3

mental models

Beliefs: Those things we hold to be true, despite evidence to the contrary.

Now we know what systems thinking is, we can relate it to the basic assumptions behind how we think and solve problems. A decision is only as good as the process used to produce it. Be ready to explore your own thinking with puzzles and illusions.

We will use systems thinking in four ways:

1. To solve problems directly. And not only solve them, but *eliminate the thinking that led to the problem in the first place.* Systems thinking is more than lateral thinking, it is vertical, horizontal, deep and circular thinking too.
2. To challenge, probe and clarify habitual ways of thinking.
3. To appreciate how our thinking is inseparable from the problems we encounter. Problems are not simply 'out there'. They are a co-creation of events and how we think about those events. We are the common element in all our problems and, as Einstein said, we cannot solve a problem with the same level of thinking that created it.
4. Lastly, you can gain more insight into your beliefs and ways of acting by applying systems thinking to your own system of thinking, because our beliefs are themselves a system.

We bring many deep-rooted assumptions, strategies, ways of looking and guiding ideas to whatever we do. These are known as *mental models* in systems thinking literature. Why mental models? 'Mental' because they exist in our minds and drive our actions, 'models' because we construct them from our experiences. They are our general ideas that shape our thoughts and actions and lead us to expect certain results. They are our theories in use, based mostly on observation and experience, but with a sprinkling of received wisdom and a dash of hope. They are what have worked in the past and therefore what we expect to work in the future. They are the maps we apply to our future explorations, drawn from our experience of what seemed successful on our past journey. They form our beliefs as we apply them to real life. We may not preach them, but we do practise them.

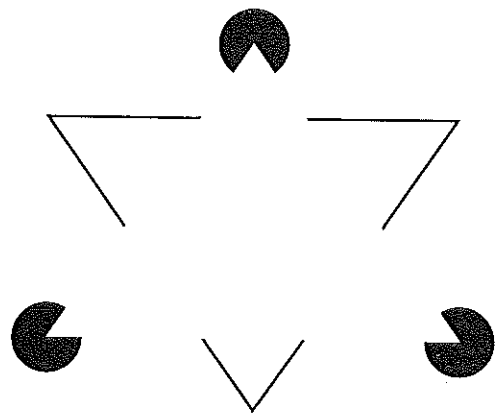
Mental models are quite natural, everyone has them, they are there whether we are aware of them or not, and we see the world through them. They are prized and personal. They are *ours*. We live inside them. The language we use about them is revealing. We talk of 'having' beliefs, of 'adopting' and 'acquiring' them. We say we 'hold' them, 'drop' them or 'abandon' them. We will 'defend' them from attack. When we 'lose' a belief it is usually gone for good and leaves a void that needs to be filled by another. Our mental models belong to us, but they do change and evolve with new experience, and we may need to refine them when we enter unfamiliar territory.

In short, our mental models guide all our actions. They provide stability, something to count on. We seek reinforcing feedback to confirm and reconfirm them, sometimes so insistently that we even welcome disaster as long as it corroborates our beliefs – the 'I told you so' scenario.

So our mental models give meaning to events. We interpret our experience in the light of them. They are not *facts*, although

we sometimes take them to be so. For example, we agree on the basic physical properties of matter as far as they affect us. Qualities like mass and volume are known as first order properties. To these first order properties, each of us adds *meaning* – second order properties. A ring made of metal has some obvious first order properties, as any metallurgist will tell you. However, if it is a wedding ring, it has personal value and significance that far outweigh those physical properties. There is a passage in the film *Raiders of the Lost Ark* where Indiana Jones, the archaeologist hero, confronts his enemy Belloc in a café in Cairo. 'Look at this watch,' says Belloc. 'To you and I it is worthless, but bury it in the sand for 1,000 years and it becomes priceless. Men will kill for it...' A lump of metal can become an archaeological treasure.

Our mental models are deep rooted and they predispose us to experience in a particular way. We use them to discriminate and decide what is important and what is not. We may then mistake our view for reality, we mistake the map for the ground it represents. You can see this for yourself by looking at the next diagram. It is a figure called a Kanizsa triangle, named after the psychologist Gaetano Kanizsa. What do you see?



