The Logic of Causal Order

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Last revised February 15, 2015

[NOTE: Toolbook files will be used when presenting this material]

*** *First, go over the handout on variable names and conventions* ***

Adapted from Davis, The Logic of Causal Order

Two variable case (p. 9): Variable X is a cause of variable Y when

- Change in X (sooner or later) produces change in Y

- or (because some X's don't change) Ys tend to line up with fixed values of X.

EXAMPLES: (1) Employment is a cause of earnings: People who get (lose) jobs increase (decrease) their earnings.

(2) Race is a cause of party affiliation: Blacks are more likely to become Democrats than are whites

(3) Education is a cause of occupational prestige: People who hold college degrees are more likely to get high status jobs

Note that to say "X is a cause of Y" is not to say "X is the cause of Y"; and, correlation alone does not prove causation.

For the two variables, X and Y, we can distinguish among 4 possible relationships.

(1)	X —> Y	X might influence Y but Y does not influence X
(2)	Y —> X	Y might influence X but X does not influence Y *** *Note that Davis has a typo here, p. 10*
(3)	X —> Y X <— Y	X and Y might influence each other
(4)	X <—> Y	X and Y might show statistical coordination (correlation), but for present purposes I do not assume anything about direction of effects.

Note that we are talking about potential flows here; the effect does not have to exist, but if it does exist the effect is in the indicated direction. (Example: Race may affect party affiliation, but party affiliation definitely does not affect race.)

The first two types of relationships are asymmetrical, the third symmetrical.

The fourth relationship says nothing about causality; X and Y are related or are not related for whatever reason, we don't claim anything about either variable affecting the other.
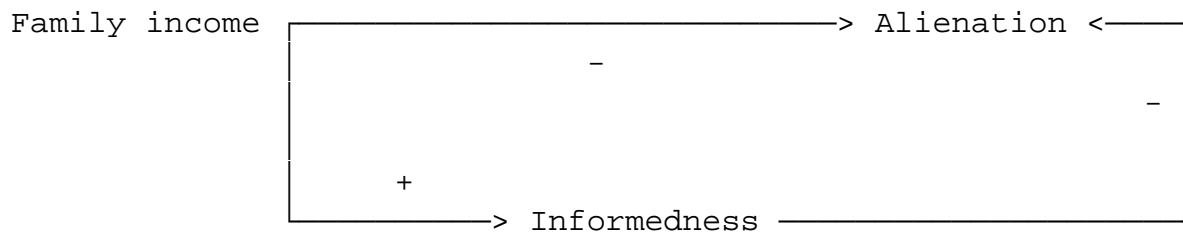
Let's now consider how the possible causal relationships among variables can become more complicated when we look at three variables simultaneously. Consider the hypothesis that how well-informed you are affects your level of political alienation. Graphically, this hypothesis can be expressed as

INFORMEDNESS —> ALIENATION

It might also be important to consider the effects of economic background, since economic background may be related to both informedness and alienation. But, how would we fit it in? Lets consider some possibilities:

(1) "Everything is related to everything else" - Family Income affects Informedness, and Family Income and Informedness both affect Alienation. (Family Income --> Informedness --> Alienation, and Family Income --> Alienation) Or, Family Income and Informedness are correlated (for whatever reason) and both affect Informedness.

Figure 1. Full Model

```
Family income ┌─────────────────────────────────> Alienation <─────┐
              │                      _                              │
              │                                                    _│
              │                                                     │
              │      +                                              │
              └──────────────> Informedness ────────────────────────┘
```
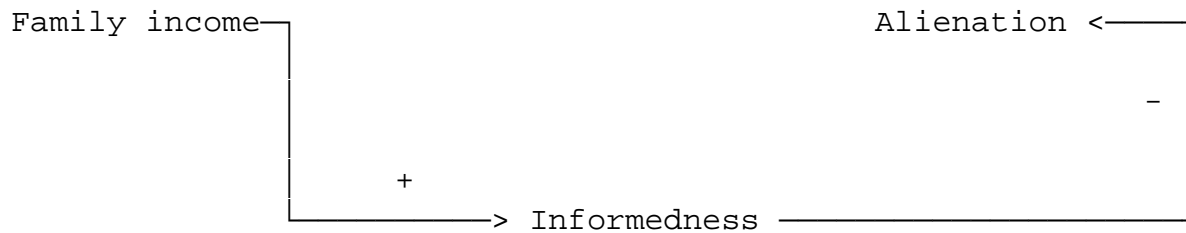
Here, we say, Family Income and Informedness both directly affect Alienation.

