Does Intelligence Evolve?

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Abstract

Alfred Russel Wallace, co-founder of the theory of evolution, argued that human beings are exempt from the normal processes of evolution by virtue of their exceptional 'mental and moral qualities', which enable them to anticipate, annul, sidestep and defeat the normal processes of evolution. This paper examines how far current knowledge of natural intelligence (human and otherwise) supports Wallace's hypothesis. It concludes that Wallace's overall claim was substantially correct, but his explanation for how this situation had arisen was not. A Piagetian analysis of intelligence justifies Wallace's insight, especially when extended to show how intelligence is also the basis of the massive cultural and technological systems by which human beings have surrounded themselves. Taken together, these factors explain how it is possible for the logic of variation and selection to be first superseded and then subordinated to that of intelligence itself. Indeed, once the specific nature of intelligence is recognised, this model also implies that intelligence's independence of evolution is far more radical than even Wallace realised.

1. Introduction

One of the best known (and perhaps most notorious) ideas hatched in the early days of Darwinism was Alfred Russel Wallace's suggestion that human beings were exempt from the normal strictures of natural selection: unlike other animals, our 'mental and moral qualities' allow us to circumvent the selection pressures on which evolution relies.

> So when a glacial epoch comes on, some animals must acquire warmer fur, or a covering of fat, or else die of cold. Those best clothed by nature are, therefore, preserved by natural selection. Man, under the same circumstances, will make himself warmer clothing, and build better houses; and the necessity of doing this will react upon his mental organisation and social condition - will advance them while his natural body remains naked as before…
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> Thus man… has taken away from nature that power of changing the external form and structure which she exercises over all other animals. As the competing races by which they are surrounded, the climate, the vegetation, or the animals which serve them for food, are slowly changing, they must undergo a corresponding change in their structure, habits, and constitution, to keep them in harmony with the new conditions - to enable them to live and maintain their numbers. But man does this by means of his intellect alone; which enables him with an unchanged body still to keep in harmony with the changing universe. (Wallace 1864: 163)

As a result, 'We must… look back very far in the past to find man in that early condition in which his mind was not sufficiently developed to remove his body from the modifying influence of external conditions, and the cumulative action of "natural selection"' (Wallace 1864: 167). Nor was Wallace alone in this belief.

> [I]n the scale of life there is a gradual decline in physical variability, as the organism has gathered into itself resources for meeting the exigencies of changing external conditions; and that while in the mindless and motionless plant these resources are at a *minimum*, their *maximum* is reached in the mind of man, which, at length, rises to a level with the total order and powers of nature, and in its scientific comprehension of nature is a summary, an epitome of the world. (Chauncey Wright in Norton 1877: 104)

Unfortunately, neither Wallace nor Wright had a credible explanation for these remarkable 'mental and moral qualities'. Waqllace could only argue that 'some different agency, analogous to that which first produced organic *life*, and then originated *consciousness*, came into play in order to develop the higher intellectual and spiritual nature of man' (Wallace 1905: 17). This 'explanation' cannot be distinguished from divinely ordained creation, and his position eventually descended into mysticism (Oppenheim 1985: 303-325; Richards 1987: *passim*; Robinson 2004: 324-327).

In fact, the capabilities Wallace believed bestowed on us a special position – abstraction, foresight, reasoning, calculation, concepts of symmetry and infinity, and so on (Richards 1987: 183) – remained largely unexplained by science until Piaget's studies of child development (e.g., Piaget 1953a). However, not only is Piaget's solution completely naturalistic but it is also logically opposed to Wallace's. So, as I shall argue below, if Wallace should have the credit for defining the problem, it was Piaget who gave Wallace's thesis its ultimate plausibility.

Meanwhile, Darwin's reaction to Wallace's argument was one of surprise and caution, but initially he could not resist its logic:

> I have now read Wallace's paper on Man, and think it most striking and original and forcible… I am not sure that I fully agree with his views about Man, but there is no doubt, in my opinion, on the remarkable genius shown by the paper. I agree, however, with the main new leading idea.[1] (Quoted in Eiseley 1961: 305)

Nevertheless, whenever Darwin discussed human evolution (in his major works at least), he disregarded Wallace's argument. Certainly *The Descent of Man* (Darwin 1901) is quite untouched by Wallace's 'new leading idea'.

But the idea was not quite dead. James Mark Baldwin (by whose theories Piaget's own views were strongly conditioned - Piaget 1979, 1980a) argued that human beings might buffer environmental pressures (Baldwin 1895, 1896, 1902; Richards 1987) by cultural means, pending the evolution of appropriate organic adaptations. Much later still similar ideas were elaborated by Waddington (1957), and Deacon and others have since adopted Baldwin's ideas as part of a more general account of the relationship between language, symbolism, culture and evolution (Deacon 1997).

However, Baldwin's reasoning also creates the opposite possibility. If a functional (i.e., behavioural) response works then the pressure for structural (e.g., genetic or organ) modifications will actually be reduced. This creates space not only for non-genetic biological inheritance (as modelled by developmental systems theory – Oyama *et al.* 2001) but also for the kind of process

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[1] Contrast Darwin's reaction to Wallace's later spiritualism (e.g., Darwin 1901: 72–73; also pp.195ff). On Darwin's later attitudes to Wallace, see Desmond and Moore (1992, *passim*).

Wallace was describing. However, although Baldwin's ideas are now studied widely, Wallace's more radical conclusions remain unconvincing to the modern ear. For example, the complexities and power of culture and technology, of social and economic systems, of science and politics, all make his emphasis on our 'mental and moral qualities' seem extraordinarily narrow. However, this is surely a little churlish, given the radicalism of Wallace's underlying idea and the relatively undeveloped nature of the human sciences in his day. On the other hand, his practical examples are not particularly convincing, and it is not difficult to show that Wallace's claim is overstated or to catalogue ways in which the human body has been modified by natural selection more recently than Wallace's hypothesis, taken at face value, allows (e.g., Moran 2000; Harrison 1993).

However, many of these instances are of physiological and anatomical modifications that arose before we had reached the cultural or technological level needed to pre-empt the relevant selective pressures. If the last few millennia have seen a convergence of European and African lactase tolerance (Tishkoff *et al*. 2006), or Andeans acquiring permanent physiological adaptations to high-altitude hypoxia, or the long-term inhabitants of tropical regions dealing with humid heat better than the rest of humanity, this is perhaps because cold, heat and humidity are features of the environment to which human intelligence had no effective 'mental or moral' response until very recently. Now, of course, we have innumerable devices, from pressurised cabins to air conditioning to food supplements to disease eradication programmes, that would render any permanent organic adaptation quite redundant.

For example, the human body has probably not evolved much since the plague pandemics of the sixth and fourteenth centuries. Nor has plague gone away: it remains endemic across the planet (WHO 2005). Yet, unlike much of the rest of the world, Europe and North America managed to avoid the next plague pandemic, which closed the nineteenth century. This is certainly because the changes to our 'mental organisation and social condition' introduced since the previous outbreaks – through medical science and epidemiology, public hygiene and drainage systems, health education, the pharmaceutical industry, welfare systems, and so on - make it extremely unlikely that a modern outbreak would have the usual cataclysmic impact on industrial societies. Indeed, between 1947 and 1996 there were 390 cases of plague were reported in the United States (*Morbidity and Mortality Weekly Report* 1997), but no epidemic. In short, we have 'adapted' extremely successfully to plague, yet without undergoing biological changes that could properly be described as 'adaptations'.

