The
Book
of
Models

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triggers accounts that could plausibly be about another object.*

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Ceremonies and models

John Monk

In his dialogue, *D'Alembert's Dream*, Diderot used the spider's web and the way it propagates vibrations as an analogy for the nervous system — with the spider analogous to the brain:

> 'Imagine a spider at the centre of its web. Disturb a thread and you will see the creature rush up on the alert. Now suppose that those threads that the insect draws from its own body and draws in again at will were a sensitive part of itself.'
>
> (Diderot 1769 p.182)

And when the character Bordeau challenged the explanation by making the observation that 'messages weaken in proportion to the distance they come from'. Diderot responded by providing Mademoiselle de L'Espinasse with an analogy for the threads of a web and she says 'if there is the very gentlest tap on the end of a long rod I can hear it if my ear is applied to the other end' (Diderot 1769 p.184).

Diderot was attached to the use of analogy (Hobson 1995). Wittgenstein too used analogy widely, for example, when explaining how to teach about philosophy he uses the analogy of finding his way in a town:

> '… to be a good guide, one should show people the main streets first … and just as a good guide will show one new streets everyday, so I will show you new words.'
>
> (Wittgenstein 1939 p.44)

Wittgenstein also saw 'proofs in mathematics as analogous to explanations offered in Freudian psychology' (Göranzon & Karlqvist 1995). Sophocles used the often employed analogy of the state as a ship in Antigone:

> 'The image tells us that a city, like a ship, is a tool built by human beings for the subjugation of chance and nature. The city-ship, in the tradition of the image is something safely water-tight, a barrier against imminent external dangers.'
>
> (Nussbaum 1986 p.59)

In all these cases a mere statement of the analogy is not enough. It is the use of analogy that exposes its power and institutes it.

THEORIES ABOUT ANALOGIES

Diderot, again in *D'Alembert's Dream*, tried to explain how analogy is worked out by the brain. 'Analogy, even in the most complex cases', he wrote 'boils down to a rule of three progression working itself out in the sensitive instrument' (Diderot 1769 p.162). The *rule of three* that Diderot mentioned is a way of working out a term in a ratio. For example, I can write the ratio

$$2 : 4$$

and say it is equivalent to the ratio

$$5 : 10$$

or I might write the expression

$$4 : 16$$

and say it is equivalent to

$$8 : ?$$

The *rule of three* gives me an algorithm, a way of reckoning what should be put in place of the question mark. The matter

is not quite so clear cut as it first seems. Applying the rule of three makes $4 : 16$ equivalent to $8 : 32$ but clearly the two expressions are not the same — they involve different numerals — so in some ways they are not equivalent. There was also the assumption in applying the rule of three that the notation $4 : 16$ meant that what is to the right is four times what is on the left. Another possibility is that what is to right is the square of what is to the left then $4 : 16$ would be said to be a short-hand for $4 : 4^2$ (or $4 : 4 \times 4$) and if the second expression is equivalent then it should be $8 : 8^2$ (or $8 : 8 \times 8$) which becomes $8 : 64$. In adopting one of these particular approaches to solving the mathematical puzzle we are inclined to make assumptions, indeed we have to make assumptions, about how equivalence is to be assessed.

In *D'Alembert's dream*, Diderot gave a number of examples of analogies, for instance between common people and heroes:

> 'If the lance of the ordinary soldier is ten feet long, how long is the lance of Ajax?'
>
> (Diderot 1769 p.162)

Presumably Ajax is taller or stronger and is able to use a longer lance. The implication is if we knew how much taller, or stronger Ajax was we could work out the length of his lance. The analogy suggests that there is a relationship between the size of a lance that someone can comfortably use and their stature. Diderot also suggested that this relationship is precisely known since it can be used to calculate the length of a lance. As Diderot put it:

> 'The strides of the gods and the leaps of their steeds will be in the same ratio as the gods are deemed to bear to men'
>
> (Diderot 1769 p.162)

But before this can be done something must be said about the equivalence of two situations. What is involved in finding the ratio that gods are deemed to bear to men? How does Ajax

relate to the ordinary soldier? What is being compared? What is the ratio that Diderot mentions? Is Ajax taller, or stronger? What if Ajax is both stronger and taller what algorithm should we use to work out the length of a lance?

There is a difficulty here because Diderot was saying that two ratios or situations are somehow equivalent. And when you look into equivalence you discover there are many different kinds — even in mathematics. There is identity where one object turns out to be exactly the same object as something that was originally thought to be different. There is the idea of congruence where one object is not identical to another but it can be used satisfactorily in place of another. There is definition where one object is used as the name of another. There is similarity (and translation and symmetry) where some, but not all, properties are the same in two objects. Your image in the mirror, for example, is similar but not the same as your appearance. There is procedural equivalence where it can be shown that one object could be used in some way to generate or make another distinctive object. For instance, where a plan is used to construct a building, or where a computer program plays a part in causing a computer to behave in a characteristic fashion.