One of the things you will learn, however, is that when building models, the real trick is not to figure which causal relationships are there, but which ones are not there.

(2) Family Income ——> Informedness ——> Alienation; no direct effect of Family Income on Alienation.

```
Figure 2. Indirect effects

Family income┐                                    Alienation <──────┐
             │                                                      │
             │                                                   ─  │
             │                                                      │
             │        +                                            │
             └────────────> Informedness ─────────────────────────┘
```
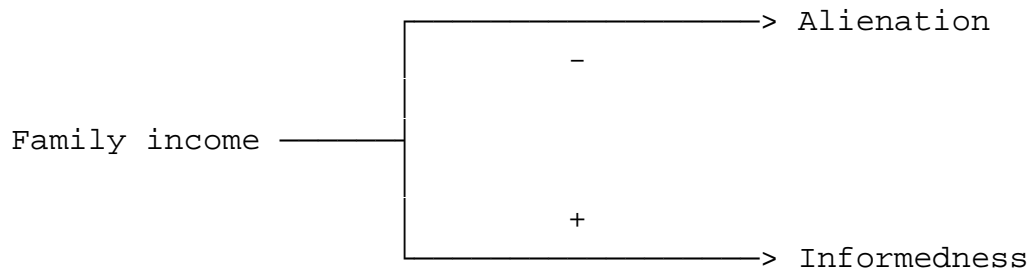
Here, we say the effect of Family Income on Alienation is <u>indirect</u>; or, that Informedness <u>mediates</u> the influence of Family Income on Alienation; or, that Informedness is an <u>intervening</u> variable; or, informedness is the <u>mechanism</u> through which family income affects alienation. Once you <u>CONTROL</u> for Informedness, there is no direct effect of Family Income on Alienation. This does not mean that Family Income is irrelevant for your Alienation, it just means that Family Income affects Informedness which in turn affects Alienation.

To put it another way, the model says that how well-informed you are affects how alienated you are. Further, how well informed you are is determined, in part, by your economic background; those from wealthier backgrounds will tend to be better informed than those who are not so wealthy. HOWEVER, the model does NOT say that economic background perfectly determines how informed you are. It is possible for two people from different backgrounds to both be equally well-informed.

(3) Family Income --> Informedness, Family Income --> Alienation, no effect of Informedness on Alienation.

```
Figure 3. Common cause; Spurious Association

                                       ───────────> Alienation
                     ┌───────────────┘
                     │            -
                     │
Family income ───────┤
                     │
                     │            +
                     └───────────────
                                       ───────────> Informedness
```

This says that, once you <u>CONTROL</u> for Family Income, there is no relationship between Informedness and Alienation. Informedness and Alienation only appear to be related, because both increase or decrease as Family Income increases or decreases. Any observed relationship between Informedness and Alienation is spurious.

*** *Work through the handout on Figures for the Logic of Causal Order; then continue with the following explanations.*

<u>More comments on figure 2:</u> The model says that, IF you have a person from a wealthy background and a person from a poor background who are equally well-informed, the two are EQUALLY likely to be alienated or non-alienated; that is, GIVEN two people that are equally well-informed, the rich person is just as likely to be alienated as the poor person.

To put it yet another way: Suppose we had two people, one of whom came from a family that made $10,000 a year and the other from a family that made $50,000. According to the model, we would expect the person from the family who made more to be better informed, and hence less alienated.

Suppose further, however, that we had two people who were equally well informed. According to the model, the one from the wealthier family would be just as likely as the one from the poorer family to be alienated.

Suppose, on the other hand, we had a well-informed person from a family that made $10,000 a year, and a poorly informed person from a family that made $50,000. According to this model, the poorer but better informed person would be less likely to be alienated.

To sum up: According to the Figure 2 model, those from wealthier economic backgrounds are more likely to be well-informed. A person who is better informed is less likely to be alienated. GIVEN that two people are equally well informed, the one from the wealthier background is just as likely to be alienated as the person from the poorer background.

EX: status attainment literature argues that the effect of socioeconomic background on educational attainment is fairly large - but after that the effects of SES background on later life events are very small. That is, parents' money and so on can help you get started, but after that you have to earn things on your merits. This does not deny the importance of SES, it just clarifies how SES produces advantages or disadvantages that persist from one generation to the next. Thus, if your family is better off, you have a better chance of getting off to a good start in life; but if you come from a poor background and somehow manage to get off to a good start anyway, then your chances of success later in life are about as good as the person from a better-off background.

