Post-lecture Questions III.4 – Causation from Correlations

Study Questions

What is the definitive (i.e., definition-based) difference between experiments and correlational studies?

What difference in labeling do we use to keep the above difference clear? [Hint: first think about the labels given to the manipulated and measured variables in an experiment.]

Assume that you have found a significant correlation between X and Y. What are the three possible explanations for this? [In other words: what are the three possible cause-and-effect relationships that fit this finding?]

Now assume that the particular cause-and-effect relationship that you are interested in is X causes Y. What are the labels for the other two possibilities?

How, in general, do you determine whether X causes Y or Y causes X? [Give the name for the procedure, then say what new data are needed, then say how the data are interpreted.]

How, in general, do you determine whether Z causes both X & Y? [Give the name for the procedure, then say what new data are needed, then say how the data are interpreted.]

1. Assume that there's a strong correlation between X and Y (e.g., depression and anxiety). Which of the following **might** be true?
   (A) X causes Y
   (B) Y causes X
   (C) some other variable causes both X and Y
   (D) *all of the above*

2. If Z causes both X and Y, but X doesn't cause Y, and Y doesn't cause X, then _______ .
   (A) the correlation between X and Y must be zero
   (B) any correlation between X and Y would be spurious
   (C) *both of the above*
   (D) *neither of the above*

Answers to Study Questions

The key difference between experiments and correlational studies concerns the variable that is thought to be the cause. In an experiment, this must be a manipulated variable – i.e., a variable that is completely under the control of the experimenter. In a correlational study, the cause is a measured variable, just like the effect.

The manipulated variable in an experiment is called the "independent variable." The measured variable in an experiment is called the "dependent variable." Both variables in a correlational study are measured, so we name them in terms what we think they are doing, instead of what they are. The one that we think is the cause (of the other) is often called the "predictor variable" and the one that we think is the effect (of the other) is often called the "predicted variable."

A correlation between X & Y can be explained as: (1) X causes Y, (2) Y causes X, or (3) Z causes both X & Y.

If you are interested in whether X causes Y, then the possibility that Y causes X, instead (which is called "reversed causation"), illustrates the "directionality problem"; while the possibility that some other variable, Z, causes both X & Y illustrates the "third-variable problem."

To determine the direction of a causal relationship, you run a cross-lagged study. You measure both variables at two (or more) points of time, using the same subjects at both times so that you now have (at least) two pairs of X & Y for every subject. If X is the cause of Y, then the correlation between X-at-time-1 and Y-at-time-2 (hereafter: X1-Y2) will be stronger than the correlation between Y-at-time-1 and X-at-time-2 (Y1-X2). On the other hand, if Y is the cause of X, then the Y1-X2 correlation will be stronger than the X1-Y2 correlation. In general, because we think that causation always happens forward in time, the cause should be measured *before* the effect to get the best correlation.

To test whether a third variable is responsible for an observed correlation – i.e., to test whether your X-Y correlation is spurious – you need to first identify what third variable is. Then you run a new study (or have a new session with your original subjects) in which you measure the third variable, together with the original two variables, and conduct a covariance analysis (which removes any part of the target relationship that can be explained by the covariate). The new correlation between X & Y is called a "partial correlation (with respect to the covariate)." If the partial correlation is just as strong as the original, then the third variable did not cause the X-Y correlation. If the partial correlation is zero, then the original X-Y correlation was probably spurious. Anything in the middle is a mix of the two.

> If you'd like to know how to express partial correlations in symbols, it done by putting a **p** in front of the **r** and then listing the covariates in the subscript after a dot. For example, the partial correlation between X & Y with respect to Z is written $pr_{XY \bullet Z}$
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> To be clear: if $pr_{XY \bullet Z} = r_{XY}$ then Z is not the cause of the X-Y correlation; however, if $pr_{XY \bullet Z} = 0$ then the X-Y correlation could very well be entirely spurious

1: D: A correlation between X & Y can be explained as X causes Y, Y causes X, or some other variable causes both X and Y.
2: B: If Z causes both X and Y, but X doesn't cause Y, and Y doesn't cause X, then any correlation between X and Y would be spurious. Note, the answer is not C because A is definitely not true. If Z causes both X and Y, then the correlation between X and Y will almost defintely not be zero.