Introduction
What is intelligence?

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Though everyone agrees that there could be no science without intelligence, the very existence of intelligence has often been seen and used as an argument against the modern scientific explanation of the world. Is not intelligence that makes living beings act in a non-mechanical and often unpredictable way? It is not that their behaviour is erratic, but, rather, that what determines it is of the order of reasons, not of causes. What modern science does, however, is precisely not to look for the reasons stars or atoms may have for moving the way they do, but to pinpoint the causes that determine their movements. The dominant model of the universe before the seventeenth century was largely inspired by observation of the living world: each thing seemed to have its own purpose or finality – in the same way as, for instance, the very coexistence of the parts of an eye could only be understood by reference to the function of the organ as a whole: seeing – and, in turn, all the particular finalities found their reason in the ultimate purpose of a supreme intelligence. Intelligence was, then, a general means of explanation. However, as soon as the dominant model of the universe became the mechanical interaction of non-living things, intelligence obviously had to be explained away.

There were two ways of doing this. The ‘dualists’ postulated that intelligence was a faculty exclusive to beings ruled by an immaterial substance, a soul, of which one of the clearer manifestations in the
world was the command of speech – or rather language, for parrots speak, but, as Descartes said, what they say is not à propos (that is, at the same time appropriate to the particular circumstances and denoting something), except by accident. It is just an acquired physical reaction to modifications in their environment that may have nothing to do with the meaning of what they ‘say’. Not that in this case there could be no regular relation between the environment and the utterance: one could train a parrot to say ‘What a lovely day!’ whenever the sun shone. But what is wrong here is precisely that the link is immediate: the environment triggers the utterance irrespective of its content (the parrot could be re-trained to produce the same utterance whenever it rained). By contrast, appropriateness is not a causal relation, but a referential one, in which what directly refers to the environment is the content of the utterance, not the utterance itself. Now, contents of language are necessarily more than inert images, even if linguistic reference is often built on images. It is true that abstract words derive from metaphors (the word ‘metaphor’ for instance, is built on the image of the transportation of an object from one place to another in space, though nothing of the sort happens in a metaphor), but this is precisely what makes linguistic references something more than images (or than what images are usually taken to be, mere reflections): they are acts of isolation or abstraction of certain features or states of an ‘outside’, whether to refer to the world, to ‘inner’ psychological states, or to pure abstractions. No wonder then that from the consideration of the nature of language one should be led to postulate the existence of a separate ‘inside’, a soul, as the agent of the intelligent activities it requires.

Tool-making has been generally considered as another distinctive property of intelligent beings, in so far as it implies the ability to endow a material object with a mode of existence determined by an aim largely unrelated to the nature and origin of the object (as when one breaks off a branch to use it as a stick). But the use of speech can itself be seen as an act of tool-making in which some material objects, sounds, are so to speak detached from their own nature as instinctual reactions (as in cries), to be attributed meanings totally unrelated to
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their biological and physical nature, that is conventional ones. This is clearly shown not only by the diversity of languages invented by beings endowed with the same speech organs, but also, again, by the fundamental capacity of language to express abstractions, that is things that could not possibly have any onomatopoeic relationships with sounds.

Thus, if the dualist point of view is right, that is if only those beings whose behaviour implies the actions of an irreducible autonomous (i.e. self-regulatory) soul can be called intelligent, then intelligence must be the subject not of a deterministic science of nature (physics) but of a science of non-physical or non-solely-physical beings: men, angels and gods (metaphysics). While intelligence had formerly been the dominant principle of explanation, exhibited in various degrees in the amazing properties of even the smallest ‘creatures’, the generalisation of the mathematical approach to science made it the privilege of a single species in the natural world: man. Again Descartes pointed out that the stupidest human being was in a different league from the seemingly most intelligent animal.

Such a position can also be defended from a non-metaphysical point of view. Thus Daniel Dennett, one of the contributors to the present volume, has stressed the importance and the systematicity of the different ‘intentional stances’ we adopt, for instance towards mentally handicapped persons or very young children, whose behaviour we often perceive as being more determined by causes than by intentions.

