Models, Theory and Reality

Model and Truth

Model and Reality

Model as representation

Model as structural similarity

Model as partial truth

Complete models?

When asked whether a scientific results is true, scientists quite often answer: “no, it is just a model.” Scientists also acknowledge that their result are not completely certain and the critical interviewer concludes: so this is just a theory.” By which the word ‘just’ is included to indicate that the result is very far from robust. So it is obvious that the words ‘model’ and theory’ sometimes at least are used in order to reject truth claims.

If theories and models are not true, they must be false. But, then, what’s their use? Surely, we are not interested in false results. The reasonable answer is that models and theories are approximately true, or true in some respects.

This notion of approximate truth, or truth in some respect is the focus of my present talk. The core concepts are thus **Truth, Reality, Theory, Representation, Model and Structure.**

Truth. Philosophers have argued about the concept of truth since ancient times. The most common view is that truth should be conceived as a *correspondence* between the content of a statement and part of reality. This is expressed in Aristotle’s famous dictum:

“To say of what is that it is not, or of what is not that it is, is false, while to say of what is that it is and of what is not that it is not, is true” (Metaphysics, 1011)

Many philosophers have tried to develop this idea by saying that a statement is true if it corresponds to a fact. But in order to be able to compare the statement with the fact, the fact must be described or expressed and what we get is yet another statement. In general, to be able to judge whether there really is a correspondence between two things, a linguistic item and a fact, we must have access to both directly. But how do we access facts? Presumably by observing. But an observation is a mental act and how do you compare a mental act and a statement? The only way is to express the result of your observation as an observation statement. Now we have two comparable things, two statements. But our problem is not solved, for it was how to compare statements with reality. The conclusion to be drawn is that we cannot make sense of the idea of accessing a fact without using language; hence the idea of correspondence appears incoherent. So what are the alternatives?

Truth as Coherence

The discussion above indicates that all what can be achieved is a coherent set of statements, and that is precisely the content of the concept of truth. A statement is true when is coheres with all other truths. This is certainly a necessary criterion; two true statements cannot contradict each other. But is this criterion sufficient? One argument against is the possiblity that two theories of part of reality might each fulfil the strongest possible criteria for coherence, but they might very well contradict each other. So which of them is true?

Redundancy theory.

Some have said that the so called T-schema is all there is in the idea of correspondence:

'p' is true if and only if p.

This schema gives us a necessary condition for using the word 'true'; to say that the sentence p is true is simply to assert the sentence. Many hold that this is all there is in the concept of truth and the position is the redundancy theory; in a logical sense the word 'true' is redundant. To claim that a theory is true is just to assert the theory; but we need the word 'true' when talking about the theory, i.e., all the statements in the theory without expressing them.

My own view is that this theory is closest to truth.

Approximate truth.

Many philosophers have claimed that there cannot be such thing as approximate truth; truth and falsity is an absolute dichotomy. But, surely, there is a difference between saying about Sweden that it has 9 million inhabitants and that it has 10 million inhabitants. In a strict sense one could argue that both are false, since the real population number is a little less than 9 millions. Or take the statement 'only fishes have gills'. This is not absolutely true since for example tadpoles have gills, however, the statement i is almost correct.

Approximate truth of a entire theory.

Still more important is the idea that a theory might be approximately true, since this is arguably what we often think. We believe in many theories, but we also believe that they are not completeley true.

Popper tried the analysis of the proportions of true sentences in the theory as the degree of truthlikeness, but it failed, so another approach is necessary. My guess is that one could analyse the notion of approximate truth as truth in certain respects.

Reality.

Since only statements which assert something can be true, and assertion always is about something, we need a concept of that something as a whole, *Reality*. The world, or 'REALITY' is supposed to refer to all there is, everything which exists.

