Simultaneous Causation

Suppose we have collected some data from observing a person standing with an umbrella in a blowing rain. For simplicity of discussion, let us suppose that the density of the rain and the force of the wind remain constant while only the direction of the wind varies, changing from one point of the compass to another as the person stands there trying to keep a dry face.

Let Y = amount of rain in the face per unit of time.

X = angle of umbrella stem to the direction of the wind.

The first statement of our theory is that the amount of rain in the face depends on the angle of the umbrella:

$Y = aX + b$.

Here **a** and **b** serve to convert units of angle into units of rain in the face per second and also to incorporate constants such as the density of the rain, the force of the wind, the diameter of the umbrella, and the distance of the umbrella from the face. Those are all physical constants. They could be evaluated using a stationary dummy instead of a person.

The physical link here between the angle of the umbrella **X** and the rain in the face **Y** is the wind carrying the rain to the face, the amount arriving there being whatever is not diverted by the umbrella. No behavior intervenes once the angle of the umbrella is set. So it seems, at least, at this point. Suppose we evaluate the constants and get

$$Y = 4X + 5.$$

Now let us look at the link from the face to the umbrella. The person feels rain on one side of the face or the other as the wind shifts direction, and the person moves the umbrella accordingly. If the person acted instantaneously and was perfectly accurate in pointing the umbrella, the person would get almost no rain in the face. As soon as one drop hit the face, the umbrella would turn just enough to block the next drop.

But let us say the person is not that sensitive to droplets on the face, the muscle action takes a little time, and the person sometimes moves the umbrella a little too far, or the wind suddenly reverses its shift, and the person lags a little in following. Furthermore, the droplets do not always blow in a straight line; the air is turbulent past the edge of the umbrella, and it becomes physically impossible to avoid some of the swirling droplets just by moving the umbrella. So some rain strikes the face. Nevertheless, most of the rain can be held off if the person is sufficiently sensitive and skillful.

The amount of rain that gets past the umbrella to the face will depend largely on the person's behavior. More exactly, it depends on the interaction of the person with the physics of the situation. The amount will vary from person to person because of differences in overall sensitivity and skill. But the amount will also vary from moment to moment for any one person because of irregularities in the shifting of the wind, because of changing turbulence, and other difficulties that overwhelm the capabilities of muscles and umbrella.

Let us use **D** to stand for what the person does to change the angle of the umbrella. Then the angle **X** of the umbrella will follow from **Y** and **D**, its two determinants:

$$X = aY + b + D.$$

Here **a** and **b** again serve to convert units. Suppose we evaluate the constants and get

$$X = 1 - 2Y + D.$$

That is the second link in our theory. We can now solve the two equations simultaneously to find out how **X** and **Y** each depend on the behavior **D**. But before doing that, I should mention that I have omitted a couple of characteristics of the situation from the equations.

First, the amount of rain in the face cannot follow $Y = aX + b$ for any angle **X** whatsoever. Once the umbrella has moved to an angle large enough that it is blocking no rain at all, the rain hitting the face is at maximum. No more rain is going to hit the face as the umbrella moves to wider and wider angles. That equation, therefore, should be specified to hold only up to that maximum. Second, the angle **X** should be specified as an absolute deviation; we expect the same amount of rain in the face whether the umbrella is too far either to the left or the right.

With those small matters out of the way, let us solve the two equations simultaneously. We get

$$Y = (4/9)D + 1$$

and

$$X = (1/9)D - 1.$$

At the outset, it seemed obvious that the angle of the umbrella could be set only by the behavior of the person. Neither the rain, the wind, nor the umbrella itself could set its angle. So we put **D** into only the equation for **X**. But now that we have solved the equations simultaneously--for both must hold at every moment--we see that both **X** and **Y** depend on **D**. And that, after all, is the way it should be as the person stands there moving the umbrella to keep the rain off the face.