But there have been other criticisms of Wallace's hypothesis. From the present point of view, the most important is the argument that the greatest selective pressures on human beings now come from competition between social systems. Far from selective pressure having ceased, it has been internalised into the human way of life. But this is not altogether convincing. First and foremost, this point was not lost on Wallace himself, who expressly included in his analysis 'the competing races by which they are surrounded' among the forces to which human beings respond. Secondly, it is doubtful how much pressure social forces really exert on either social systems or their members' reproductive fitness (Hallpike 1984, 1988). Finally, if our neighbours are as intelligent as we are, then both the critical inter-societal pressures and our major responses to them – political, economic, and so on – are actually only further expressions of our common intelligence. Such pressures are created by competition *between* intelligent beings, take specifically intelligent forms, and are responded to in intelligent ways. These are neither created nor structured like biological variations and adaptations, and neither do they lead to noticeable biological changes.

Even a massively selective event such as the Second World War was not even metaphorically a variation in that evolutionary sense, however much its architects may have imagined that they were carrying out evolution's dictates. More generally, the fact that major aspects of human existence (wars, large-scale economic systems, cultural shifts, and so on) are poorly understood and hard to control by those involved in them does not turn their vicissitudes into biological variations, not even in the sense of 'extended phenotypes' or meme theory (Dawkins 1976, 1982; Blackmore 1999). Conversely, once they *are* understood, such fluxes and irruptions always turn out to follow a plainly non-biological logic that the human sciences can analyse without recourse to biological concepts.

By contrast, the unstructured character of strictly biological variations is inherent in the process of variation. That is, they are essentially random, although not generally in the usual stochastic sense. There is actually a great deal of structure to most biological variation, not only in its origins but also its mechanisms, the constraints and conservation processes that regulate its effects (Maynard Smith and Vida 1990) and the layers of the process of inheritance itself, which is by no means limited to the traditional Mendelian genes (Jablonka in Oyama *et al*. 2001). The global biological context within which variation occurs also has an immense effect on its significance (e.g., Oyama 2000). Not much variation is of the popular 'cosmic-ray-flips-codon' type.

Yet there is more to randomness than, as has been suggested (e.g., McKinney 1998), simple lack of knowledge of the real causes. As Eble has said of stochastic and evolutionary randomness, 'The former implies a combination of indiscriminate sampling and unpredictability due to multiple causes; the latter codifies independence from adaptation and the directionality imposed by natural selection' (Eble 1999: 75). Or as Ghiselin put it, for Darwin variation 'is not random but fortuitous' (Ghiselin 1969: 165; see 164-167 generally). That is, evolutionary variation is objectively random in the *functional* sense that there is no link between the causes of variation, the effects such causes have on the organism's structure, the impact this change of structure has on the organism's functioning, and the consequences of this behaviour for the organism's reproductive fitness – which is to say, with the main functional criterion by which the variation will ultimately be 'judged'. Variations are not 'for' anything at the point of variation, no matter what 'use' selection may put them to later.

Exactly the opposite is true for intelligence: to act intelligently is (among much else – Robinson 2004, 2005) to design, execute, monitor and judge that act for the sake of and in terms of a definite goal, rule, value, and so on – which is to say, specifically in terms of the criterion by which it will be judged. This break with the rules of evolution is fundamental to humanity's extraordinary qualities: we can manage biological problems like plague *only* because we no longer rely on biological 'methods' such as variation and selection to do so. To return to the problem of plague, although medical research throws up a hundred failures for every successful remedy, not one of those failures is a 'random variation' in *any* sense. Not even the most poorly conceived drug development programme happens without a prior purpose, success criteria, a rationally structured methodology, explicit specifications, a development plan and all the other trappings of a rational project. Neither does a mass vaccination or sewer-building programme. On the contrary, they are all explicitly and more or less rationally connected to the nature of the problem, the goals of their agents and a large corpus of established knowledge and powers, solutions and methods. Even 'blue sky' research relies on the ability to anticipate a desirable outcome.

Likewise, the systems, processes and mechanisms of human culture, history, technology, and so on, can hardly be said to rely on biological changes, if only because massive variation has occurred in them without their being accompanied by any detectable biological differences in ourselves. In the last ten millennia we have been everything from hunter-gatherers to industrialists and used every technology from sticks and stones to linear accelerators, without any apparent change in either our biology or the nature of our intelligence (though its level seems to have increased markedly – Hallpike 1979; Wynn 1979, 1981, 2002). This is not evolution, even though it represents far more change than any other species has ever undergone, not only in such a short time but perhaps *at all*.

This immediately raises two questions. Firstly, what are the implications of this unprecedented departure from the normal rules of evolution? And before that, what is the nature of the intelligence that is capable of such unprecedented results?

2. Theories of intelligence

Until the recent rise of adaptationist and modular explanations for everything, most scientists (biologists included) asked what it is about human beings that makes them so unusual would have answered, their intelligence. Despite this, science finds it difficult to say what this elusive term means: like 'mind', 'consciousness', 'thought' or 'reason', 'intelligence' resists definition even by those who have the most of it. But perhaps exact definition is too ambitious a goal: trying to define intelligence in our present state of knowledge is like trying to define matter or life two centuries ago. After all, in more than sixty books and hundreds of papers, even Piaget provided no convincing definition. This creates an extraordinary paradox that any self-aware being may experience: as Sir Thomas Browne put it in his *Religio Medici* in 1643, 'Thus we are men, and we know not how'.

For present purposes, I suggest a simple (and perhaps annoyingly abstract) definition of intelligence. An action is intelligent when it knows itself to be that action and is that action by virtue of that knowledge (Robinson 2005). Likewise for intelligent relationships and experience. That is, intelligent activity is more or less explicitly informed of and by its own structure, content and context. This in turn implies a capacity for insight into the nature (signs, properties, qualities, structures, and so on) of the things, situations and events that provide so much of that structure, content and context, in terms of which they may be created, explained and controlled. Hence the intimate link between intelligence and the rationality, for by this definition, an intelligent being can always be expected to give the *ratio* (reason, explanation and justification – Smith 1993 – plus supporting motives, goals, attitudes, and so on) for their activity. It also implies the ability to reflect on and criticise those structures for their validity, effectiveness, compliance with norms and values, and so on. Or if it doesn't, it is hard to imagine what philosophy and then science have been doing for the last few millennia.

