4

cause and effect

Cause and effect may seem straightforward. When cause A happens, effect B follows. And if B happens, that means A has happened. Doesn't it?

As we've already seen, it's not quite that simple. Let's take an obvious and undisputed example of cause and effect. Surely gravity causes objects to fall? However, like all physical laws, it has the unwritten proviso *everything else being equal.* So a feather would not fall in a strong wind, nor an iron bar in a strong magnetic field. (And even something as obvious as the force of gravity depends on the distance between the objects, in other words the relationship between them, so systems thinking must apply there too.) Or take the example of the virus that 'causes' the common cold. Ten people can be exposed to the virus and only one may come down with a cold – the person must somehow have been predisposed, so everything else was not equal. Even physical laws depend on a whole network of influencing factors.

When we think of a cause leading to an effect with everything else being equal, that 'everything else' is actually the larger system that contains the piece you are looking at. The laws of physics, for example, are idealized. They are seen as universal and applicable everywhere, but really they are applicable in their pure form nowhere except in an artificial experimental environment! They do not take into account the context, the environment or the system of influences that surround them. Reality is a lot more complicated than it may seem.

When we come to other types of cause and effect, for example, fast driving 'causes' accidents or unemployment 'causes' crime, the link is even more complex and arguable. There are other, complicating factors involved. We use the same word, 'cause', but these two examples do not depend on any law of physics or logic. We make up causal theories all the time: more police means less crime, more money means a happier life, seat belts save lives or computers make work quicker. They are all debatable. They may be true in the majority of cases, but it is impossible to say they are true with conviction in any *individual* case. Even when we say, 'Cigarette smoking causes lung cancer,' it means there is a very strong statistical link between cigarette smoking and lung cancer, but it is not the single cause, otherwise everyone who smoked would get lung cancer, and they do not. Smoking is one important factor – again, with everything else being equal.

When we are asked to answer a difficult question like 'What causes crime?' we tend to generate a list of factors like poor education, unemployment, law and order policy, housing conditions, opportunity and breakdown of values. We also tend to weigh each factor on the list from the most important to the least important. This has been called 'laundry list thinking'.[1] It assumes a one-way passage of influence from cause to effect and each factor has a fixed relative importance. Systems thinking goes far beyond laundry list thinking by showing circles of influence and that the relative importance of each factor may well change over time, depending on the feedback loops. Causes are dynamic, not static.

It makes more sense to think about *influencing factors* rather than causes. In systems thinking, it is the relationship between the elements that makes them into a cause or an effect. And that relationship depends on the structure of the system.

Ultimately, causes lie in the structure of the system.

Take population increase as an example. Birth rates cause the population to rise, death rates cause a decline, so it is possible to have a positive birth rate but a declining population, if the death rate is greater. So what causes the population to rise is neither one factor nor the other, but the relationship between them.

Finally, do not mistake the leverage point as the cause. We know that we can get a big shift if we change the right element, but that does not mean that element was the cause of the trouble, only that changing it was the easiest way to change the structure of the system because of the knock-on effect.

Three Fallacies

Systems thinking highlights three fallacies of cause and effect:

1. CAUSE AND EFFECT ARE SEPARATE AND THE EFFECT COMES AFTER THE CAUSE.

Cause and effect are different words, but depending on your point of view, they may refer to the same event. Feedforward demonstrates how the effect of a cause can be the cause of an effect. Does the shortage cause the hoarding or the hoarding cause the shortage? It is an impossible question because we are dealing with circles – go along the line for long enough and you will come back to where you started. Which one comes first depends on where you start. We are used to thinking in terms of either cause *or* effect. In systems it can be both.

2. EFFECT FOLLOWS CAUSE CLOSELY IN TIME AND SPACE.

We expect this, and when effect does closely follow cause, it is easier to connect the two, but it is not true in systems. In systems there are always delays and an effect may appear in a different part of the system. So when we deal with systems we have to extend our time horizon and look further afield for cause and effect chains.

Referred pain is an example. Trouble in a part of the body that does not have pain receptors appears as pain in a different part of the body. Heart trouble is often heralded by pains in the left arm. A trapped nerve in the back can cause pains down the leg. The effects of injury in one part of the body can lead to pain in another. An osteopath we know told us about one of her patients with severe neck pain. Treating the neck directly had no effect and it took a few weeks to get to the bottom of the trouble. The patient had hurt her right big toe. This caused her to walk a little awkwardly, shifting the weight from her painful foot, and this put a slightly different strain on her pelvis. The muscle groups in her back and neck tightened to compensate, and this muscle tightening led to the neck pain.