Now I must confess that I have delayed an important part of the theory. The two equations just above tell us how **X** and **Y** depend on **D**, but that is not enough to predict **X** or **Y**. Will **D** take on any value whatsoever? Will it vary randomly? No, what we say about **D** is the crux of the matter; what we say about it is the prediction we make of behavior. And actually, I have been saying a lot about it implicitly. I have been writing as if the person would always act to keep as much rain as possible off the face; that is, as if **Y** = 0. Let us add that specification as the third equation in the theory.

BILL: Here I have gone astray, and I can't figure out what I have done wrong. I can't seem to latch on to how to get the reference signal for zero rain in the face into the three equations. Actually, Y = 0 can't be the right way to do it. If I specify Y = 0, then I can substitute that value into the equations that come out of the simultaneous solution, and I get constants: D = -(9/4) and X = -(5/4). It doesn't seem right to me that everything should simplify to constants. Does my trouble lie in the fact that I am writing static equations instead of differentials? Or have I misconceived the whole thing, or what? I'll go ahead and write as if Y = 0 _is_ the right thing to say so that you can see the kind of argument I want to present. But I hope you can tell me how to get the equations to work right. AND THANKS.

Now you can see that the kind of theory I am putting into the three equations cannot be seen in any one of the equations singly. The statement Y = aX + b is not about behavior at all; it is about physics. The statement X = aY + b + D is in the form of S-O-R. It is the linear "model." It is insufficient, alone, to predict the behavior of any one person. And the statement Y = 0 is about a particular individual. The theory lies in the choice of the three equations to be solved simultaneously. The theory is about what is proper to be observed in juxtaposition. The theory asks what, given certain physical events in the environment and a certain link between the person and the environment, will be seen to be _held_ _constant_ by the person.

The theory (the three equations together) says that _if_ we have a person who wants to keep a dry face (Y = 0), and _if_ the environment threatens rain in the face (Y), and _if_ the environment and the person's connection to it offers a way of keeping the rain off the face (D and X), then what we should predict will be given by the simultaneous solution to those three equations.

The theory is not a correlational one about input and output. We do not test it by fitting data to each linear equation in turn. As I said earlier, if we collected data for the equation for **Y**, we would be studying physics, not behavior, and the equation would be matched by the data very closely except for the effects of turbulence in the flow of air.

If we were to take the equation for **X** by itself, we would have no way to evaluate it for a single individual; it allows anything to happen. Using the method of relative frequencies, we might calculate a multiple correlation. To evaluate **Y**, we might ask each person, "How much rain in the face do you like?" We might then note the angle **(D)** at which the person holds the umbrella.

BILL: That doesn't sound right, either.

After we had done that with 30 or 100 people, we could calculate the correlation. That would tell us how the data fell in that collection of people, but it would not tell us what was going on in any single person.

As to the equation Y = 0, we might ask a hundred people how much rain they liked in their faces, we might find that most of them said they didn't like it at all, or not usually, and we might postulate a universal "tendency" not to like rain in the face. That would not help us, either, to predict the behavior of any particular person.

The three equations together are meant to predict the behavior of any particular person. The crux of the matter is the person's <u>purpose</u>: Y = 0. We must <u>not</u> assume that any person we come across will prefer zero rain in the face. A person with a freshly made up face, standing on a street corner trying to get a taxi to take her to a board meeting, might worry about every drop. The same person on a summer's day at the beach might enjoy the warm rain on her face. The theory in the three simple equations does not undertake to predict the purposes people have. It says simply that <u>if</u> the person wants to keep a completely dry face, then the action will be as specified. It says that the action is a resultant of the simultaneous requirements of the physical contingency $Y = aX + b$, the availability of the umbrella to do something about **Y**, and the internal standard for $y = 0$. The test of the theory is to see whether the person does indeed hold **Y** at zero.