Most philosophers are realists, which means that they think reality exists independently of our thoughts and minds. Well not everything; my own thoughts and my own mind is also part of reality and these things are not independent of my thoughts and my mind. But everything else. Others claim that the only things we know about are the states of our own minds. If these states are caused by something external we cannot know. Hence reality should be conceived of as the content of our minds. Trees, houses, cars, other people are ideas in my mind, and if there exists something in addition to these ideas of mine, I cannot know. This is idealism. But a realist believes that reality is something different from the content of my mind and so the question of the relation between a particular mental process, and a fortiori its linguistic expression, on the one hand and the real world on the other.

Can we intuit reality without any mediation of concepts? Kant famously answered *no* to that question. Some thinkers of religious bending say yes. My own inclination is to accept Kant's stance. "Das Ding an sich selbst betrachtet", to use a famous phrase from Kant, cannot be known or talked about. Cognition is only thinkable as mediated by concepts. So the only conceivable conception of reality is reality as mediated, as given to us in a framework of concepts. When we talk about a part of reality and thereby use concepts, we represent that part of reality. Then the central concept is representation.

***Representation*.**

In modern philosophy of mind the notion of a representation is often used and the idea that the relation between model and reality is a kind of representation appears promising.

The core idea is that my thought processes, and derivatively the sentences I utter and the theories I construct, are *about* facts, features or objects in reality. The sentence *represents* something in the world; a fact or a state of affairs. This idea of representation is somewhat similar to the idea of correspondence. For example, the reading of a thermometer represents the temperature in the air. When looking at the thermometer we are informed about the temperature of the air. We say that the state of the thermometer is a representational state, and that is possible since information is transmitted from the air to the thermometer and then to our mind. The transmittance of information can, in this case, further be analysed as a causal process. The information transmitted can be expressed as that a quantitative property of the air is one-to–one mapped onto a quantitative property of the thermometer and the mapping relation could be conceived as a description of the causal interaction between the air and the thermometer. Unfortunately, the analysis of representation as a causal link cannot in general be the correct one. I'll return to the concept of representation later.

When a picture of a person is said to represent that person it is obvious that there is a similarity between the object and the representation. But in most cases this is not so: for example, we represent each person living in Sweden by a personal identification number consising of 10 numerals. There is no similarity between these ordered 10 digits and the human it represents. (The fact that the date of birth is used for constructing the identification number is of no importance). But some representations are indeed similar in some respect to the object represented; and this sub category I would call models. Now we have finally reached the concept of model; models are an important kind of representations.

Model. The word 'model' presupposes a relation; something is a model of something else. For example we can build models of molecules by using balls and sticks. Kids build models of aeroplanes, boats, cars or castles. Mathematicians build abstract models of complex mechanisms, for example the fusion of hydrogen in stars.

The relation between the model and the object or process modelled could also reasonably be called a representation; the model represents something, *some aspects* of reality.

It is obvious that there are differences between the model and the part of reality being modelled. But must it not be some similarity also between the model the object or process modelled? How else could it *be* a model? If the model is a representation of something, how is this representational relation generated? Is it a free invention by us humans? Or is it something which exists independently of our cognitive processes.

It seems obvious to me that when we say that something is a model we view the object being a model as related to something else, and this relation is in a sense a construction made by us. But our constructions of model cannot be made at will; If I say that something is a model of something else, you must be able to decide whether I am right or wrong in saying so. It means that there must be objective criteria for judging whether the relation really obtains or not.

It seems equally obvious to me that a model must be similar to what it is a model of in some respects and not similar in other respects. When something is a model of something else, there is a partial similarity: some aspects of the model are intended to represent reality, some other not.

Example 1. Models of molecules.

Example 2. Causal model of factors behind myocardial infarction.

Example 3. General law of gases; pV=nRT

Example 4. A map.

Similarities. In all cases we use the model in order to get some *information* about the objects, events or processes modelled. In order to be able to use the model we need to know what kind of information there is in the model, i.e., we need to know how it *represents* the world.

It is obvious that some aspects of the models are not intended as representations. Consider for example our way of representing the benzene ring. Each corner represents a carbon atom and each line represents a covalent bonding consisting of two electrons. The angles correctly represents the angles in real benzene molecules. Likewise, the fundamental fact that around each carbon atom there is 8 electrons in covalent bondings is correctly represented in the model. But it is not correct that the three double bondings are placed as depicted; in reality they are hybridised and the charge distribution is homogeneously dispersed around the ring. And there are several other aspects which is not representing real properties.