This difference of attitudes not only shapes the way we interact as individuals; it is also fundamental to the institutions we have developed to regulate our interactions. For instance, most legal and, as a consequence, penal systems now in place throughout the world, are based on the notion of responsibility. Can one consider a non-intelligent being as responsible for the damage it may cause? Being responsible means, at the very least, being able first to foresee the consequences one’s own course of action could have, and, secondly to perceive the relevance of moral, social, or legal principles to those consequences, whether or not one then decides to comply with them.
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There is no doubt that both abilities are essential to the notion of intelligence. So, whether the assertion of an irreducibility of intelligence is based on metaphysical considerations about real differences between a physical and a metaphysical world, or on the analysis of the assumptions that regulate our interactions with one another (from ‘folk psychology’ to legal theory), from this point of view, intelligence is not a question of degree or quantity, it is an absolute or qualitative difference.

Nevertheless, there has always been an opposite approach, first criticising, and then, as science grew in strength, aiming to eliminate this last residue of a ‘prescientific’ conception of the world in which men, not being aware of the causes that determine their actions, have considered themselves as ultimate causes, determined only by their own ends or finalities (this is one of the origins of the usually derogatory characterisation of such an attitude as ‘finalist’). As Spinoza said, they ‘seemed to have conceived man in nature as a kingdom within a kingdom’. Great hopes were placed, from the beginning of the twentieth century, in the idea that in the same way as the physical complexity and adaptation of living beings could be explained by the gradual and completely mechanical process of the selection of features that simply allowed an organism to survive within a competitive natural context, the complexity of intelligent behaviour could be reduced to the selection of sets of reactions mechanically elicited by the expectation of some reward experienced in the past in similar circumstances. This had two important implications. First, the link between the behavioural reaction and what triggered it could be purely arbitrary: it did not consist in any kind of understanding. And, second, if intelligent behaviour could be reduced to combinations of simple mechanical reactions, such behaviour was not specific to one species but could be found, to varying degrees, in almost all species. This is what the most sophisticated exponent of ‘behaviourism’, B. F. Skinner, tried to show in his famous experiments: a rat could be trained to press a lever to obtain some food whenever a light was on (or off, according to complex schedules). As this is obviously not an innate pattern of behaviour, if one were to witness it without being aware of the past training
history, one could not but think that it required some sort of intelligence. The behaviourist’s point was thus that if we could produce such a result by the mere conditioning of a physical reaction to any ‘stimulus’ with which it had usually been associated in the past with a beneficial effect, there is no reason to assume that other types of apparently intelligent behaviour could not be explained in the same way, removing the need to refer to metaphysical entities, or to use non-causal, finalist modes of explanation.

The problem is that these experiments were too successful. They showed that animals could be very intelligent indeed, too intelligent in fact, for the theory. For if the rat’s paws were tied, it used its nose; if a lever were shortened, it did not press in the air but moved forward. Which means that what had been conditioned in the experiment was not simply a specific muscular reaction to a particular stimulus, but some understanding of a particular causal state of the world. The difference is that once the link was understood, a large class of possible actions (instead of a single fixed reaction) could be executed, of which the only common characteristic was intentional: they would produce the desired effect. The action in the contrived environment of the box was only fixed or regular because pressing a lever with one’s paw or hand rather than nose is the most natural thing to do in such circumstances, whether one is a rat or a man (but not when one is a seal). Therefore, though associative learning theory had produced some astonishing results, and also demonstrated the ability of human intelligence to invent unexpected methods of enquiry, it could not meet its eliminative goal: intelligence remained a problem that could not be solved by a simple mechanistic approach. And if much has been done lately in the cognitive sciences to tackle the problem of intelligence, there is still no agreement as to whether solving it will be a process of reduction to the biological and physical sciences, or whether we should review the way we think knowledge should be organised and unified.

The emergence of intelligence is an evolutionary problem: why is instinct suddenly insufficient at a particular stage in the history of adaptation? Are there necessary limits to instinctual solutions when
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the living world has reached a particular degree of complexity? And anyway, is the difference between instinct and intelligence such a clear one? After all, one of the effects of the ‘cognitive revolution’ is that in all corners of the life sciences we now find intelligent processes at work. Finally, are there degrees of intelligence, as of other natural faculties? It is because of questions such as these that this book is organised along an evolutionary plan, and starts paradoxically by examining this apparently most passive of life’s functions, perception, at the level of the brain, to finish with a study of language. However, such a plan should not be taken to suggest that the evolution of intelligence is in itself linear and progressive, reaching its pinnacle in the human mind. Most of the papers have at least one conclusion in common: there are varieties of intelligence and they cannot be easily compared, let alone rated on a common scale.