This analysis places intelligence in an ambiguous position from an evolutionary point of view. Most of all, any appeal to the fantastic scale of the difference between human and non-human accomplishments and their impact of their respective environments can look suspiciously like one of those near-magical saltations that, like a vacuum, nature is supposed to abhor. On the other hand, if human beings are plainly intelligent by this standard, so are certain primates (Parker and McKinney 1999), and so may various cetaceans and birds be. But the claims of less sophisticated mammals and birds to, say, some degree of insight into their own actions (Vauclair 1996) is often as difficult to judge as disputes as to whether a virus is alive. So it is often simpler for scientists to concentrate on the continuities between intelligent and non-intelligent forms of activity, or perhaps to ignore the intelligent nature of human activity and experience, altogether. However, I do not believe that this is any more fatal to my definition than the existence of viruses is to the idea that life is fundamentally different from chemical reactions.

There is no lack of would-be scientific theories of intelligence. Three are especially prominent: neo-Darwinism, various forms of information processing theory and, trailing rather badly these days, Piaget's 'genetic epistemology'. Neo-Darwinian arguments are not only extremely widespread throughout psychology, philosophy and the human sciences in general, but a neo-Darwinian solution would create a relatively simple and direct link to the natural sciences as a whole. Information processing theory is equally prominent, and widely used in conjunction with neo-Darwinism in areas such as 'cognitive science', and unlike neo-Darwinism its relationship to intelligence is at least superficially self-evident. Piaget's influence, by contrast, seems to be rapidly waning, but as I shall argue below, his account of intelligence offers much the most convincing solution.

Many neo-Darwinians have claimed to explain aspects of human intelligence in evolutionary terms, under such rubrics as 'sociobiology', 'evolutionary epistemology', and 'evolutionary psychology' (e.g., Barkow *et al*. 1992; Campbell 1974; Hahlweg and Hooker 1989; Radnitzky and Bartley 1987; Ruse 1986). They have generally argued that human cognition, perception, motivation, memory, and so on, are conventional biological adaptations, shaped by selection and ultimately driven by reproductive fitness. Species-specific characteristics are traced to species-specific contingencies, often in a putative 'Environment of Evolutionary Adaptation' (EEA), though not always (e.g., Tooby and DeVore 1987). However, even the latter case assumes that the nature of intelligence is adequately explained by its evolutionary origins, and that it will continue to be shaped by these same evolutionary forces. The only distinctions human 'mental and moral qualities' can claim are exceptional effectiveness and (perhaps) extraordinary methods. In particular, culture is often credited with an alternative, quasi-Lamarckian mode of inheritance, though this does not alter culture's ultimate biological *raison* d'être, which remains reproductive fitness.

So how is it, generally speaking, that evolutionary methods might *not* apply to intelligence? In brief, the fact that intelligence is indisputably a *product* of evolution (Robinson 2005) does not imply that, once it exists, intelligence remains subject to *further* evolution, any more than the fact that life emerged from and, in a sense, consists solely of chemical reactions means that chemistry can adequately describe or explain the organism, evolution, heredity, and so on. If I take poison, how can I express this in chemical terms? The poison itself maybe purely chemical and the pathways through which it has its dire effect may be open to chemical assay, there are no strictly chemical criteria differentiating between 'alive' and 'dead'. Or rather, there are none that adequately reflect the radical biological result.

An intelligent organism is likewise still an organism and its intelligence has a massive and profound impact on its adaptiveness, fitness or biological performance generally, yet one should not necessarily expect evolutionary theory either to explain the nature of intelligence or to define what an intelligent organism is doing when it is being intelligent – even when it doing something obviously adaptive. After all, evolutionary theory starts with the assumption that the concept of evolution is necessary and sufficient - which, if intelligence turns out not to be susceptible to evolution, it plainly is not. So if, from a neo-Darwinian perspective, intelligence is just another adaptation, that is precisely the problem. If neo-Darwinism *assumes* that intelligence not only was created by but also continues to be shaped by evolution, then the question of whether *or not* intelligence evolves cannot even be posed. Conversely, if intelligence is immune to further evolution, then there is nothing in neo-Darwinism's intellectual armoury that can explain (or even describe) this fact. As neo-Darwinism's Humean approach to knowledge and activity is far from self-evident (Smithurst 1995), this is a fundamental obstacle. Hence the inappropriateness of neo-Darwinism from the present point of view: it assumes the very thing that needs to be proved.

Information processing theory is equally blind to the possibility of a qualitative break between the intelligent and the non-intelligent. Its basic definitions and models are assumed to be equally applicable to all species. By analysing *all* forms of activity in terms of 'encoding', 'transformation', 'processing', 'storage', 'coding', 'attention', 'access', 'retrieval' and so on, it necessarily glosses over any qualitative differences that may exist between intelligent and non-intelligent organisms. Thus information processing theory too assumes the very thing the present essay calls into question. As with neo-Darwinism, its rejects the possibility that intelligence may not be subject to evolution not by proving it false but by rendering it unthinkable.

Indeed, although it is possible to imagine experimenting in a classically 'intelligent' area such as, say, causality or means-ends relationships in such terms, it is hard to see what it is about causality or means-end relationships that could be 'explained' within such a framework. I may be able to discern how causal relationships are encoded, stored and retrieved, but what this tells me about causality as such is not clear, given that means-end relationships are analysed in exactly the same terms. Rather, it seems as though all the knowledge of causality or means and ends is in fact injected by the experimenter.

Hence, perhaps, the rise of the all-purpose doctrine of 'modules'. Being unable to specify what causality is when one is limited to the extremely generic logic of 'information processing', it becomes necessary to postulate the evolution of a special purpose unit that accounts for the actual function (e.g., causality, face recognition, and so on), whose external functioning can then be analysed in standard information processing terms. But how is it that this module is capable of grasping causal relationships? Because it was 'adaptive', so it 'evolved'. The problem of explanation is thus delegated to omniscient, omnipotent, omnipresent Evolution. Or perhaps an Intelligent Designer put it there.

The common problem underlying all this is that, if the hypothesis that intelligence is immune to evolution is to be properly examined, this examination can only be based on a clear conception of the *nature* of intelligence. By this I mean an analysis of its *functions*, its *structure* and its *genesis*. Only this can explain whether it is the kind of entity to which concepts such as evolution or information processing apply. There are after all plenty of structures to which they do not apply. Practically everything changes, of course, and many things develop – certainly the elements (in a sense), and perhaps even physical laws. However, such things do not change in the manner of biological variations (however understood) or by being subjected to any kind of exogenous selection process. There are after all no functional criteria analogous to 'reproductive fitness' among atoms and molecules, by which physical or chemical selection could be driven. Quantum theory rejects the idea of intermediary atomic orbits or electron counts between the few fixed alternatives dictated by its own laws.

In fact in any but metaphorical terms, evolution seems to be absent from any plane of material organisation but the strictly biological. However, this argument applies not only to structures operating below the biological level: if there are also structures that operate *above* the level of the organism, then they too may well be free of variation and selection, in the specifically Darwinian sense. I suggest that intelligence is such as structure. In the case of chemical and physical structures, this freedom from evolution follows from their lack of any idea of function; intelligence, by contrast, is free from evolution because it realises a self-reference and closure, so to speak, that short-circuits the basic logic of evolution, and replaces it with an altogether more powerful logic.

