- A feedback loop is negative if it contains an odd number of negative causal links.

Thus, the polarity (sign) of a feedback loop is the algebraic product of the signs of its links.

As described in chapter 1, and as may be evident from these characterizations, positive feedback loops amplify deviations and destabilize, while negative feedback loops strive to control and stabilize. Negative, in this context, has nothing to do with bad, and positive has no necessary connection to good.

Guidelines for Causal-loop Diagrams

The apparent simplicity of causal-loop diagrams is decep-

them. The following suggestions may help to prevent the more common difficulties.

1. Think of variables in causal-loop diagrams as *quantities* that can rise or fall, grow or decline, or be up or down. But do not worry if you can not readily think of existing measures for them. Corollaries:

   - Use nouns or noun phrases in causal-loop diagrams, not verbs. The actions are in the arrows. (See figure 2.6.)

   - Be sure it is clear what it means to say a variable increases or decreases. (Not "attitude toward crime," but "tolerance for crime," for example.)

   - Do not use causal-links to mean "and then... ."

2. Identify the units of the variables in causal-loop diagrams, if possible. If necessary, invent some: some psychological variables might have to be thought of in "stress units" or "pressure units," for example. Units help to focus the meaning of a phrase in a diagram.

3. Phrase most variables positively ("emotional state" rather than "depression.") It is hard to understand what it means to say "depression increases" when testing link and loop polarities.

4. If a link needs explanation, disaggregate it -- make it a sequence of links. For example, a study of heroin-related crime claimed a positive link from heroin

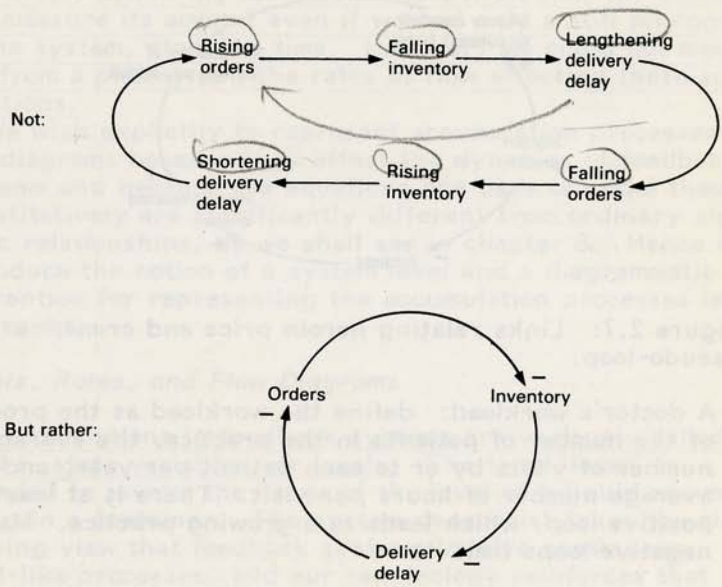

Figure 2.6: Loops illustrating that the action in causal-loop diagrams is best left to the arrows.

price to heroin-related crime. The link is clearer if disaggregated as in figure 2.7 into the sequence of positive links from heroin price to money required per addict, frequency of crimes per addict, and finally heroin-related crime. Some might feel a high price deters addicts and so lowers the number of addicts as it well might, but that is another link (see figure 2.7).

5. <u>Beware of interpreting open loops as feedback loops.</u> Figure 2.7, for example, does not show a feedback loop.

To exercise the understandings developed thus far about causal-loop diagrams, the reader may wish to draw some causal-loop diagrams of feedback loops for each of the following systems:

1. The arms race: find a positive loop and at least one negative loop. Is the structure symmetric for both protagonists?

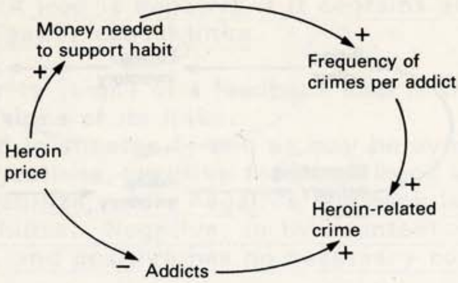

Figure 2.7: Links relating heroin price and crime; a pseudo-loop.

2. A doctor's workload: define the workload as the product of the number of patients in the practice, the average number of visits by or to each patient per year, and the average number of hours per visit. There is at least one positive loop, which leads to a growing practice. Many negative loops limit it.

3. An inventory control system: include orders, an order backlog, shipments, an inventory from which to fill orders, and production to replenish inventory. The structure is likely to contain no positive feedback loops.

4. Some recurring phenomenon: select some repetitive happening with which you are familiar (such as breathing, eating, arguments in a family, colds, business cycles, changing jobs, street cleaning, the rise and fall of civilizations, oscillations in the width of neckties or length of skirts) and sketch one or more causal-loops which seem to account for the recurring pattern over time. (Take care not to use causal links to mean "and then".) You should find at least one negative loop. (Why?)

Accumulations

Causal-loop diagrams treat only implicitly an essential aspect of feedback structure that we have largely ignored up to this point: the notion of accumulation. Wine in a wine glass accumulates as it is poured in. Production accumulates in an inventory that is depleted by shipments. We implicitly acknowledged such accumulations when we noted that some links in causal-loop diagrams should be interpreted as addition or subtraction rather than proportional change. Accumulations are conceptually quite different from the flows