So, looking for the effect close to the cause can lead us to false conclusions. We may also be misled by plausible explanations because we tend to look for events that prove our pre-existing mental models. Remember that in systems thinking the explanation does not lie in different single causes, but in the *structure* of the system and the relationships within it.

Be particularly careful when you see a repeated pattern. Look for the cause in the *pattern*, not in the different explanations on each occasion, especially if they involve blaming external factors. Repetition is a clue to an underlying systems structure:

- Once is an event.
- Twice is noteworthy.
- Three times is a pattern – it will lead you to the systems structure.

One man we know seemed to have appalling luck with his car. He was involved in three accidents in a year and was not even in the car at the time. Other cars just kept running into it. He lived in a residential road and parked his car outside his house. In the first accident, a drunken driver hit the front of his car one evening. Two months later, a sober driver was distracted by a dog running across the road and scraped his car. The third time the car was hit was in heavy rain. Each accident was unique.

The drink, the dog and the rain were certainly important, precipitating causes, but our friend was tempting fate. He insisted on parking right outside his house and this meant parking on the wrong side of the road a few yards from a fairly sharp bend that fed into a much faster road. After the third debacle, and a letter from his insurance company, he parked much further up the road and has been accident free since then.

Now suppose we take the example of a business that regularly misses its sales targets. Maybe the first quarter's figures are adequately explained by the slow post-Christmas market. The poor second quarter is put down to economic factors beyond the company's control. The third quarter was bad because the top salesperson left and the fourth quarter was Christmas, so there was a lot of competition. But the figures will remain bad until the management addresses the underlying factors. To do this they will need to look at the business as a system. The cause could be a combination of low staff morale, inadequate customer service and poor recruitment procedures. The targets may be unrealistically high, but are set high to finance a high borrowing requirement. With systems thinking you can look beyond surface events, however tempting, to the deeper factors that are causing the pattern.

3. THE EFFECT IS PROPORTIONAL TO THE CAUSE.

This idea is true of physical objects – when one car hits another, the damage and the impact depend on the mass and velocity of the cars – but it cannot be generalized to living or mechanical systems. In mechanical systems, you can get a big effect from a small input, like a surge of power when you put your foot on the accelerator of a car, because the system can amplify the effects with reinforcing loops. Cause and effect are even more uncertain in living systems. A huge epidemic can be caused by something as small as a virus. Introducing a single pesticide can have widespread effects on the ecological balance of a region. If you hit a living creature it may run away or turn around and bite you. The energy for the response (the 'effect') comes not from your force but from within the creature and is known as *collateral energy*. It was there before your action (the 'cause').

Sometimes an action has no effect at all, because systems have thresholds. When the stimulus is below the threshold, nothing happens. Once it reaches the threshold, you get the complete response. The animal will not half bite you, depending on how hard you hit it. The response does not vary in proportion to the input.

Conventional physics deals with closed systems, those that can be considered isolated from their environment. In a closed system, the final state is completely determined by the initial conditions. A thermostat is a closed system. Given a temperature setting, you can predict its behaviour. Social systems and living systems are open systems – they maintain themselves from moment to moment by taking in and giving out to the surrounding environment. We take in oxygen and food to maintain ourselves and give out carbon dioxide and waste to the environment. We change constantly in order to stay the same. We do not suffer the same wear and tear as a closed system, we can heal ourselves. One year hence, your appearance will be much the same, yet over 90 per cent of the atoms in your body will be different.

Open systems are extremely sensitive to starting conditions. One morning a traffic jam may not disturb you at all. The next morning a similar jam will be incredibly frustrating. Your reaction will depend on how you felt at the beginning. This is what makes living systems so unpredictable. A very small difference in starting conditions can lead to a very different result given the same stimulus. This is the starting-point for the science of chaos that looks at the behaviour of complex systems.