3. Piaget's theory

If neither neo-Darwinism nor information processing theory can judge whether intelligence is immune to evolution, are there any alternatives? Few other conventional approaches seem appropriate. For example, intelligent awareness, knowledge and insight are substantially independent of perception, memory, communication and the other psychological functions we share with non-intelligent species (Langer 1998: 40-46). Although human beings are not especially strong performers in areas such as location memory or the direct perception of numerosity, as soon as they start to introduce strictly cognitive forms (e.g., true number systems, symbolic forms, technological support, etc.), their performance in all these domains is infinitely greater than that of any non-intelligent species. Nor is any model that assumes that the basic mode of interaction between intelligent being and their 'environment' is passive observation likely to suffice. *Action* actively disturbs, relates and transforms objects, and so reveals previously unobserved features, non-empirical aspects of the object, inter- and trans-object relationships, the structure of the activity itself, and the overall logical properties of the situation in which it takes place. Without these, no knowledge of the world can be rational or even substantial, even if it can quite enough to support reproductive fitness.

My own view is that, of the theories that can address the evolvability of intelligence, Piaget's is most capable of testing the present hypothesis fully. This may seem an odd choice: isn't Piaget's 'genetic epistemology' a little passé, if not downright obsolete? In fact, although regularly criticised and occasionally pronounced dead, Piaget's theory remains intact (Lourenço and Machado 1996), and the evidence in its support continues to grow. Of course, his ideas are no longer focal even to child development or education, and his original findings have certainly been subjected to a great deal of refinement and correction. Yet the idea that a single structure informs intelligent action, experience and relationships, and that it develops according to a sequence of stages of the kind Piaget originally described, and that both its activity and its development revolve around continual rational re-structuring, remains robust. In addition, because it analyses intelligence in structural as well as functional terms and is grounded in a very mature developmental model, Piaget's theory provides a more promising starting point for evaluating the evolvability of intelligence than any of its competitors.

Furthermore, Piaget's theory is one of the most wide-ranging in the whole of psychology, so the support it might offer – or deny - the present hypothesis is considerably more telling than that offered by most theories. Piaget's intelligence infuses a universal (if not always homogeneous) structure into activity of all kinds, including the full gamut of psychological, social and symbolic relationships. Piaget's more than sixty book-length publications cover not only a huge range of cognitive and educational topics but also perception (Piaget 1969) and memory (Piaget 1968b); social relationships and values (Piaget 1995); moral judgment (Piaget 1932b); affect and emotion (Piaget 1981); play, imitation, mental imagery and dreams (Piaget 1951, 1971c); judgement, reasoning and language (Piaget 1928, 1932a, 1951); the epistemology, history and philosophy of science (Piaget 1950, 1971b Piaget and Garcia 1989); the psychology and epistemology of logic and mathematics (including geometry, quantification, number and chance) (Beth and Piaget 1966; Piaget 1952, 1953b, 1972; Piaget and Garcia 1991); identity, contradiction and dialectics (Piaget 1968a, 1974, 1980b); both general biology and evolutionary theory (Piaget 1971a, 1979, 1980a); and consciousness (Piaget 1977, 1978).

But not even this monumental personal *oeuvre* has exhausted Piaget's ideas. Areas to which his ideas have been extended include primatology (Antinucci 1989; Parker and McKinney 1999; and many others); the anthropology and archaeology of cognition (Damerow 1995; Hallpike 1979; Wynn 1979, 1981, 2002); the historical development of religion and moral values (Barnes 2000; Fowler 1981; Hallpike 2004); the transformation of medieval reasoning, theology and architecture and drama (LePan 1989; Radding 1985; Radding and Clark 1992); the history of art (Gablik 1977); the nature and logic of norms (Smith 1993); animal rights (Wise 2002); and even the large-scale structure of history itself (Robinson 2004).

Despite its enormous scope, Piaget's theory is fundamentally simple. With only a few exceptions, such as his accounts of moral judgement and emotion, the whole of Piaget's account is characterised by a profound unity. On the other hand, like any powerful simplicity, there are as many ways of looking at it as there are interests in its subject matter, but for present purposes only a few basic elements need be identified.

Firstly, notwithstanding the widespread misunderstanding of his theories even among psychologists, in the Piagetian model intelligence is not essentially either intellectual or even cognitive, at least insofar as the latter term is narrowly defined. Piaget's intelligence is a universal structure informing all forms and aspects of activity, from cognition and memory to values and social relationships. As I have argued elsewhere, this can be extended up to the very possibility and most general structures of culture and technology (Robinson 2004). This unity allows Piagetians to conceive of problems such as space, play, scientific method, number, moral values or history as simply different facets of activity as such. As a result, they move seamlessly from the central abstract problem of how we (for example) experience 'objects' in general or objects as such to innumerable more concrete aspects of objects (such as identity, topology or causation, or even religious belief and artistic expression) and back again; or from a narrow component of activity (such as grouping, seriation, reversibility or possibility), up to the logic of activity in the abstract (and especially its formal logico-mathematical structure) and back again; and to do both without losing track of the wider picture of intelligence as a whole.

Secondly, intelligence is inherently reflexive. Like any organism, intelligence experiences its environment by acting on it, and this activity creates an awareness that fuses the things on and through which intelligence acts with the patterns of the activity itself. In non-intelligent organisms this confusion is not resolved, but because, in intelligent activity, the product of this fusion takes the form of an *object* – which is to say, of an entity that is experienced as existing independently of both the agent and the activity through which it was constructed – successive constructions will progressively define three things. Firstly, they will define the object itself - for its own sake, in its own right and on its own terms. Secondly, by allowing the same activity to be applied to a multiplicity of objects in a multiplicity of circumstances, it will define the activity too. This will culminate in recognition (i.e., objectification) of both the activity 'as such' (e.g., 'throwing', dropping', 'hiding', and so on) and the abstract relationships between various forms of activity (i.e., logic and mathematics). Finally, the progressive differentiation of activity and object will also reveal (i.e., objectify) a further feature, namely the agent of that activity and the structure that unites the activity with its objects, namely the *subject*.

Hence the third crucial feature of Piaget's model of intelligence. This constant process of reflection on its objects drives experience in two directions: towards *empirical* abstraction of the features, properties and structures of things, situations and events, and towards *reflecting* abstraction of the features, properties and structures of its own activity (Piaget 2001). This in turn provides the basis for intelligence's development. The objects the infant can construct during its sensorimotor phase are recognised as existing independently of the infant but, from the infant's own perspective, possess only sensory and motor properties. However, by reflecting on the actions through they are composed, arranged, transformed, and so on, the toddler constructs stable groupings, classes, series, and other structures, which are then reconstructed by the older child into yet higher structures such as number, which are themselves re-synthesised by the young adolescent into intellectualised structures such as formal logic and mathematics. At the same time, practical action and experience are also progressively constructed and reconstructed and, like the logico-mathematical structures, used to inform yet higher cycles of activity.