Kanizsa triangle

There is no white triangle, but the illusion is compelling. Why? Our eyes do not work like a camera, objectively recording the world. They work with the brain to interpret shapes in a certain way. So what we are aware of seeing is created by how our eyes work, as well as what is 'out there'. In the same way our mental models shape what we see, hear and feel. It is hard to examine our mental models, just as it is hard to see how the eye works. Our biases seem to be really 'out there', just like the ghostly Kanizsa triangle. We can know our biases by examining what we do and how we react, and deducing our assumptions about what we experience.

Mental models are like the filters in the eye and brain that create the Kanizsa triangle, but whereas the filters are built into our physiology and are therefore unchangeable, *we can change our mental models.*

How We Make our Mental Models

Given we all have mental models, how did we build them? A baby does not arrive with a built-in set of beliefs, but with the capability to construct them. Different people can have the same experience, yet explain it in very different ways and read very different meanings into it.

We make our mental models partly from our social mores, partly from our culture and partly from the ideas of significant adults in our childhood. The rest we construct and maintain from our experience of life in four main ways:

DELETION

We are selective about what we notice. Every waking moment, our senses are being stimulated and there is no way we could notice and deal with all the possible information. So we select and filter according to our moods, interests, preoccupations and general alertness.

Try this experiment. Look at the black dot below with both eyes from about 6 inches (15 centimetres) away. Now close your right eye and look straight at the black dot with your left eye. *Keep staring straight ahead* and slowly move the page to your left. At one point, the spot will disappear, because the image is falling on the blind spot in your left eye, where the optic nerve enters the retina from the brain, so there are no light-sensitive cells to receive the image.

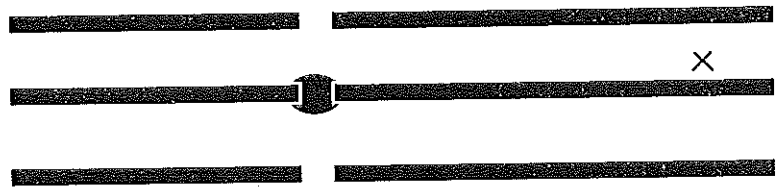
The blind spot

We delete information and form our ideas from what we notice. There is always other information, but it carries no significance for us, so for all intents and purposes it is not there. Deletion also maintains our mental models once they are formed. For example, parents often simply do not notice that their child has grown up – they continue to see them as a child, and are blind to their increasing independence and maturity until it suddenly seems to happen all at once. (Sometimes with explosive results!)

CONSTRUCTION

Construction is the mirror image of deletion: we see something that is not there. Seeing is believing. Look at the next diagram. Hold the book about 12 inches (30 centimetres) away, focus on the small cross on the right and then close your right eye. Now, keep focusing on the cross and move the book slowly towards you. After a few inches, not only will the circle disappear, but you will also find the middle horizontal line looks unbroken. Your brain has filled in the gap. This is also the reason why you do not see a 'hole' in your visual field caused by the blind spot. We fill in the gaps so the world makes sense and appears how we think it ought to be.

We have a lovely example from researching this book. Later in this chapter there is some quoted research from a psychologist named Wason. When we looked up the original research, we misread the name as 'Watson' several times because that is what was expected – it is a much more usual name. Seeing 'Wason' in the index of another book, we assumed they had made an error! It was only noticing 'Wason' in the index of yet another book that we started to doubt our version and double checked all the references.



Ambiguity is almost guaranteed to induce construction. We read ambiguity like a fortune-teller's tea leaves, finding patterns and significance in the most obscure or random events. Indeed, one of our strongest mental models, and a very useful one, is that there is pattern and sense to the world, only sometimes we jump at it too soon or create one that is not there. A resolution – any resolution – seems preferable to continued ambiguity.