Diderot himself appears to have been aware of the difficulty of saying what kind of equivalence an analogy is since he resorted to analogy to talk about the equivalence he felt existed in an analogy. He compared analogies with vibrating strings and the sympathetic resonance that can be set up in vibrating strings. His analogy (for analogies) demands a situation where four strings simultaneously resonate or at least it demands a situation that can be imagined because the situation that he chose for his analogy, as he wrote, 'does not occur in nature'. What Diderot chose for an analogy gets a point across, but the source of the analogy, he proposes, is unrealistic. Diderot's analogue, he admitted, was a fantasy and, while this may disturb the scientist, he pointed out that it 'matters little to the poet'. Diderot

turned this substantial blemish in his analogy into a moral to the tale and he suggests that nature often presents the philosopher 'with a quite different phenomenon from the one he had been counting on', then, Diderot continued, 'he realizes that analogy has been playing tricks on him', and this implies that on occasions the equivalence at play in an analogy is not the equivalence that was originally presumed.

Saussure applied analogy to the evolution of the sounds of words. Saussure saw analogies in terms of proportions rather than their close cousins, ratios. He felt that

> '… any analogical creation may be pictured as similar to a proportion'
>
> (Saussure 1974 p.166)

and in giving his examples he used a notation which he referred to as equations which he solves. One of his examples where he gave the solution for x is

$$\tilde{o}r\tilde{a}t\tilde{o}rem : \tilde{o}r\tilde{a}tor = h\tilde{o}n\tilde{o}rem : x$$

$$x = honor$$

<div align="right">(Saussure 1974 p.167)</div>

Saussure explained that there are four components in an analogy: the analogical form, a model, a set of examples from which the model arises and a rule. These ingredients are put together so that an 'analogical form is a form made on a model of one or more forms in accordance with a definite rule' (Saussure 1974 p.161). But finding a definite rule for establishing equivalence, as we have already seen, is not as straightforward as this implies. And in the example

$$pardonner : impardonnable = décorer : x$$

$$x = indécorable$$

<div align="right">(Saussure 1974 p.167)</div>

it is certainly not clear what either the rule or the model are. In the examples the model and the rule are not made explicit.

There seems to be an assumption in Diderot's and Saussure's writing that there is an unwritten calculus at work in analogy but nowhere is the calculus spelled out. All that can be concluded is that in the examples that Saussure gave, he would have said that an analogy is at play and that he therefore believes the words in each example are related. Wittgenstein offered an account (Wittgenstein 1939 pp.58–67) which leads us to see Saussure's and Diderot's demonstrations of analogy simply as examples. Each example shaping our view of what an analogy is. None of the examples provides an explanation of what an analogy is nor a theory for creating new analogies. There is no calculus for analogies and therefore no way of predicting what will stick as an analogy, but when you create an analogy you add to the meaning of the word analogy (Wittgenstein 1939 p.76).

MODELS

In the book *Real-time object-oriented modelling* there is a statement attributed to Douglas Ross:

> 'x is a model of X if we can learn about X by asking questions of x'
>
> (Selic et al. 1994 p.3)

This statement resembles Saussure's formulation and the situation where Diderot would apply the rule of three, however the models being referred to in the book are models of engineering systems. I can write the statement out using Saussure's notation:

$$x : \text{Answers to questions about } x = X : \text{Answers to questions about } X$$

The model is explicitly the term x, but x has an essential property and that is we should be able to ask questions about x and get answers, and the objects x and X will be analogous if the answers to the questions about x and X are analogous.

Engineers' models are often couched in mathematical nota-
tion. Here is an example of a mathematical model of part of a
power station

$$\frac{dh}{dt} = 0.04(W_f - W_s)$$

(T394 1989)

But to accelerate the discussion I will use an everyday example
of a mathematical model. At lunch time the other day I had a
look in a shop window, in Stockholm, at a menu. One item
on the menu was

Soup 85 SKr

Here we have a mathematical model of soup. I could use the
model like this: I could assume that I went into the restaurant,
ordered some soup, ate it and gave the cashier 100 SKr. I
would get 100 SKr minus 85 SKr back. With a little arithme-
tic, I could calculate that my change will be 15 SKr. So I
could, with the model of the soup and a model of a situation,
work out what would happen. Notice that the model is lim-
ited, it does not tell me everything about the soup, and the
model is not soup or money. You might say the model corre-
sponds in some way to reality. And use of the model helps me
figure out what would happen in reality.