In the first chapter, Richard Gregory deals with visual perception, and shows that a great deal of intelligence is required by what seems prima facie a receptive state. In fact what this seminal paper tells us about perception leads to an understanding of general features of intelligence, and in particular of the fact that it is a property of processes, not of predetermined beings. Thus, visual perception can be seen as the result of the work of particular forms of intelligence: on the one hand, the sedimentation of evolution in the physiological forms of sense organs (the store of solutions or the ‘knowledge’ that life has evolved, what Gregory calls its ‘potential intelligence’), and, on the other, the actual use of decision-making mechanisms when the amount of sense data available either under-determines or overwhelms the assumptions embodied in the physiology of the organs, and leads to perceptive ambiguities in the identification of an object or a phenomenon (this inventive type of intelligence he calls ‘kinetic intelligence’). These considerations set out the problem clearly, both in theoretical and in practical terms: the main theoretical question, which runs throughout the book, is that of the respective importance first of knowledge and secondly of the means and ways of accessing and using it. An important practical question is the validity of
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Attempts at measuring degrees of intelligence on a single scale, such as IQ tests. If they are so unsatisfactory, it is precisely because they reduce intelligence to only one of these aspects, turning it into an empty formal ability.

In chapter 2, Nicholas Mackintosh systematically compares attempts at explaining animal behaviour on the basis of associative learning with intentional approaches. While in most tasks involving the perception some animals have of abstract relations the first approach fails, the intentional approach appears unnecessary in unexpected and important cases, such as communication, where most of what seems to require the attribution of beliefs by some animals to other ones can in fact be reinterpreted from the point of view of an associative theory of learning, as techniques for manipulating the other's behaviour. Here again it seems difficult to point to a unique dimension of intelligence, different species being better or worse than others at different tasks, and sometimes in ways that contradict our expectation of what the hierarchy of intelligence among them should be.

At the next level, that of the emergence of intelligence in humans, George Butterworth re-examines the best-known theory of the development of intelligence in children, that of Jean Piaget, and shows that in many respects, the idea of a regular development through necessary stages, according to the degree of physical interaction the child has with the world, proves inadequate: several fundamental concepts (such as that of 'permanence', that is the assumption that objects that have been removed from perception continue to exist) are in fact present at a very early stage and are best explained by an examination of the structure of perception. Also, children who have severe motor handicaps from birth can develop intellectually in roughly the same way as children who can interact normally with their physical environment. Again, processes that we would want to call intelligent are at work very early on in the structure of perception itself. The driving force of the development of intelligence seems to lie more in the ability to translate a perceptual understanding from one sense to another,
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or to transfer it to a different type of activity, that is in the ability to
generalise solutions that are already present. By contrast, stupidity is
a form of absolute specialisation.

Having acquired a better understanding of the diversity of intelli-
gent processes in nature, it is only natural to consider the possibility
of an artificial intelligence (AI). In chapter 4, Roger Schank and Law-
rence Birnbaum forcefully assert that the problem is similar to the
one faced by educators; intelligence is a question of learning, of
acquiring a memory or knowledge-base of sufficient size, and of
developing the retrieval mechanisms necessary to use it. Since ‘AI is
in the size’, creating such an intelligence is largely a progressive or
cumulative process. The strength of the argument is that since the
alleged theoretical problems of AI are in fact pedagogical ones, the
solutions AI researchers devise can also offer original ways round
pedagogical problems. Conversely, most of the objections raised
against it come from conceptions of intelligence and knowledge that
ultimately deny the possibility of true learning or teaching.

Schank and Birnbaum’s claim of a continuity of intelligence
between all species, natural and artificial, is obviously quite contro-
versial. To measure its implications and also to understand those who
disagree with such a claim, it was necessary at this point to examine
specific features of human intelligence. The second group of chapters
look at two intelligent activities (mathematical science and art) where
invention is crucial, before moving on to language.