The interesting series of experiments conducted by the psychologist John Wright in 1960 is a nice example of construction.[1] Volunteers played a machine similar to a one-armed bandit. There were 16 identical small buttons and a counter. The object of the game (we abbreviate the experiment a great deal in this description) was to gain as high a score as possible by pushing a sequence of buttons in the correct order. The subjects had no clues and were given no rules about the sequence, except they were told a buzzer would sound when they succeeded in getting the correct order. So they tried to get the buzzer to sound as many times as possible.

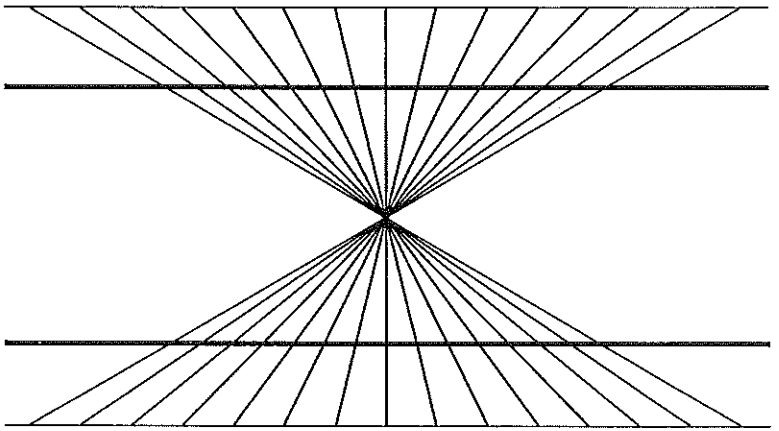
Imagine for a moment you are a subject in this experiment. You sit in front of the machine and you have to rely on your memory because you are not allowed to keep written notes. There are 13 trials, each consisting of 25 attempts. During the first 10 trials, you experiment with various combinations and get about half of them right. Then for two trials you do not get any right, so you revise your theories. After that, you are right every time. You feel proud and satisfied – you have cracked the code. You backtrack in your mind and get ready to tell the experimenter the winning sequence and how you found it.

Then the experimenter confounds you – the whole experiment was a set up. For the first 10 blocks, the buzzer was pre-set to sound 50 per cent of the time at random intervals. Then two trials of silence, regardless of what you did. For the last 10, it was pre-set to sound every time. In other words, there was no connection between what you did and your success or failure as signalled by the buzzer. Many subjects in this experiment were so sure they had discovered the sequence, they did not see how it could have been random. It fitted in with their strategy so perfectly that they thought the experimenter was lying.

The experiment shows how easy it is to construct plausible explanations and mistake the connections we make with the actual events. With the benefit of hindsight, everything is rational. And we tend to link probable cause with possible effect, smoothing the rough edges of a story we want to be true.

DISTORTION

Distortion is how we change our experience, amplifying some parts and diminishing others. It is the basis of creativity as well as paranoia. Again, we have a visual analogy. Look at the next diagram.



Hering figure

This is known as the Hering figure; the horizontal lines look tilted, but they are not.

When we distort events, we give more weight to some experiences than others. It is not a bad thing to do, but it can lead us astray. It is all too easy to reclassify experiences to back up preconceived ideas. For example, many gamblers continue to believe that they can and will win despite the fact they keep losing. They do so by reframing losses as 'near wins'.

Jealousy is a good example of how distortion can be limiting and painful. A jealous person can distort all sorts of everyday, innocent events into suspicious, threatening and painful possibilities.

GENERALIZATION

Using generalization, we create our mental models by taking one experience and making it represent a group. For example, a child sees how their parents treat each other and generalizes to make a mental model of how men and women treat each other. Generalization is a basic part of how we learn and apply our knowledge in different situations. We recognize something we already know, so we know how to deal with it. Without the ability to generalize, we would have to work out every problem from scratch. Whenever we use words like 'always', 'never', 'all', 'everybody' and 'nobody', we are generalizing.

The danger is to take an unrepresentative example, generalize to many other similar examples and then become blinkered to any evidence to the contrary. For example, a manager may believe consultants are useless in his industry, because he has generalized from one bad experience with a consultant. This generalization has to be maintained by deleting all the examples where consultants have done good work and made a difference.

Generalization combined with prejudice is an unpleasant mix. It is the basis of all racial and sexual discrimination.