The trouble is, in this case, I did not buy the soup, or eat it. So
what I worked out using the model was a fiction. The story I
constructed based on the model seemed to be just like the
story I would have constructed had I written an account of
going into the restaurant and having some soup. The model
guided me in constructing a story, involving the soup, that was
plausible. It is important to add that the model did not tell me
everything I needed to complete the story. It did not offer
signs or clues of a number of things that in the kinds of situa-
tions that I described we often, but sometimes mistakenly, take
for granted, for example, the model did not tell me about how

money is used or how soup is served. Use of the model provided me with an account that could have been furnished by an experience or an experiment involving the soup, but with the model I did not consume anything or run any financial or culinary risks. However using the model, instead of experimenting with soup, left me hungry and I still had to find somewhere to eat.

DIFFERENT KINDS OF MODEL

Perhaps when I use the word model in the context of engineering you think not of a mathematical model but of a scale model, perhaps a scale model of a building, ship or aircraft. A scale model of a building is not a piece of text or mathematics but an artefact. Nevertheless the use of the model, even looking at it can help me to fabricate a story that would also be plausible if told about the building being modelled. So I look upon a model as an object (a text and a piece of paper with mathematics written can be objects too) that stimulates people to give accounts that could also be triggered by the object being modelled.

The model is different from the object being modelled so some accounts of the model are meaningless in the context of the modelled object. For example, comments on the colour scheme of the menu may make no sense in a situation where I ate and bought soup. A model cannot trigger all possible stories about the modelled object so a model is in some way specialised and limited. Of course if all the accounts of the model and the object being modelled were the same then the objects would be indistinguishable and we might even conclude that they were the same object. However, such a conclusion would always be provisional since sometime later distinctive accounts may emerge.

One special group of models is the set of models created by instruments — measurements. Instruments are machines for

creating models or rather the appearance of the instrument is taken to be a model. For example, if I want to bath a baby I need to be sure the water is not too hot. I can put a thermometer in the bath and look at it. From the appearance of the thermometer I will be able to give an account of the bathing the baby. When the thermometer indicates 40°C — the bath is too hot — my account of bathing the baby would have a shocking effect, so shocking that it would prevent me from actually proceeding without first cooling the water.

Maja-Lisa Perby (Perby 1995) has talked about the process operators, people who operate large industrial installations such as power stations and chemical plants. They are surrounded by instruments. Their collection of instruments presents a picture, or a model, of the process they are controlling. The plant operators' accounts, triggered by the picture composed of the faces of a collection of instruments, are also taken to be their accounts of the process. The point of the instruments is to help operators give accounts that are confidently received as tales about the process that they are working with but without them having to directly experience the high temperatures, pressures or radiation hazards in large and dangerous plant. But without direct experience their accounts can only be accounts of a model of the process, or, for the listener, the plant operators' accounts are models of the accounts that might have been told about the process.

There is no limit to the number of models that a modelled object may have and every object is a potential model. A picture can be a model. Plans can be models. The text of a computer program can be a model for a computer running a program A computer running a program can be a model. Any object can be a model if it is used as a model — that is if it triggers accounts that could plausibly be about another object.

Hybrids

The account triggered by a model is a hybrid. It includes words that are associated with the model but it, naturally, includes words that would be associated with the object being modelled. Whether this kind of account makes sense or not is impossible to predict. The criteria will be whether people find it useful or not. Can they make new predictions, gain new insight, save effort or avoid danger? Are they satisfied by the results?

The same criteria apply to analogy. People will say 'it's a good analogy because it is useful' (Wittgenstein 1939 p.67). Use of an analogy involves transplanting words used in one situation into a new context, or as Saussure puts it creating 'a garment covered with patches cut from its own cloth' (Saussure 1974 p.171). Transplanting a single word is, perhaps more properly called a metaphor. An analogy is more. An analogy is the import, wholesale of words and phrases, a collection of metaphors and linguistic practices. Using an analogy involves transplanting a word and allowing other words that seem to be attached to drift along too. Where the hydraulic term *flow* is applied to electricity we also use the term *current* and more recently the hydraulic terms *channel* and *drain* have also been adopted by electrical engineers to describe parts of certain transistors where currents flow.

A model, or an analogue is an object that we can talk about; it is an established object that causes us to have conversations and is associated with a particular vocabulary and linguistic practice. It becomes a model, or analogue, when we regularly use these particular linguistic practices as though some other object was the focus of attention. The hybrid linguistic practice is analogy.