In the model of causes behind heart infarction the aim is to give a model of causal relations. Each arrow represents a causal connection. The model represents one important aspect of the causal network, viz. the causal chains. We can say that a certain diet, viz., excessive intake of saturated fat, is a cause of hyperlipidemia and hypertension. These two events in turn causes coronary arteriosclerosis, which is turn is one of the causes of myocardial infarction. In other words, the transitivity of causal relations is depicted in the model. But one relevant aspect of real causation is lacking, viz. the relative strength of the factors.

No model gives complete information about that which is modelled. And the model most often has features which are not really representations of anything; the are there for other reasons. Hence, it is important to have an instruction for the model; we need to know what aspects of the model which are intended as representations of the real world and which are not.

What is a representation?

Consider once again the relation between the temperature of the air and the state of a thermometer. We look at the thermometer and, neglecting the possibility of incorrect calibration, the length of the column of the fluid represents the temperature in the air. The relation between temperature and length of column is a causal relation; an increase in temperature causes an increase in length. This is the simplest case of a representation: by a causal mechanism we get a one-to-one-mapping of temperature to length.

Next consider the equation pV=nRT. This is, one could say, a representation of the relations between pressure, volume, amount of matter and temperature in a portion of a gas. But this cannot be conceived as a causal relation; the gas doesn't cause the equation. Rather, we humans have after elaborate research formulated the equation. The equation is an abstract object and abstract objects cannot be caused, since they do not exist in the same way as real objects, events and properties exist in space and time.

For most people the equation doesn't say anything at all. In order for the equation to really represent the relations in the gas, the formula must be understood as a *representation*. It is the same with all words in our language; the word 'öl' represents a beverage in Swedish, but oil in German. Outside a community of language users the word doesn't represent anything at all. In fact, the physical realisation of a written word, black marks on paper, wouldn't even be a word, unless it is understood as such. When you hear a person using a completely unknown language, how do you know whether he really talks or whether he just makes meaningless noises? The point is that in order to know that something is a word, you must know that it has a meaning, that it *represents* something.

This relation, that something *represents* something else, is difficult to understand. Just as certain marks on paper under certain conditions can represent something, a model represents something outside the model, such as events, states of affairs, processes, or relations between quantities in the real world. And in order for the representational function to do its job, there must be humans who interpret and understand the model as precisely being a representation. There is an unavoidable *intentional* aspect in these non-natural representations.

The difference between the relation between an ordinary word or sentence and what it is *about* one the one hand, and the relation between a model and what is being modelled, on the other is that in the latter case there must be some structural similarity, which is not necessary in the former case.

A model, and a representation in general, cannot be a completely free invention. In order for really being a representation, there must something in common between the model that being modelled. I would suggest that this common feature can be described as structure. Can we say something general about the notion of 'the same structure'?

Quine: “Structure is what matters to science, and not its choice of objects.”

The idea is that of a one-to-one mapping between a data set and a model. And the obvious candidate for filling the notion “same structure’ with some content is the concept of *isomorphism*.

In order to define this concept we need *group theory*.

Group Theory

Group: a set of elements with a unit or identity element, a closed binary operation *o*, the associative law is valid, and to each element there is an inverse.

Homomorphism: A mapping *f* from a set G to a set H such that if a and b [G, then a*o*b=f(a)*o'*f(b), where o’ is the binary operation in the group H.

Isomorphism: every element in G has a map I H, and every element I H is the map of an element in G.

The mathematical concept of an isomorphism is one way of making the intuitive notion of ‘same structure’ or ‘same relation’ precise.

Now, is it the case that the concept of isomorphism can be used for analysing all cases of modelling? I don’t know.

The first thing to consider is whether a given data set really is a group in this mathematical sense. And if it is not, we cannot say that the relation between the data set and the model is a an example of an isomorphism.