These four principles of deletion, construction, distortion and generalization are not bad in themselves – they are the basis of our learning, creativity and all our beliefs, including the ones that serve us well. From a systems viewpoint, we want to know how these four principles combine to make the reinforcing and stabilizing loops that keep our belief system in place. Then we can see where they limit us and how we can expand our thinking.

Mental Models as a System

Mental models form a system. All systems have a purpose. The purpose of your belief system is to explain and give meaning to your experience, and looked at *from this point of view only* it does not have to provide you with a healthy or happy life. It is possible to have many beliefs about yourself and others that are limiting and unrealistic. But it is in our power to examine and recreate our belief system. We want a set of mental models that are realistic and useful, and provide ourselves and others with the greatest possible happiness and well-being. We can do this by looking dispassionately at our mental models, seeing them as a system and choosing what models to adopt, rather than holding those we already have regardless.

This suggests three courses of action:

- Look and question how you gather reinforcing feedback that strengthens existing beliefs and how balancing feedback between your mental models keeps the whole system from changing.
- Define the qualities of mental models you want – those that are realistic, and give you and others the greatest possible health and well-being.
- Gather balancing feedback based on your goal of building realistic mental models that give the greatest possible health and well-being. Then your new experiences will affect and update your mental models.

There are three main factors that can cause us to misinterpret our experience so that it seems to provide reinforcing feedback that strengthens our existing mental models – regression, time focus and one-sided events.

REGRESSION

Regression is a statistical principle that can lead to mistaking a connection for a cause. Generalizing from this will make it worse. For example, suppose today is exceptionally sunny and hot. What are the chances of tomorrow being equally hot? Not so good. The more extreme one event, the more likely the next will be closer to the average. Any extreme experience is more likely to be followed by one that is closer to average, otherwise over the long term, the extreme would become the average. Very bad weather is likely to be followed by better weather. Very tall parents tend to have less tall children. A poor business performance will probably pick up given time. A superb success is likely to be followed by something more mundane.

Now, suppose you did some weather magic, believing that you could influence the weather to be cooler tomorrow. Would cooler weather tomorrow prove your magic was effective? No. It is much more likely to be due to the principle of regression.

Because events tend to regress towards their average value, it is dicey to predict on the basis of exceptional events. Many a business has been lost and many a poor investment made through not taking this principle into account.

Regression is a statistical fact of life, but instead of taking it into account, it is tempting to make up complicated theories to account for events. But beware of a prediction or explanation based on an unusually good or bad result, especially if it confirms your beliefs. For example, a poor performance is usually followed by a better one without a reward as a motivation to do better or a punishment as a deterrent for slacking. What is taken for evidence for the efficacy of rewards and punishments is mostly due to the regression principle. A poor sales month is usually followed by a better one, but the improvement may be put down to a new training course or bonus scheme. We construct an explanation that is not warranted by the facts or use regression as evidence that our actions have the desired effect and thereby confirm our mental models.

TIME FOCUS

Events are often mistaken as reinforcing feedback because no time limits have been set. In other words, we do A and expect B to happen. Whenever B happens, whether it be hours, days, weeks, months or even years afterwards, we take it as the effect of A and as proof of the connection. This evidence is not *focused in time*. (This is quite different from analysing a system in the present and predicting a time lag between cause and effect where the time lag can often be accurately predicted.)

Here is a typical example of unfocused evidence. Many managers believe that people can be motivated to work creatively by financial rewards. It is easy to get evidence for this belief – reward someone and then wait for the creative work. Whenever it happens, whether today, tomorrow or in a month's time, it can be used as evidence to confirm the belief. If it does take some time, then a handy back-up belief is something like, 'It takes time for people to see their own best interests.' The regression principle almost guarantees they will come up with creative work sometime in the future and it will not necessarily be connected to the reward. In fact there is considerable evidence that rewards are motivating only on very limited occasions.[2] Twenty-five years of research has produced no evidence that people work any more productively when they are expecting a reward than when they expect to be equally rewarded or on the basis of need.[3] The exception is when the task is very easy and not very interesting, i.e. when there is no intrinsic reward in the task itself.