Family SES ——> Educ attainment ——> Later life success

More comments on Figure 3: According to this model, people who are better off will be both better informed and less alienated. Thus, people who are better informed will tend to be people who are less alienated - their will be a negative correlation between informedness and alienation. Their informedness, however, has no causal effect on their alienation. If we had two people from identical economic backgrounds, the one who was better informed would be just as likely to be alienated as the individual who was not so well informed. Or, if we had one person from a family that made $10,000 a year who was very well-informed, and another person from a family that made $50,000 a year who was poorly informed, according to this model, the poorly informed person who made $50,000 a year would be less likely to be alienated.
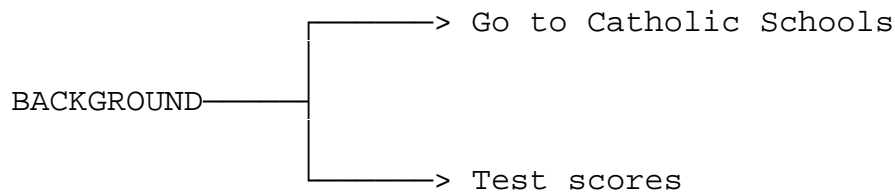
To sum up: According to the model of Figure 3, better informed people will tend to be less alienated; alienation and informedness are correlated. However, their lower degree of alienation is not due to their being better informed; rather, it is because of their economic background. Those who come from more prosperous backgrounds will tend to be both better

informed and less alienated. Once you take economic background into effect, you see that there is no effect of informedness on alienation.

EXAMPLE: Studies show that Catholic school students tend to score higher on standardized tests than do students from public schools. This does NOT necessarily mean that Catholic schools do a better job of educating their students than do public schools, i.e., it need not be true that

CATHOLIC SCHOOL ATTENDANCE ——> TEST SCORES

It could be that background characteristics of the students cause them to (a) attend Catholic schools and (b) do better on standardized tests. (e.g. Being Catholic may make you more likely to attend a Catholic school, and Catholics may also be smarter and more motivated which leads them to do better on standardized tests, i.e.,

```
                        ┌──────────> Go to Catholic Schools
                        │
BACKGROUND──────────────┤
                        │
                        └──────────> Test scores
```

(4) Informedness --> Alienation, but the strength and/or direction of the effect is dependent on Economic background.

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Figure 4. Interaction effects

Family Income    ─────────┐
                          │
                          │
Informedness     ─────────┴────────> AL
```
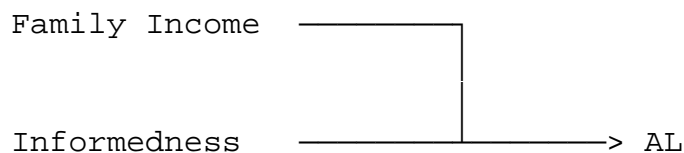
This model provides an example of an <u>INTERACTION</u> effect; there is an interaction between Informedness and Family Income; or, economic background moderates the effect of informedness on alienation.
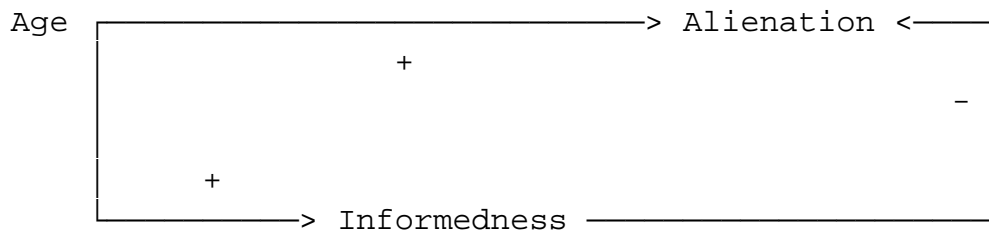
EXAMPLE. Informedness may affect Alienation ONLY among those who are poor off, i.e. if you come from a poor family, how well-informed you are might affect how alienated you are, but if you come from a wealthy family how well-informed you are may have no effect on alienation.

EXAMPLE. Perhaps a better example would be if we substituted AGE for Family Income. We might suspect that, if informedness does affect alienation, it takes a while to do so. Thus, informedness might not affect alienation for young college students, but it could have an effect with older people.

EXAMPLE. Researchers often look at the effect of SES on fertility - the higher the SES, the lower the fertility tends to be. It could, however, also be that the effect of SES is contingent on desires - higher SES will help you to achieve your goals, regardless of whether your goal is to have children or to not have them.

(5) AGE --> Informedness --> Alienation, AGE --> Alienation. Age positively affects informedness, and also has a positive effect on Alienation; that is, age causes you to become more alienated. At the same time, age leads to better informedness, which leads to less alienation.

Figure 5. Suppressor effects