Consider a set of data about pressure, volume and temperature of a given portion of gas. Since the portion of gas is constant, we can neglect the number of moles as a variable; so we have sets of triplets $\{(p_i, V_i, T_i)\}$. If the gas is ideal, or nearly so, and we have made correct measurements, the data fulfils the condition that pV/T is a constant. Does this set make up a group? It is unclear to me whether the answer is no or yes. The problem is to identify a complex operation on triplets of numbers which fulifils the condition in the definition of a group.

It seems to me that the isomorphism condition is not well suited for expressing what we are interested of in this case. The crucial thing is if the data set really, or nearly, satisfies the condition pV/T =constant. When we say that the ideal gas law is model we simply want to say that the equation is nearly, but not completely, satisfied by concrete samples of gases. We call the equation a model since the fit is not total: no gas is perfectly ideal and we can never perform any experiment without error.

Complete models.

Intuitively, it seems reasonable to suppose that any model can be improved by adding more structure. For example, we know that the ideal gas law is not always a correct model of a real gas. For example, if the pressure is very high, the gas molecules do in fact interact when being near each other, contrary to the assumptions in the model. But the model can be improved by adding parameters accounting for these additional features; in the case of thermodynamics the improved result is van der Waal's law. And we can continue the process of improvement by taking relativistic or quantum effect into account.

Those who are realists assume that it is possible to come closer and closer to a complete and perfectly true model. And it appears also possible to reach the goal of complete truth, albeit we will never know that we are in fact there.

Against this train of thought quite a number of people have said that there is no reason that nature is so well-behaved so as to be possible to describe in one coherent theory. It might very well be the case that it is so irregular and chaotic that our human cognitive capacities are insufficient to construct any such model, not to say grasp a final complete model. Against that James Brown has claimed that set theory is such a strong tool that any way the world might be, we can construct a representation of it using set theory:

"We already have set theory in our possession. In some important and relevant sense we can grasp it. When we do science we in effect assert that some part of the physical world (or even the whole universe) has the same structure as some mathematical object. Since the realm of sets provides all possible mathematical structures, any way that the world could be is exactly isomorphic to some set-theoretic object. Since all of these mathematical structures are graspable in some relevant sense by the human mind, any way that the physical world could be is also graspable by the human mind. Of course, any alleged isomorphism between the physical world and some set-theoretical structure is a conjecture which may be false; science after all, is very difficult and very fallible. But there is no way of thinking about physical reality which is ruled out by our genetically cognitive capacity, since (standard) set theory can provide the representation of any possible way reality might be. The mere fact the we possess set theory shows that there can be no (non-logical) constraints on our thinking."

J. Brown: *Smoke and Mirrors*, s. 76.

Against this optimistic view some have pointed out that quantum mechanics provides a good example where it is impossible to construct one unified model for all phenomena. The argument is built upon the well-known fact that quantum phenomena sometimes show particle behaviour, sometimes wave behaviour and these two aspects of reality cannot be integrated into one coherent model.

Quantum duality; wave and particle behaviour.

Wave behaviour: a quantum system propagates in space and time as a complex wave, i.e. two waves with a fixed phase, i.e., $\pi/4$. This wave is scattered throughout entire space, at least in principle. This feature is responsible for interference phenomena.

In interactions any quantum system behaves as a point particle: it collides with other quantum systems and exchanges quanta in indivisible processes, at well-defined places.

Is it possible to combine these two models of quantum systems, one saying that it is spread out in space, one other model which says that it is point-like? Isn't this a contradiction? No, it is not, if we can give criteria telling us when to apply one model and when to apply the other. And that we can; it goes roughly as follows: when considering interactions (exchange of quanta) between quantum systems we shall use the particle model, and when describing evolution of isolated systems in space-time, we shall use the wave model. And since interaction and isolation are opposites, no system can at the same time be isolated and partaking in interactions, we have no contradiction.

Should we say that we here have a complete model with two sub-models, or should we say that we have two completely different models each with criteria for application which ecludes each other? I don't think it matters much what we say here.