It is much safer to make evidence time focused, in other words look for evidence within a specific time, then the result will be memorable and significant whether it confirms your belief or not.

ONE-SIDED AND TWO-SIDED EXPERIENCES

When you have no time focus, you only notice confirming evidence that provides reinforcing feedback for your beliefs. This means you have set up a one-sided experience – only one result is significant and noteworthy. For example, a manager may be really enthusiastic about a new advertising campaign. When sales eventually pick up, they are pleased and remember the upturn. Memory comes from attention in the past tense.

Does it seem as though you always need to stop for petrol when you are in a hurry? Or the telephone always rings when you are in the bath? It's the same effect at work. You remember the times it happened, but not all the times it did not, because those were non-events. A person who only looks for evidence in one-sided experiences is the sort of person who will wonder why someone always answers the telephone when they dial a wrong number!

Two-sided experiences are those that are memorable regardless of what happened, favourable or unfavourable. Going on a date, taking a holiday or gambling on the stock market are all two-sided events. All the possible outcomes evoke the same intensity of emotion, or even the same emotion.

It is still possible to back up mental models from two-sided experiences by justifying any result that did not confirm your mental model. For example, our manager who firmly believes in their advertising campaign may explain away a downturn in sales that is too big to ignore by attributing it to external difficulties, economic factors or the campaign not being done quite right, but next time...

- *One-sided, unfocused experiences* will always provide reinforcing feedback for existing beliefs. There is no possibility of balancing feedback, so no possibility of new information. You wait for as long as it takes to confirm your idea.

  An example of a mental model that sets up one-sided, unfocused experiences is: 'People will only change when they are ready.'
- *One-sided, focused experiences* can also confirm existing mental models. One example would be looking for an upturn in sales in the next quarter due to a new

incentive scheme. If the result does occur within the time frame, then that is taken as evidence for the incentive scheme. If it does not occur, then it may be explained away, leaving the mental model intact. Sometimes the time focus gets a bit blurry and elastic...

- *Two-sided, unfocused experiences* are generated by our long-term strategies. Both outcomes are significant, but hard to evaluate because there is no time limit on when they occur. An example is a man applying for work. The result of any one application is important – success or failure – but the effectiveness of his strategy is hard to gauge because he will keep trying until he is successful.
- *Two-sided, focused experiences* provide the most valuable feedback for our mental models. We pay attention to all the possibilities within a time limit. When predicted effect follows cause, we can have some confidence in the result as reinforcing feedback, provided we have taken regression into account. If our prediction does not materialize, then this is also significant and becomes useful balancing feedback that casts doubt on the belief.

Self-fulfilling prophecies (balancing feedforward), where the prediction or anticipation of change drives the system towards its predicted state, relies mostly on unfocused, one-sided experience as evidence for the predicted outcome.

What can we learn about our mental models from our experiences?

- Unfocused experiences are little use in telling us whether our mental models are accurate. Useful feedback should be time focused.
- Two-sided experiences provide the most useful feedback.

Ask this key question when an experience seems to confirm a mental model: 'If the exact opposite happened, would I take that as also confirming my mental model?' If the answer is yes, then you have set up your experience so that you cannot get good feedback on your ideas.

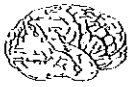
This does not mean you should try to set up all your evidence in a two-sided focused way. It is just not possible. It does, however, mean that you should be careful about taking one-sided, unfocused experiences as evidence for your mental models, because they are not reliable.

We need to be scientists of our mental models. Scientists learn from their experiments however they turn out. Experiments that fail are the most valuable, because they show something has been overlooked – there is something to be learned, the model is not completely accurate. Experiences that contradict our mental models provide valuable balancing feedback if you pay attention to them. Whenever there is a discrepancy between what we expect and what happens, seize the opportunity. Become curious. What are you missing?

In general, we pay too much attention to experience that provides reinforcing feedback. We ask questions of our experience designed to get a 'yes' response. When events reinforce our beliefs we tend to ask ourselves, '*Can* I believe that?' And when events do not back up our beliefs we ask ourselves, '*Must* I believe that?' One word changed that makes a great deal of difference to our inner experience. Say both phrases to yourself, one after the other, and notice the different effect each has on your internal state.

