In trying to understand common sense, we shall take a similar course. We won't try to understand it all at once, but we shall feel that progress has been made if we are able to construct idealized mathematical models which reproduce a few of its features. We expect that any model we are now able to construct will be replaced by more complete ones in the future, and we do not know whether there is any natural end to this process.

The analogy with physical theories is deeper than a mere analogy of method. Often, the things which are most familiar to us turn out to be the hardest to understand. Phenomena whose very existence is unknown to the vast majority of the human race (such as the difference in ultraviolet spectra of iron and nickel) can be explained in exhaustive mathematical detail – but all of modern science is practically helpless when faced with the complications of such a commonplace fact as growth of a blade of grass. Accordingly, we must not expect too much of our models; we must be prepared to find that some of the most familiar features of mental activity may be ones for which we have the greatest difficulty in constructing any adequate model.

There are many more analogies. In physics we are accustomed to finding that any advance in knowledge leads to consequences of great practical value, but of an unpredictable nature. Röntgen's discovery of X-rays led to important new possibilities of medical diagnosis; Maxwell's discovery of one more term in the equation for curl H led to practically instantaneous communication all over the earth.

Our mathematical models for common sense also exhibit this feature of practical usefulness. Any successful model, even though it may reproduce only a few features of common sense, will prove to be a powerful extension of common sense in some field of application. Within this field, it enables us to solve problems of inference which are so involved in complicated detail that we would never attempt to solve them without its help.

1.3 The thinking computer

Models have practical uses of a quite different type. Many people are fond of saying, 'They will never make a machine to replace the human mind – it does many things which no machine could ever do.' A beautiful answer to this was given by J. von Neumann in a talk on computers given in Princeton in 1948, which the writer was privileged to attend. In reply to the canonical question from the audience ('But of course, a mere machine can't really *think*, can it?'), he said:

> You insist that there is something a machine cannot do. If you will tell me precisely what it is that a machine cannot do, then I can always make a machine which will do just that!

In principle, the only operations which a machine cannot perform for us are those which we cannot describe in detail, or which could not be completed in a finite number of steps. Of course, some will conjure up images of Gödel incompleteness, undecidability, Turing machines which never stop, etc. But to answer all such doubts we need only point to the