If Piaget's analysis of this process is correct, then intelligence's developmental potential is logically unlimited. On the one hand, essentially the same cycle of objectification, reflection and synthesis recurs over and over again. That is, it does not require new abilities to reach each new developmental stage. It may be limited only by general neural capacity – a limitation that human evolution has consistently pushed back, no doubt because the rewards higher intelligence brings is always worth the additional investment in such 'expensive' tissues (Aiello and Wheeler 1995; Passingham 1975). On the other hand, notwithstanding the intellectualism and phenomenalism of so much psychological experimentation, the core process for creating the higher objects on which this development relies takes place primarily in the external world created by our increasingly complex cultural and technological systems. This world is not only accessible to every intelligence (including members of other cultures and even other intelligent species) but also capable of supporting new objects of any scope, depth or complexity, limited only by the objective laws of the universe.

But perhaps the most radical feature of Piaget's theory is that none of these unprecedented features are built into the infant. There seems to be is nothing in a newborn baby that tells them how to develop or what stages they should pass through, any more than a stone contains instructions for rolling downhill or water for splashing. That such propensities are the results of universal structures of matter rather than peculiar to the objects in question is shown by the fact that the same principals of 'splashing' are shared by oil, custard, piles of fine dust, and hypothetical falling horses encountering the unyielding bottom of a mineshaft. Instead of being determined by any positive feature of the objects in question, it seems to be the *absence* of either constraints or positive propensities that causes all material objects to fall in the same manner, all fluids to flow in the same way and the development of all intelligences to follow the logic of the *object as such* and the logic of *activity as such* rather than any predefined method or template, biological or otherwise.

Although this point will be elaborated later, it may seem paradoxical, but in fact precisely as much material effect is caused by the lack of structure as by its presence. For example, the singularity of black holes, the colour of blue eyes, albinism, cystic fibrosis, and so on, all arise from the absence of specific 'programming'. I have argued elsewhere (Robinson 2005) that the origins of intelligence lie in driving adaptation to the limits of 'adaptability', but adaptability is at least partially a lack of predetermination (i.e., specific forms of 'adaptedness') as to which structures are applied to or how they be coordinated. In that respect Piaget was many decades ahead of recent ideas on emergent structure, complex systems, and so on. Conversely, built-in solutions, practically useful though they might be in the short run, would prevent intelligence from pursuing to its logical conclusion the nature of the objective reality by which it is confronted and of which it is composed. Built-in modules and genetic programmes may get the organism off to a flying start, but in the long run they can only hinder it from coming to the finish line set by reality. That is why we start out inferior to so many species in every arena we enter, yet quickly overtake every other contender. A century ago we could barely get off the ground, but I would challenge any other species to out-fly us now.

The final aspect of Piaget's theory that is relevant is that it is inherently social and symbolic. With the partial exception of mental objects (images, ideas, dreams, thoughts, and so on), objects exist for the most part in a public arena where they may be encountered by any other competent intelligence. A child's ball, experimental evidence, a corporate bureaucracy, are all 'out there', even if what we make of them is not. By the same token, our cognition of objects produced by other subjects (including specialised social objects such as language, facial expressions, gestures, writing, cultural artefacts, and so on) and our developing grasp of the objective relationships through which we relate to other intelligences (exchange, roles, property, rules, gifts, theft, obligations, shared values, negotiation, war, etc.) allow us to construe a good deal about, and establish relationships with, other individuals, and indeed to create systems, institutions and other structures that embody and further social relationships of various kinds. Finally, if objectifying something is the consequence of construing the internal structure that 'must' be responsible for its detectable functioning, then there is no special problem in objectifying the internal structure of another intelligence – which is to say, in objectifying and understanding other subjects, and no special theoretical problem in understanding how one human being can understand another.

Hence the inescapably social character of the development of intelligence – the very antithesis of the 'lonely scholar in the pram', as Piaget's infant was once called. From the very first there is very little that intelligence creates that is not either produced with, directed at or mediated by other intelligences, starting with its caretakers, siblings and peers and culminating with massively abstract social systems such as (in our society) law, roles, employment, money, markets and commodity relations. In addition, these others' actions and constructions are themselves mediated by their own expectations, goals, capabilities and relationships, and by wider social structures of various kinds. Even the radical individuality and individualism that psychologists tend to take for granted (and which alone allow them to proceed in such isolation from the remainder of the social sciences) are actually relatively recent and historically very specific social developments, having become the norm with the widespread formation of capitalist societies (Robinson 2004). In other words, this individualism is itself possible only by virtue of the radically social dimension of intelligence.

The object is also the basis for intelligence's propensity for symbolism. Because intelligence is capable of constructing objects in terms of supra-empirical classifications, models, structures, and so on, it can refer from one object to another by any number of relationships such as analogy, equivalence, simile, metaphor, metonymy, and so on. At the same time intelligence also acquires the especially telling capacity for completely arbitrary and conventional symbolism – a defining feature of so much of human language and culture. Because its development is equally driven by empirical and reflecting reflection, intelligence can increasingly reflect on the structure of its own actions without reference to any particular empirical content or context. This distinction is present from very early on (for certain purposes, throwing a feeding bottle out the pram is just as good as ejecting a toy), and eventually reaches the point where the empirical object is required only to instantiate the action, and can be selected from all possible objects that are accessible to the action in question. From that point onwards, to the extent that a completely conventional object will do for the activity in question (i.e., not only a sound or written mark but also a team colour, a national flag, a gesture or stance, and so on), the symbol itself can be completely arbitrary even though what it symbolises is anything but.

It would be difficult to exaggerate the significance of intelligence's social and symbolic dimensions. Although this is not the place for an extended analysis (but see Robinson 2004), the long chains and complex systems of subjects and objects to which social and symbolic relationships lend themselves allow intelligent activity to be constructed, transmitted and reconstructed over epochs and continents. This raises the possibility not only of culture and technology but also of history itself. When combined with the ability to construct objects, systems of objects and systems of systems to implement and support social and symbolic relationships, then the methods, tools and techniques available to an advanced intelligence quickly replace the more or less hand-to-mouth and individualistic strategies of even the most sophisticated non-human primate with true economies, and the chimpanzee's small-scale and primarily face-to-face social systems with true political systems. It is hardly necessary to say what the impact of such changes has been, not only on human existence but also on the planet as a whole.

So much for the main dimensions of Piaget's theory. But what specifically allows intelligence to rise above evolution? Answering this questions requires a more detailed analysis of three interrelated aspects of his model of intelligence: object permanence; the internal structure of intelligence (which I will refer to as the 'subject'); and the organisation of subjects and objects into the fundamentally new form of 'environment' we call 'the world'.

4. Object permanence

The single best known and most widely researched Piagetian concept is *object permanence*. As a neo-Kantian, Piaget assumes that it is impossible for us to know what things are 'in themselves'. However, we are still capable of recognising *that* things exist in themselves, which is to say, independently of any experience we may have of them (Piaget 1953a, 1955). Indeed, intelligence is not capable of *not* recognising this fundamental property of objects: it is both one of intelligence's earliest constructions and all-pervasive in its scope and consequences.

Furthermore, it is *only* insofar as we construct things and events as objects that we can know them. Even things that are normally treated as non-objective, such as mental images and opinions, exist for intelligence only to the extent that they are formulated as objects. Only when we detach ourselves from them can they be dealt with, or even properly recognised for what they are. Only as objects can specifically intelligent operations such as identification, analysis, evaluation, comparison, ordering, valorisation, planning, and so on be applied to emotions, bodily states, and other affects. Indeed, although Piaget himself did not address this issue clearly, my own view is that consciousness *is* object permanence, and *vice versa*.