```
Age   ┌──────────────────────────────────> Alienation <──────┐
      │                      +                                │
      │                                                      │  −
      │                                                       │
      │          +                                            │
      └──────────────> Informedness ─────────────────────────┘
```

Here we have an example of <u>suppressor</u> effects. When suppressor effects are present, X has a certain influence on Y, but X also sets off other causal chains that tend to dampen or undo the effect. In this case, on the one hand, the direct effect of age is to make you more alienated; on
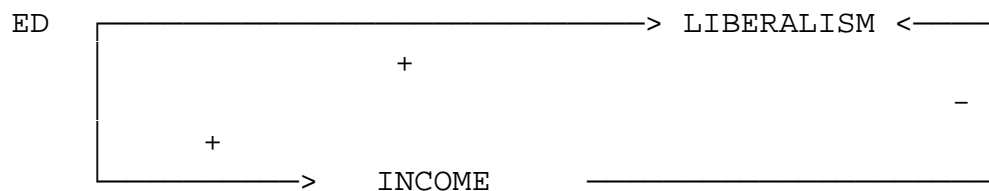
the other hand, age causes you to become better informed, which makes you less alienated. Thus, according to this model, all other things being equal, being better informed makes you less alienated. However, if you are better informed, odds are that you are also older, and your greater age will tend to increase your alienation. Thus, the effects of age and informedness may tend to offset each other, and it could create the appearance that neither variable has an effect on alienation.

Suppose, for example, you had two people of the same age. According to this model, the one who was better informed would be less likely to be alienated.

Suppose you had two people who were equally well informed. According to the model, the older person would be more likely to be alienated.

NOTE: How might you test this with a sample of students? Split the sample by age, or by informedness.

EXAMPLE. Voting research shows that educational attainment tends to move one toward a liberal position on social issues. However, education also leads to more income, and increased income tends to make one less liberal.