The Two Sides of Chaos

Chaos and the sensitivity of complex systems to initial conditions are exemplified in the so-called 'butterfly effect', named after a talk given by the meteorologist Edward Lorenz at the Massachusetts Institute of Technology. Its title was 'Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?' The talk came out of his research in 1961, examining computer models of weather patterns. On one occasion, he wanted to examine a sequence at greater length and instead of starting the computer run from the beginning, started it halfway through, typing in the initial conditions from the earlier print-out. When he returned later, the new print-out, which he expected to be exactly the same as the old, was wildly different. Lorenz had rounded up the initial numbers when he typed them in. He had typed in three decimal places instead of six, assuming that the difference was so small as to be inconsequential. The simulation proved that in a complex system such as the weather, a tiny initial change can be magnified into a completely different pattern over time. Short-range weather forecasts are usually reasonable accurate. Long-range forecasts are much riskier.

We can see the same forces at work in the small, seemingly random events that shape our lives. There are many science fiction stories (including the *Back to the Future* films) that play on how life would be different if some small event had not taken place. And small events can have large consequences. A chance telephone call can lead to a meeting that starts you on a new career path. A few words spoken in jest can change your life. And we can never hit the replay button and see how it might have been. We create our future from the small, seemingly unimportant decisions we make every day and we only know which were important when we look back later.

Chaos theory also has a flip side. Events that seem random may have some hidden order if you know where to look. If you take a simple system and apply the same simple change over and over again, it can become very complex indeed. Chaos is not random. The same pattern may be repeated, however deeply you look. For example, the pattern you see when you look at a coastline from the air is very like the pattern you see of a smaller piece of coastline from the ground and the same again when you look even closer. It never smoothes itself out; the pattern is an emergent. These patterns that are repeated at every level are called *fractals*.

There is an apocryphal story of the American psychologist William James fielding a question and answer session at the end of a public lecture on religion and cosmology at Harvard University. Asked by a member of the audience what keeps the Earth from falling through space, he thought it wisest first to ask his questioner their thoughts on the matter.

'That's easy,' said the enquirer. 'The world is resting on the back of a giant turtle.'

James asked the obvious question. 'But what stops the turtle from falling?'

'You can't catch me with that,' came the reply. 'It's turtles all the way down!'

Chaos theory is fractals all the way down.

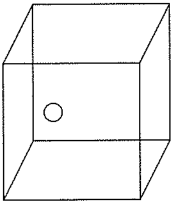
We do not usually create a new branch of science without someone trying to make money out of it and chaos theory is no exception. The stock exchange is a very complex system and the holy grail for financially minded chaos scientists is some pattern, some fleeting order in the seemingly random fluctuations of the prices from day to day, week to week, that they can pounce on and use to make their fortune. In 1996, a physicist who had created a computer model of the flow of crowds in a confined space found that when he ran the program substituting the ebb and flow of currency prices produced by the interactions of thousands of traders the world over for the ebb and flow of the crowds, he was able to predict some trends in the dollar-yen exchange rate a month in advance. The movement of crowds and currency seem to share some of the same patterns. But before we celebrate the wealth that might be made from such a program if it were made more precise, we might, as systems thinkers, ask what would be the reinforcing feedforward consequences? If the stock market were predictable, how would that predictability change its behaviour so that in effect it would become unpredictable again?

There may be two kinds of complexity: inherent and apparent. Inherent complexity is the real thing, the dark side of chaos. Small variations at the beginning make huge differences as time goes by, the feedback loops form such a tangle that the whole system is a Gordian knot and not even the most powerful computer could come up with the sword of Damocles to cut it. Apparent complexity is the light side of chaos – it looks complicated, but there is order in there, even sometimes quite simple patterns. As systems thinkers, we are looking for the patterns in apparent complexity. High inherent complexity is the realm of the Cray super-computers and chaos theorists. It is fascinating territory, but this book will not attempt to map it. Low complexity, and apparent to boot, is the home of the easy problems. We are interested in the middle ground, where apparent complexity is high, but real, and inherent complexity is low.

There are two ideas that help to understand and limit complexity in a system. First, establish useful boundaries. So if you are looking at your finances, on one side you can safely exclude the molecular structure of the coins and notes, and the holographic structure of the image on your credit card. On the other side you can also exclude how your spending pattern fits into the projected national figures for fiscal flow in the present financial year. However, your state of health, goals and dreams for the future may well be relevant. You decide the boundaries. The wider you cast your net, the more complexity there will be.