More generally, for an organism with object permanence, 'out of sight' is definitely *not* 'out of mind'. Without object permanence, it is impossible to recognise that hidden things are still 'there', that things 'go somewhere' when they disappear, that reality is not defined by appearances, that there are different points of view, and so on. Conversely, the implied existence of things despite their phenomenal absence makes a huge variety of human phenomena both literally and metaphorically thinkable, including not only individual consciousness and cognition but also cultural and technological artefacts and social systems more complex than face-to-face interactions (Robinson 2004). Object permanence also engenders various forms of strictly cognitive (as opposed to perceptual) conservation, implication and invariance. But permanence is also expressed in the recognition that objects possess a fundamental ‘otherness’, with autonomous powers. Hence the growing recognition even among babies that things can be used as instruments, tools, supports, screens, weapons, doorstops, and so on, or among adults that the right lift-drag co-efficient will support powered flight. On the other hand, if objects harbour their own potential causality and effects, they need to be watched out for and even wary of, even if we don’t have any use for them ourselves.

So object permanence entails more than internal representation, which would not be enough to differentiate intelligence from its non-intelligent cousins and ancestors. Or rather, intelligence’s internal representations represent things as existing independently of the organism that represents them, or of the representation itself. Later they develop into both reflexive awareness and higher-level insights into – and designs for – still abstract relationships and systems of relationships, which can be apprehended and worked on without reference to any concrete object. Hence the possibility of, amongst much else, logic, theory, philosophy and religion. From a strictly biological point of view, internal representation need never go so far, being quite plausibly limited to mediating and informing outward action and experience by more or less complex internal framing effects, models, mediating states, cognitive maps, and so on. These may subtly regulate the organism’s actions and experience without needing to extend as far as recognising the objective reality of things or their hidden structural and functional depths, let alone a reflexive awareness of either the self or of the very process of comprehension, with all that that would entail.

It is not hard to imagine selective pressures to which evolution is most unlikely to offer an effective response but which are amenable to object permanence. To take the single most famous event in the whole of evolution, the ability to recognise that a very large and rapidly approaching asteroid threatens one’s very existence and then do something about it assumes a number of abilities. Unfortunately none of them is intelligible in normal biological terms, but all of them come quite naturally once one has mastered object permanence.

Firstly, the entirely stochastic and pragmatic logic of natural selection makes it extremely unlikely that earthly organisms would ever adapt to a threat that typically arises only once every few tens of millions of years (French 1998: §2.3). So an organism that depended solely on natural selection for its defence against asteroids is unlikely to have picked up the knack for seeing such things as threats, or indeed seeing them at all. Even if (somewhat bizarrely) treated as a generalised version of a more earthly problem (perhaps as a 'looming' stimulus), it is incredible that natural selection could have refined such an understandable capability to the point where it encompassed the detection or avoidance of plummeting asteroids. Selection is driven not only by the maximisation of benefits offered by adaptations but also by the minimisation of the costs they incur, and it seems disproportionate to invest any resources whatsoever in such extravagant talents - even if one *could* imagine a sequence of selections by which they could be created.

Conversely, what are we to make of the human ability to spot not only incoming asteroids but also quanta and quasars, not to mention speculating on the fate of dinosaurs that have been dead for 65 million years – all without any evident addition to either our biological natures or our reproductive fitness? In fact we spend a good deal of our time speculating about such things and their even more speculative reasons and implications. Were it not so, ideology and science would be equally unthinkable, not to mention entire literary genres from *Revelations* to science fiction.

Secondly, assuming that one recognises the fact and significance of an approaching asteroid, how exactly is one supposed to deal with it? It is not a threat that can be dealt with by running faster, biting harder, growing a thicker carapace or developing a more robust digestive tract. The only practical solution is extremely advanced technology. Shooting down asteroids really is rocket science, and would certainly demand vast conceptual sophistication, immense chains of means-end linkages, innumerable integrated technologies, organisations that coordinate millions of individuals, and almost immense (though not inconceivable) political, economic, ideological and scientific forces. Although object permanence is far from all that is required for such an enterprise, it would be quite impossible without it.

Not all evolutionary scenarios are quite as theatrical as incoming asteroids, though many are almost as dramatic in their impact on those concerned. For example, a single pleiotropic gene may affect many different and perhaps unrelated aspects of the phenotype. This makes it extremely difficult for selection to 'decide' whether or not the gene in question should be expunged or promoted: its 'bad' effects, severe though they may be, may still be outweighed by the 'good'. In sickle cell anaemia, the heightened immunity to malaria conferred by heterozygosity outweighs the risk of fatal genetic illness in homozygotes. But how much better it would have been for human beings, even from the point of view of reproductive fitness in its narrowest sense, if its victims had the one without the other. Yet it is unlikely that evolution will create any such solution.

It is important to recognise what the problem is here. In cases like this, extricating genetic causes from phenotypic effects is not simply complex or difficult. Natural selection cannot even 'see' sickle cell anaemia's 'bad' effects in isolation from the 'good'. The distinct phenotypic effects are effectively fused together by their genetic connection, which presents evolution with an undifferentiated, and on average perfectly acceptable, result. By contrast, although we don't yet know how to re-engineer the human body to eliminate the anaemia while preserving the resistance, it is not impossible *in principle*, and the residual difficulty is certainly not attributable to intelligence not being able to recognise what the problem is, how it might be solved or indeed that the problem exists. Evolution, alas, is capable of none of these. And of course, we are already able to treat many of its symptoms (surgery, infection control, analgesics, nutrition, hygiene, rest, support groups, and so on) in ways that probably enhance reproductive fitness – but no thanks to evolution.

Like all aspects of intelligence, object permanence develops through a succession of stages. The initial, sensorimotor object is limited to its global existence as an undifferentiated 'thing': it exists or not, has gross perceptual and behavioural properties rather than relationships, dimensions, and so on. Sensorimotor object permanence adds little to the infant's adaptiveness, which is actually assured primarily by its caretakers rather than its own direct adaptiveness. However, during the subsequent 'pre-operational' period, the child's activities progressively organise its objects into various kinds of grouping, classification, series and other patterns. As the great apes, African grey parrots and dolphins who also achieve this level of development show (Parker and McKinney 1999; Pepperberg 1999; Marino 2002), this is enough to permit individual survival in the right conditions. The next major stage, 'concrete operations' (Inhelder and Piaget 1964), progressively relates these more or less discrete and isolated patterns to one another until they are synthesised into highly structured *systems*. This initiates the stage of 'formal operations' (Inhelder and Piaget 1958), when intelligence is capable of a level of insight, coordination and control that is unimaginable in non-intelligent organisms. Impressive enough in individuals, taken collectively formally structured intelligence is capable of the advanced economic and political systems and global cultures and technologies most of the readers of these words inhabit, and without which these words would never have been written (Robinson 2004).