We do not see linear causation here. The input perception of rain on the face does not produce one particular act. You cannot even say that a certain amount of rain on a certain part of the face produces a certain amount of arm motion. The amount of arm motion will depend on how fast the wind direction is changing, including sudden reversals of change. And if we wanted to think strictly in the S-O-R mode, we should think of the output not as arm motion, but as muscle tension, and that will vary even though the arm motion is the same, because of the changing tensions needed to move the umbrella to a particular position as the shifts of wind press upon it.

The arm motion is not a series of distinguishable acts. The motion is continuous until the rain in the face reaches zero. Then the muscles reverse against the inertia of the arms and umbrella to stop the motion. But the muscles do not then stop working. They now act to hold the umbrella in place and the rain in the face to zero. The change in arm position is now zero and so is the rate of change, and the muscles are working to maintain that state. The number zero is as good a quantity as any other as far as the muscles know anything about the matter, and that zero motion maintains the zero rain in the face the person wants.

Once the rain has begun, there is no clear unit of S-O-R here. Action is continuous, and the causations between **X** and **Y** are simultaneous and circular, not linear and sequential.

Now let us pretend the causation is linear and that the person positions the umbrella through a series of S-O-R sequences. In the first S-O-R sequence, a splat of rain in the face causes a motion of the umbrella. In the second, the motion of the umbrella causes a cessation of the rain in the face, and so on. If we were to use our two equations in alternation instead of simultaneously, what would we predict?

Let us begin with no rain in the face; that is, with Y = 0. Then we would predict

$$X = 1 - 2Y + d$$

$= 1 - 2(0) + D$

$= 1 + D.$

Taking $X = 1 + D$ for the second S-O-R, we would predict

$Y = 4X + 5$

$= 4(1 + D) + 5$

$= 9 + 4D.$

Taking $Y = 9 + 4D$ for the third S-O-R, we would predict

$X = 1 - 2Y + D$

$= 1 - 2(9 + 4D) + D$

$= 17-7D$

And so on. The fourth S-O-R would give $Y = 73 - 28D$, the fifth $X = -145 - 55D$, and the sixth $Y = -575 - 220D$.

You can see that we are getting new equations at every cycle. If **D** varies only a little up and down, as it would, then this alternating use of the equations in S-O-R fashion would predict larger and larger oscillations of umbrella angle and rain in the face as the cycles continue--an absurd prediction. A reasonable prediction about this person standing in the rain must be made from the simultaneous solution of the equations.

Nor could we make a reasonable prediction from any of the equations singly. If we were to use the equation for rain in the face **Y** as a function of umbrella angle **X**. we would learn nothing about the behavior of the person; we could study a motionless dummy, varying the angle of the umbrella ourselves to get readings of rain in the face. If we used a person, we would have to take very fine readings, because the person would keep the umbrella pointed very closely into the wind (given a constant force of wind, not sudden gusts). But any scatter of the data points would be due to turbulence. The fall of the data points would be due entirely to the physics of the situation. If we were to use the equation for **X**, we would be in the situation I described earlier. The equation would not enable us to predict the behavior of a person taken singly. We would be forced into a correlation over people. That would be pretty silly, since the internal standards for rain in the face would differ among the people, and the direction of the wind when we happened to measure angles would be different.

In sum, the assumption of simultaneous causation fits the behavior of living creatures, one at a time, every one at every time. The assumption of linear causation does not. The thing to predict is the perception the person holds constant (no rain in the face), not a change in particular action (tensing of muscles) following upon a change in particular stimulation (rain in the face). The latter kind of prediction in <u>not</u> invariant over persons. It changes with the internal standard (Doesn't that rain feel good?). It changes with the environmental events that disturb the perception of input--changes of rain density, gusts of wind, and so on. It changes with the way the person makes use of environmental opportunities--the distance away from the face the person holds the umbrella, the sensitivity and skill of the person, and even whether the person chooses to use an umbrella to keep rain off the face instead of going inside a nearby building.