Like us, you may have done some DIY house improvements. Perhaps you needed to wallpaper a room. While you are moving the furniture, you decide to replace some old chairs. And stripping the wallpaper would be a good opportunity to replace the light rose on the ceiling and the light switch on the wall that are looking decidedly grubby. Maybe a dimmer switch would be nice... When you start that, you realize the wiring is rather old and could really do with being replaced. Might as well do the whole lighting circuit, it would save money... That would mean taking up the floorboards. So it would be a good opportunity to replace some carpets... Before you know it, your simple DIY job can make you seriously consider moving house unless you define the boundaries.

Complex systems can revert to stable patterns. Imagine turning on a tap. Just a little. The water drips out in a regular way. Keep turning, and suddenly the drips coalesce and the water flows out in a chaotic, turbulent pattern. You have hit a threshold. Keep turning and you will get a different pattern again – the water will gush out like a torrent. Now what would happen if you could get the tap to just the point between one water pattern and the next? It couldn't stay there. It would fall to one side or the other, behaving like a ball balanced on the top of a hill. Complex systems seem to want to revert to some stable state. These are called *attractors* in self-organization theory – that part of chaos theory that deals with how order seems to arise spontaneously in complex systems, like a snowflake forming in the atmosphere or a crystal suddenly precipitating from a liquid. We know snowflakes will form given the right atmospheric conditions, but we cannot predict the form of any one snowflake. These ordered states are emergents and happen from the particular organization of feedback in the system. We all have particular ways of perceiving and understanding events. For example, look at the diagram.



Attractor states

Is the face of the cube marked with the small circle at the front or at the back? Sometimes you see it at the front, then it flips to the back. Both views are steady, but trying to see it in between is like trying to keep the tap balanced at the point between two different flow patterns of water – it goes to one or the other.

The implications are fascinating. On the social level, it is arguable that democracy is an attractor once a social system grows to a certain level of complexity. Other types of political organization are not stable enough. On the business level, organizations will settle into particular stable states. As a ball rolls down a slope into a valley, so these attractors are easy to slide into, but take a lot of pushing to get out of. Sometimes change management is like the labour of Sisyphus, who in Greek mythology was condemned forever to push a large rock to the top of a hill only to have it roll back down to the bottom at the last moment. However, once you make it to the top of the hill, change can be surprisingly quick.

Organizational change first involves destabilizing the system in its present state and then creating another attractor state, which must involve not only a business structure and procedures but also a vision and values.

At an individual level, we may have personal equivalents of attractor states. You are likely to have a predominant emotional state, some habitual thought patterns, strategies and habits. Do you want to make changes? Whether you are dealing with change in social systems, organizations or your own life, ask these questions:

- What keeps the present situation in place?
- What new arrangement do I want that will keep the benefits of the old, while losing its drawbacks?

If you want to change a habit, you have to look at what keeps it in place and what it is doing for you. The strength of the habit is not in the habit itself, but in what it achieves for you. The balancing loops keep it in place for some purpose or purposes. You may know what they are, or you may not. So ask yourself:

- What is this habit trying to accomplish that is important to me?
- How important is this to me now?
- How can I accomplish the same thing in another, better way?

These questions will destabilize the status quo. Then you need to create another attractor:

- What do I want to do instead?
- Can I replace this habit with something new that will keep all the benefits of the old habit?

By levelling the old attractor and creating a new one, you can bring yourself to that crucial in-between point when it will be easy to fall into the new attractor.

Here is an example from a friend of ours. He had a habit of biting his nails. When he asked himself what kept the habit in place, he guessed it was work-related stress. His colleagues were not pulling their weight and he was left to do a lot of work that was not rightly his. This made him angry, but he never expressed it directly. Simple inattention also held the habit in place; he was unaware of his body and how he felt when he bit his nails. The initial problem was nail biting, but it led to many insights. Asking the systems question of what kept the habit in place led to deeper insights than asking, 'How can I stop this habit?' He made a number of changes to create a better attractor state. He bought some worry beads, and learned to be more aware of his feelings and his physical body. He started to be more assertive at work and refused to cover for others to the extent he had previously. This all took time, but now he is acting very differently *and* not biting his nails. This is also a good example of how our habits and actions work together as a system. They all connect. To stop a small action like biting his nails, our friend had to make some fundamental changes in how he thought and acted in relation to others.

---

1 Richmond, B., 'Systems thinking: critical thinking skills for the 1990s and beyond', *System Dynamics Review*, 9, 2, pp.113–33