```
ED     ┌─────────────────────────────────> LIBERALISM <──────┐
       │                    +                                 │
       │                                                   ─  │
       │   +                                                  │
       └──────> INCOME                   ─────────────────────┘
```

*** *Work through the handout on Suppressor effects at this point* ***

<u>Some cautions to keep in mind:</u>

1. Just because things do not always come out the way a model would seem to predict does NOT mean that the model is invalid for some individual or group of individuals, or that the causal chain has been "broken". (e.g., as in when the person from the wealthier economic is not better informed than the person from a poorer background, even though the model says wealthier

people will tend to be better informed). Remember, models talk about "tendencies" - they usually deal with probabilities rather than certainties.

For example, suppose I had a coin, and I told you it was manufactured in such a way that, when you flip it, about 70 percent of the time it will come up heads. If you flip then coin and it comes up tails, you will not immediately infer that the manufacturing process is defective; you expect tails about 30 percent of the time. Indeed, if you flipped the coin 100 times, and the favorite (heads) came up every time, you would probably conclude that the process was defective because you weren't getting enough tails.

The same sort of analogy holds for our sociological models. Our models might say that people from wealthier backgrounds will tend to be better informed than people from poorer backgrounds - but, just as in the case of our coin toss, this will not always be the case. How often this will be the cause depends on how strong the effects of economic background are. Note that we've only talked about direction of effects (positive or negative) but you can also talk about how strong effects are - are people from wealthier backgrounds better informed than people from poorer backgrounds 51 percent of the time, 70 percent of the time, 90 percent, etc. The stronger the effect, the less likely we are to come up with so-called "exceptions."

To indicate that are models are not completely deterministic, we frequently draw an extra arrow pointing to each dependent variable. This arrow represents the other influences which may be affecting an outcome. We usually assume that, whatever these influences are, they will just as often increase the value of the dependent variable as they will decrease it. (i.e., for every time that the omitted variables cause an individual to be better informed than we would usually expect, there will be another time when the omitted variables will cause an individual to be less informed).

(Of course, if we do seem to come up with a lot of "exceptions", this may indicate that our model needs to be respecified. In particular, if the exceptions seem to be concentrated among some particular subgroup (e.g. blacks, females) we may suspect that the model is not adequate for representing their behavior; perhaps interaction terms are called for, or even more radical

respecifications. Nevertheless, "exceptions" do not indicate, in and of themselves, that the model is misspecified.)

2. It is important to realize that "spurious" is not the same as imaginary. If economic background causes both informedness and alienation, there will be an association between informedness and alienation, even if neither variable has an effect on the other. Further, for purposes of prediction, spurious associations can be invaluable. For example, if all we knew was that one person was better informed than another, it would make sense to predict that the better informed one was the less alienated. Another example: it is a scientifically verifiable fact that the average height of brothers of tall sisters is greater than the average height of brothers of shorter females. If you had to pick your roommates brothers or sisters out of a crowd without having ever met them, you could probably do so. There is no causal relationship here, in that one sibling affects the height and appearance of another. Rather, each's appearance is a function of their parents, and given that "common cause", you can make predictions.

ADVANTAGES OF CORRECT MODEL SPECIFICATION

Given that spurious relationships can provide us with useful information, particularly with regards to prediction. What are the advantages to be gained from specifying models correctly? Given that an association exists, why bother with figuring out why it exists?

First, sometimes we aren't able to detect an association between variables unless we have specified the causal relationships correctly. For example, when we have "suppressor effects" it can appear that two variables have little or no association with each other, when in fact the association could be quite strong, but hidden by the effects of other variables. (This is one thing you have to keep in mind when considering the statement that covariation is necessary for causation: the statement is true, but you have to realize that covariation may be hidden by suppressor effects.)

EX: Effect of education on liberalism

Second, properly specified models can improve the accuracy of our predictions. We saw that, for some of our models, there was a positive association between information and alienation; yet, in some cases, the better informed person was not the least likely to be alienated; rather, it was the person from the wealthier economic background. By knowing how variables are interrelated, we can take maximum advantage of all available information for making predictions (which is particularly important when we know values for more than one variable).

EX: Economic decision-making
       Examples given for informedness and alienation

Third, if we want to change behavior or outcomes, knowing what the real causal relationships are can be crucial.

EX: Suppose we theorize that informedness affects alienation, when in fact alienation affects how well informed you are. We could pour billions of dollars into a public information program, and not affect the level of alienation one bit. (Likewise if Family Income affects Informedness and Alienation, and Informedness does not affect Alienation).

EX: Suppose we wanted to improve student's test scores. Based on the higher test scores of students who attend Catholic schools, we might decide to create incentives that encourage parents to send their children to private rather than public schools. If, however, selection factors are the only reason Catholic students score high than public school students, then getting more students into Catholic schools won't achieve higher test scores.

EX: Suppose we want to stop cancer. Suppose that, in reality, smoking doesn't cause cancer; instead, lifestyle is a common cause of both smoking and cancer. Efforts to stop smoking would produce no benefits and would needlessly harm the tobacco industry.

EX: A few years ago, there was a controversy over infant formula; the claim was made that a million babies a year died from it. The formula companies countered by arguing it was poverty and poor living conditions that were the culprit; infant formula was actually helpful, not

harmful; that is, they argued that the negative correlation between infant formula use and death was spurious, and that income was the real cause of the association. Clearly, big stakes are riding on being right here. If infant formula causes death, then its continued usage is harmful; but if formula is actually helpful, discontinuing its use will be harmful.

<u>Fourth, correct model specification can help us identify the most efficient means for changing behavior or outcomes.</u>

EX: Suppose economic background affects informedness, which in turn affects how alienated you are. If you want to reduce alienation, you can either spend billions improving economic backgrounds, or you can spend millions on a public education program.

EX: If, as status attainment models argue, economic background affects education achieved which affects first job, if you can find some means to increase educational opportunities for everyone you may be able to reduce social inequality.

EX: Suppose going to a Catholic school really does cause students to tend to learn more. A public school administrator might want to know what their secret to success was. Why do Catholic school students do better? If you can figure out why, then perhaps you can copy those practices in the public schools (e.g. tougher discipline, greater concern for the students, moral atmosphere, higher standards, etc.).

Also, as Davis notes, proper model specification can help to indicate just how tough your job is. The relationship

X1 —> X2 —> X3 —> X4

is easier to deal with than

X1 —> X2 —> X3 —> X4, X1 —> X3, X1 —> X4, X2 —> X4