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CREATION

The binding between a model, or analogue, and specific linguistic practices is arbitrary, and there is no systematic relationship between the domains that offer analogies and the domains that provide a home for an analogy. But models are not entirely arbitrary. Models arise in the context of a history of models. The creation of new models is based on existing models and in this way successions of models form a genre. The genre becomes a body of work that affects those that create new models. But while many analogies and models are a part of a tradition, some analogies will be fresh and spontaneous.

How do new analogies and genre arise? This is like the question about the chicken and the egg, but perhaps new analogies arise in the same way as new metaphors (Rorty 1989) because someone wants to create a new effect or perhaps by accident an effect is created. The analogy makes no sense but has a useful effect. If other people think it is useful they adopt it and if not it disappears from use. Like definitions, some analogies 'are uninteresting, some will be entirely muddling, others very useful' (Wittgenstein 1939 p.76). Gradually the successful analogy becomes common currency just as

> '… one speaker had to coin a new word, then others had to imitate and repeat it until it forced itself into standard usage'
>
> (Saussure 1974 p.168)

There is a crucial point where the analogy ceases to be an analogy; a point where we forget we are dealing with a hybrid language. For example, now we talk about electric current and its flow without worrying about the analogy with hydraulics unless it is pointed out. Once we forget the analogy, the analogy becomes our reality— electric current is real. Heat really flows, information really does flow and we do really absorb information. In engineering, which has drawn on mathematics for inspiration for its analogies, some engineers might say that a

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system, a ship for example, behaves awkwardly because, and I am deliberately using the professional's jargon

> '… the ship has a pair of conjugate poles on the right half plane'

and conjugate poles, a term borrowed from the mathematics of complex variables, become a part of their reality and ships really have them (Bissell & Dillon 1993). Gradually the model becomes a signifier of thoughts about the modelled object that is signified. Explanations that were once analogous become real explanations and in this way the analogue provides a source of new theories, new predictions and new expectations.

CEREMONIES OF THE PROFESSIONS

Now a model or set of models or genre provide the way in which specialists, such as engineers, make sense of reality. To join a profession like engineering involves becoming so familiar with a set of models that the models provide the way in which someone orders their view of reality. This is not an overnight task. Spectators will not be able to make any sense of the use of a profession's models; their interest will only be aroused if the models are spectacular and engineering models are rarely that.

A model is an artefact used by a group of specialists that inspires a conversation composed of specialised linguistic practices. From their use of their model, specialists will claim to make new, reliable predictions or explanations about some other artefact. While those outside the specialism may be at sea with the explanations, those inside the specialism identify themselves by showing satisfaction. Members of the group use the models because they find the ensuing discussions satisfying. The use of specialist language, by an identifiable group which imputes to objects the group's own special meanings and whose members engage in activities that give them satisfaction turns their activity, the use of the model, into a ceremony.

Ceremonies, as Wittgenstein has said, bring satisfaction (Wittgenstein 1979a p.4), and the objects that are an essential feature of the ceremony, the models, are fetishes.

The satisfaction engineers gain comes from the accounts that are generated by the linguistic practices surrounding the analogues or models that they use. But that satisfaction only comes once the virtual reality of the analogy becomes their reality. Achieving that satisfaction is what it means to become a practitioner. It is as much as anything a matter of faith that can only be brought about by practice and struggle. It is not to be found in books or expert systems. An analogy or use of a model established within a group become a sign of the group's identity. The analogies and models a group employs separates out the group by forming the specialised language that they use. A model is an object that stimulates, in the identifiable group, a satisfying discourse about some other object.

People who have not encountered the use of an analogy may find it mystifying and confusing to use the vocabulary of one domain in a new context. Newcomers to an established analogy do not necessarily encounter the analogy in the context that led to its creation and will not be able to appreciate why it was needed, but they may invest time in becoming fluent and confident with the metaphors embedded in the analogy and so become practitioners themselves.

Some people may treat the analogies and the use of the models as something that could never make sense to them. The analogue remains for them arbitrary since they are not insinuated into the tradition. Even so they may still award the analogy a worthy status or they may place their trust in explanations exploiting the analogy and therefore recognise any group that can use the analogy fluently but this recognition is founded in awe rather than comprehension. The identity of a professional group is sustained when the use of their models provides a discourse that is valued in some way by those outside the group.

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Claims about being able to predict the future and demonstrations of satisfying explanations of the past serve to reinforce the authority of the profession. The model users become soothsayers, their models become fetishes, their encounters become ceremonies and their conversations incantations. Models, artefacts transformed into fetishes, provide the focus for ceremonies which generate, for the professionals, satisfying accounts of possible futures, or plausible explanations of the past. The apprentice's aim is to share the professional's obsessions, faith and satisfaction.

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… we shape or reshape our reality as rehearsal propels our
chosen texts from being mere models towards becoming our
actuality

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