Fruitful Thinking

Here is a puzzle. To solve it, you will have to think about what your choice tells you and also what your choice rules out. (Hint.)



Three closed boxes are labelled 'Apples', 'Oranges' and 'Apples and Oranges'. Each label is incorrect. You may examine only one fruit from each box (and no feeling around allowed!) How many fruits must you examine in order to label each box correctly?

The answer is on page 80.

You can use the next puzzle to test your tendency to pay too much attention to confirming feedback. Try it on your friends too.

Here is a set of four cards. Each has a letter on one side and a number on the other. You can only see one side of each card.

What is the least number of cards you need to turn over to test the rule that vowels always have an even number on the other side? Think about it for a moment.

E G 4 9

In research on these sorts of tests[4] fewer than 5 per cent of people gave the correct answer – turn over the 'E' card and the '9' card. The rule says a vowel must pair with an even number, therefore you must turn over the vowel card – 'E'. If there is an odd number on the other side, then the rule is broken. The 'G' card is irrelevant, whatever is on the back. The '4' card is also irrelevant because the rule does not say that even numbers have to have vowels on the back. This card only confirms what you already know from turning over the 'E' card. The '9' card must be examined, because if it has a vowel on the back then it breaks the rule.

Challenging Mental Models

Systems thinking challenges many of our mental models. First it challenges the idea that the whole is the sum of its parts. People in difficult family relationships often think that if only one other person would change, then everything would be fine and go back to normal. It wouldn't. A balanced family is the result of *all* the relationships in it. Our health depends on all our bodily systems working together. A business team or a sports team, when it truly works together, will get results far beyond what the collection of individuals could achieve, and conversely, a team of very talented individuals may underachieve, because they do not know how to work well together. Team building is not simply a matter of throwing together all the best people. That is often a disaster because they are incompatible.

Secondly, systems thinking challenges the idea that you can judge a person's behaviour independent of the system they are in. A fundamental principle of systems thinking is that the

structure of a system gives rise to its behaviour. Given favourable circumstances, anyone can shine, but we still blame and reward people as if they were independent entities, especially in the business world. A manager may be blamed for not acting correctly when in fact they were prevented from getting the information they needed because of a procedure in another department. If our mythical manager decides to play a blame game, then they may blame the other department for being slow. That department can then blame the method of collecting the data, which may have been agreed by everyone, including the original manager. Blame dissolves within a system. So when you point the finger of blame in a system you will end up pointing it back at yourself as well as everyone else because of the feedback loops and circles of cause and effect. No one comes to work to do a bad job, but the structure of the system may make good work impossible. If management falls into the blame trap, they may fire the offending individual and hire someone else – who may do no better. Rather than trying to find extraordinary people to do a job, design the job so that ordinary people can do it well. It is the structure of the system that creates the results. For better results, change the structure of the system.

Finally, systems thinking challenges us to rethink our ideas of cause and effect...

Answer to the Three Boxes Puzzle

Pick a fruit from the box labelled 'Apples and Oranges'. Suppose it turns out to be an apple. What can you say about what is in the box? Not much directly, but you know the box is not 'Apples and Oranges' because all boxes are wrongly labelled. You know it is not 'Apples' because that would not contain an orange. Therefore it must be oranges. You know all the boxes are wrongly labelled, so switch the labels of the other two boxes and you have the answer.

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1 Wright, John, 'Consistency and complexity of response sequences', *Journal of Experimental Psychology* 63 (1962): 601–9

2 McGraw, Kenneth, 'The detrimental effects of reward on performance' in M. Lepper and D. Greene (eds.), *The Hidden Costs of Rewards*, Earlbaum, 1978

3 Deutsch, Morton, *Distributive Justice: A social-psychological perspective*, Yale University Press, 1985

4 Wason, P., and Johnson-Laird, P., *Psychology of Reasoning: Structure and content*, Harvard University Press, 1972

the art of systems thinking

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Joseph O'Connor
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