about which readers have strong emotions or opinions, which can make them even more susceptible to these biases. Scientists and educators should focus on ways to intervene and enhance people's ability to reason about causal and non-causal trends.

References:
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Acknowledgements:
We thank the Office of Research and Sponsored Programs for their support of this project, especially via a 2013 Summer Research Experiences for Undergraduates grant. We also thank Dr. Mary Beth Leibham and members of the IDEP lab for their feedback on this research.