All these higher structures lead, on the one hand, to intelligence's recognition that activity, objects and the world at large are informed by abstract structures, and on the other, to the ability to control these structures, notably by embodying them in tools, resources, facilities, systems, organisations, and so on. They also allow intelligence to impute rational force (necessity, authority, legitimacy, value, propriety, obligation, and so on) to rules, ideals, money, duties, contracts, institutions, orders, roles, justice, and any number of other abstract entities that have no biological counterparts, but have extremely broad and deep implications for human cultural and technological activity, and so for human 'adaptation'.

As I have already implied, object permanence is not a peculiarly human capability. After all, we possess object permanence by virtue of our intelligence, not because we are members of the species *Homo sapiens*. So any intelligent species (or entity) would be capable of as much. Although the evidence is not wholly convincing in all cases, some degree of object permanence has been demonstrated in primates (Parker and McKinney 1999), perhaps even as far as marmosets (Mendes and Huber 2004), dolphins and birds (Marino 2002; Pepperberg *et al*. 1997; Pollok *et al*. 2000; Zuca *et al*. 2007). However, there is no evidence for it in mammals and birds generally (Kirkpatrick 2001; Vauclair 1996; Young *et al*. 2001), and in no non-human species has it reached anything like the level found among human beings. So its impact remains minimal, and only human beings exhibit the cultural and technological efflorescence advanced object permanence naturally supports.

Plainly object permanence is not simply a minor curiosity of human infancy. It is likely that cultural and technological developments over the next few centuries will make it all but impossible for nature to throw up *any* form of variation or selection that could modify human nature in directions we were not willing to accept on strictly rational grounds. Indeed, we may soon be able to do a great deal to improve on nature's rather poor designs. For all their undoubted wonders, random variation is entirely lacking in insight and natural selection is relentlessly pragmatic, eclectic and backward-looking, not to mention willing to make do with the least bad solution. It is certainly hard to imagine that intelligence would have spent three billion years creating such a flawed and vulnerable result as the human anatomy. Fortunately artifice has always been our second (if not first) nature: it is after all the logical corollary of our capacity for looking at the world in terms of what is (or could be) objectively there rather than a range of stimuli to which we happen to have been attuned by evolution.

Of course, even if we can transcend biology in this way, we may not escape evolution altogether. Whatever the originality of our means, the ends to which we apply our intelligence and the motivational systems that shape our activity may still be profoundly shaped by reproductive fitness. However, although it is likely that small residual pockets of this kind remain, it is doubtful how significant they could be. An intelligent being is after all no more simply a 'standard' organism plus a little cognition than organisms in general are chemical reactions glued together with a smattering of 'life'. Precisely because in non-intelligent organisms motivation, action, experience and goals are tightly interwoven in the body, the dissociation and reconstruction of the 'techniques' of biological activity (Piaget 1971a; Robinson 2005) into the intelligent neonate's sensorimotor reflexes, from which intelligence arises, *must* lead to equivalent changes on its 'affective' dimension: goals, motivation, drives, feelings, and so on.

So, just as organisms still consist of, yet are neither dominated nor explained by their chemistries, so one must ask whether the emergence of intelligence leaves human beings still organisms, but not exclusively or even primarily so. Certainly the assumption that intelligence is dominated by biological drivers such as adaptation or fitness may be contested. It is not that we are free from the need to reproduce, but our intelligence certainly throws into question just what we do once reproduction has been achieved. Very few of the more sophisticated aspects of human activity and experience – art, philosophy, music, religion, science, and so on - seem to have much to do with reproductive fitness (though there is no shortage of suitably convoluted arguments to the contrary). In any case, as soon as it is recognised that any innate urges and dispositions that are inscribed in our bodies and brains may themselves be open to intelligence's natural propensity for objectification, analysis, evaluation and modification, it becomes difficult to exclude any area of human existence from *future* intervention.

If this seems to defy the basic logic of evolutionary theory, then so be it. Human beings have long since learned to see into the infinite, the infinitesimal, the vasty deeps and the invisible spectrum. It is hard to see such abilities either as determined by or limited to adaptive functions or as explicable, however indirectly, in terms of either reproductive fitness or any other narrowly biological driver. It is especially incredible to regard such a massive efflorescence as a by-product of other, more directly advantageous adaptations: evolution is surely not so beneficent as to allow such expensive but biologically useless systems to be created, let alone endure indefinitely. Given that it is hundreds of millennia since human life included 'objective' forms of activity (Wynn 1979, 1981), it is hard to see how evolutionary theory could possibly explain it. Or perhaps philosophers, Latin teachers, evolutionary theorists, radio astronomers and the rest are having more children than the rest of us, and just keeping quiet about it.

So object permanence is a good deal more than simply a superior adaptation. By recognising that objects exist in themselves, independently of our relationship to them, we can have a knowledge of and an interest in them that extends beyond any functional or empirical interest that might be dictated (however indirectly) by a strictly biological concern for, say, feeding, shelter or social relationships. It is not even limited in the same way as a wide-ranging sense such as vision. In non-intelligent animals such functions are often not only limited in range and functionally specific in scope but also fragmented in organisation. For example, a frog's vision comprises a number of disparate and largely disconnected solutions to various kinds of problem - catching prey, negotiating barriers, avoiding threats, and so on (Arbib 1981).

Of course, as 'blindsight' and other neuropsychological puzzles demonstrate, the systems that underpin human vision are also fragmented (Weiskrantz 1997). Recent hypotheses regarding the modular structure of the human nervous system tend in a similar direction. But human vision is also subordinated to human intelligence, such that the scope and range of *our* vision is defined not by human biology but objectively, which there is to say, by what is to be seen. That is why we strive to extend our visual capacities through forms of technology (spyglasses, spectrometers, space-born telescopes, and so on) and culture (geometry, aesthetics, etc.) that are as indifferent to the specifics of human biology as they are irrelevant to reproductive fitness.

That is not to say that such things have no bearing on reproductive fitness. But biological variation and selection are certainly not the process through which they actually are constructed or incorporated into our activity. Conversely, it is only by virtue of our intelligence that human vision can be put at the disposal of any form of activity that may objectively be able to make use of it, rather than being limited to specific structures and functioning, as non-intelligent vision invariably is. So the notion of multiple fragmented visual systems, which is entirely appropriate to a certain level of human *biology*, is wholly irrelevant to understanding human vision considered as a function of our *intelligence*, and in particularly the *cognition* of object permanence through which the *perception* of various fragmented patterns is unified into a single point of view, indeed a single world-view.

The key issue here is the nature of the structures created by object permanence. When a non-intelligent organism relates to its environment, this relationship is more or less inseparable from its biological interests, the nature of the organs through which it is engaged, the dispositions, drives and biological functions that motivate it, and so on. In other words, its relationships are inherently non-permanent. For example, a non-intelligent predator may be capable of either interest or uninterest in its prey, but not of *dis*interest. Even when generalised motives like curiosity or gratuitous exploration intrude, they remain internal drivers, and do not require even a rudimentary objectivity.