In chapter 5, Roger Penrose shows that the process of inventing a
proof is often a particular type of visualisation much more than a
‘blind’ deduction. A good comparison might be to see it as an orien-
teeering race, as opposed to a single line road race, except that in his
thought-orienteeering, the mathematician does not have a predefined
map of all the elements he will need, nor of all the potential paths to
the solution. If he is to progress, he has to find a way to reduce the
world of all possible paths. By demonstrating the impossibility of
the mathematical mind having *a priori* ‘frames’, Penrose wants to show
that there is in mathematical intelligence a non-deductive element
that eludes any computational description. Thus, paradoxically, the
mathematician’s mental space is itself more geographical than geometrical: susceptible of exploration but not of demonstration (except for the demonstration of this impossibility). And again, such a discussion is not without practical pedagogical consequences, in particular as regards the specific problems of teaching mathematics. As structuring a space and orienteering are among the first things we do, even before being able to move (see what Butterworth says about the infant’s ability to follow its mother’s gaze), it could be inferred from Penrose’s argument that teaching methods which insist on the early acquisition of strictly deductive procedures, as opposed to the traditional ones which favoured applied or manipulative geometry, are deprived of a natural way of familiarising the child with mathematical reasoning.

Penrose’s argument against the ability of an artificial intelligence to emulate fully the capacities of human intelligence also suggests that knowledge and intelligence do have important differences. For if, on the one hand, there cannot be any a priori plan of the best ways to solve all problems, and if, on the other, an infinity of consequences can be logically derived from any particular course of action (most of them irrelevant, but without there being any a priori rule to eliminate them), then a finite intelligence cannot base its decisions on the systematic and exhaustive consideration of the consequences they may have. In fact, supposing that an infinite mind existed, able to examine all future moves on the infinite chessboard of the universe, we would still be quite reluctant to call it intelligent, precisely because it would think in a ‘mechanical’ way. Would this mean that God cannot be intelligent? That would seriously jeopardise the possibility of His existence, for a perfect being must have, by definition, all conceivable faculties. A way around this consequence would be to say that the only humanly conceivable reason for man’s freedom (supposing that this is a fact irreducible to the deterministic laws of nature) is precisely that if the world were devoid of uncertainty, God would have no opportunity to apply His intelligence in trying to understand it (surely, a great deal of His intelligence would be needed to understand man’s behaviour), and it would be absurd for a perfect being to be endowed
with a useless faculty. Hence man’s freedom would be a proof of the existence of an intelligent God (rather than the reverse). Another, more likely argument, would be to say that in fact intelligence is not a positive faculty, but simply an ability to guess successfully, a way of coping with limitations either in knowledge or in the ability to access the relevant part of it in time. Thus, by definition, God would not need to be intelligent. Which is not to say that if God exists He is necessarily stupid, for, as we have seen, the notion of stupidity is also linked to that of a limitation of knowledge, but more in a horizontal way, as a lack of breadth.

While knowledge tends towards unity, it seems that intelligence is a process of production and diversification of forms or patterns of understanding, which can shape empirical data to create knowledge, but have much wider cultural uses. An ethnologist is best placed to illustrate the diversity of human intellectual achievements, in particular when dealing with music, where such diversity can clearly be experienced and measured. In chapter 6, Simha Arom shows how it is possible to provide people living in societies where transmission of musical knowledge is oral, and based largely on example and imitation, with traditional instruments that have been cleverly computerised so as to give the musicians the capacity to examine, and work on, the very complex mental structures they were previously simply inhabiting. It thus appears, for instance, that Central African xylophonists build and tune their instruments in an ambiguous way (between two scale systems), not through lack of precision, but so as to be able to accompany on one instrument songs sung in different modes. This means that these cultures have developed a meta-knowledge of their own music, though there is no explicit theory of it. It is difficult to convey in a book the experience of understanding a foreign musical idiom through its live deconstruction and reconstruction, but what is clear here, is that there is not one artistic intelligence: the range of possibilities within which the mind works is wide enough for it to generate and apprehend extremely complex and varied forms. Aesthetic pleasure is perhaps precisely the pleasure of experiencing one’s own ability to invent such complex forms, either during