Conversely, although an immature or inexperienced intelligence's relationship to its objects is always egocentric, one-sided and conditional, the relationship itself always implies that the object exists independently of our relationship to or interest in it. The forms of experience we share with non-intelligent organisms – belief, imagery, memory, stimulation, and so on – distort reality according to the organism's state, disposition, perspective, and so on. Only when reshaped by object permanence do they become reliable. Leaving aside the vexed question of whether we are actually capable of *complete* objectivity (or, *a fortiori*, truth), merely aspiring to objectivity sets intelligence apart. It is certainly on this aspiration that science rests. So even if Kant and Hume were right and we never manage to track the object to its ontological lair, the fact that we can dream of such things makes the dreamer a very different kind of creature from one that cannot. For example, only such a creature could dream up the theory of evolution.

What general conclusions can be drawn from all these implications of object permanence? Firstly, Wallace was right: intelligence can pre-empt and even actively manage evolution (which, thanks to Wallace and Darwin, we can now construe as a theoretical object). Presumably not even the most ardent adaptationist would doubt that we might manage to deflect a threatening asteroid, even though this ability cannot be explained in evolutionary terms. But secondly, this difference represents more than simply a quantitative improvement in adaptation. Intelligence transforms the very logic of activity and development. In evolution, the *functioning* of a given organic structure is modified by (functionally) random variations, and then the *functionality* of the resulting structure is judged by its impact on reproductive fitness. Leaving aside the complex interplay between selection at one level and variation at another (e.g., Maynard Smith and Vida 1990), the ways in which certain kinds of structure limit and channel the scope and opportunities for either (Kauffman 1993), and the somewhat simplistic quality of much neo-Darwinian reasoning (Dover 2000; Oyama 2000; Oyama *et al.*, 2001; Rose and Rose 2000), it remains fundamental to biology that the two sides of this process are not only logically distinct but also materially unconnected.

For example, many forms of niche construction substantially alter how selection operates. Termite mounds radically restructured the termite environment to the point where one of their own creations became perhaps the single most powerful factor in their subsequent evolution. But the termites do not recognise this fact, and it is not a lesson from which they can profit further except through yet further biological adaptations. However triumphant this adaptation may have been from the point of view of the termites' operational sophistication and reproductive fitness, they are completely blind to it, and cannot see (in any sense, no matter how metaphorical) how this change in their functioning has affected their functionality.

The effect of object permanence, by contrast, is to abolish this distinction between the functioning of a structure and its functionality. The ability to objectify the niche and environment they occupy, their own bodies, selves, methods, goals and values, the nature, processes and mechanisms of adaptation, and all the other factors involved in their activity and experience, ultimately allows intelligent organisms such as human beings to recognise the forces of evolution and redirect them to their own benefit. They can appreciate the difference between what things area and what they should be – the kernel of the difference between a structure's functioning and its functionality - without every 'should' being defined in terms of reproductive fitness. This process of evaluation increasingly takes the form of cultural and technological systems that actively assume, apprehend, analyse, evaluate and intervene in the relationship between our functioning and its functionality, and so increasingly ensures that the normal forces of evolution cease to intrude in human affairs. With that, evolution becomes practically obsolete.

Of course, all adaptations are internalised responses to past selective pressures, and in that sense they too pre-empt future selection. A termite (or bird or fish) nest internalises an adaptive response to weather, gravity, predators, and so on (von Frisch 1974). But intelligence does much more than internalise particular selective pressures. Firstly, the ability to look at things objectively allows intelligence to determine the nature of that thing, and to identify the *possibilities* objectively inherent in it. This is a very different thing from generalising from empirical experience. For example, it means that intelligence can do something about the problems it may pose *before* they arise. Secondly, intelligence is not specific to any particular circumstance: it can apply the same general abilities to solve infinitely many similar problems. And thirdly, there is nothing random (in any sense) about its solutions: they are specifically engineered to solve the specific problems by which they were originally inspired. Unlike either natural selection or the non-intelligent organism, intelligence knows what it is trying to achieve. Of course, it may misconstrue the problem and its solution may not work, but the non-intelligent organism is simply precluded from even trying to solve problems in this active, specific and universal manner. Perhaps that is why Heath Robinson and Rube Goldberg are so amusing: yes, their fabulous contraptions work, but who in their right mind would have made them that way? Well, evolution would have. But then evolution hasn't got a mind, let alone a right one.

Finally, not content with making all forms of variation directly manageable, object permanence also engenders all sorts of new kind of 'variation'. The most obvious from a biological point of view are medicine and genetic engineering, but we have been consciously applying artificial selection to ourselves and our environments for many millennia. The process of selection, insofar as it is taken to mean the exogenous sifting of results, has also long since been replaced by intelligence's own preferences and purposes. Of course, we will, as the rules of reproductive fitness dictate, have to maintain ourselves in suitable numbers if we wish to carry out our own plans. But of what level of matter – biological or non-biological - is that not true? Our technology must also obey the laws of physics, but the laws of physics hardly explain how Einstein came up with relativity. So in what sense does that the reproductive fitness of human existence imply that our lives are 'ultimately' regulated by the forces of evolution?

5. The development of the subject

Assuming that we do not foul our own nest irretrievably – a large, dangerous and increasingly improbable assumption in the present point in history - there seems to be no evolutionary force organisms armed with object permanence could not deal with, especially when acting collectively. Quite probably the traditional view, that every species is doomed to extinction, applies to advanced intelligent species only in the sense that they might inadvertently commit suicide. But this is not a totally convincing argument for intelligence's independence of evolution. There may be other biological constraints on intelligence that leave deeper aspects of evolution beyond even object permanence's reach. They are hard to imagine, though not, as has often been argued (e.g., McGinn 1989), because the limitations of our intelligence themselves prevent us from recognising them. As almost our entire culture and technology demonstrate, object permanence situates intelligence directly and massively in the world of things and events that exist independent of our awareness of them. Were fundamental biases, shortcomings and lacunae built into our intelligence, they could not be concealed for long. Instead, they would express themselves in conflicts and contradictions not only in our awareness of things and events but also in the objective reality we try to create. At the simplest level, our actions would fail and the things we make simply would not work. At the highest level, reality would seem to contradict itself (or, at the very least, contradict *us*). Far from intelligence's limitations concealing the fact and nature of our shortcomings, object permanence would make them unavoidably explicit.

But in any case, Piaget's theory implies (though does not state) other proofs that evolution can no more modify intelligence than it can change the effect of pouring acid onto metal. However, these proofs relate to two other, quite distinct dimensions of intelligence. The way intelligence's *world* transcends any possible biological *environment* will be addressed in the next section. My more immediate concern is with the internal structure of intelligent activity, which, for want of an accepted scientific term (though very conscious of its implications), I shall call the *subject*.

In Piaget's model, the internal structure of intelligence develops through the expression, objectification, coordination and re-internalisation of prior internal structures. As developmental stages succeed one another, the infant's initial sensorimotor reflexes (such as visual tracking or auditory localisation) are articulated, embodied in objects, and then re-synthesised into concepts, relationships, systems, and so on. These developments range from piecemeal and parochial advances to a sequence of global stages, each signalling the emergence of a qualitatively new, systematically more powerful subject. Each new level of subjectivity not only combines the talents and knowledge provided by its predecessors but also abstracts from them a new level of capability, on the basis of which wholly new types of activity becomes possible.[2]

Thus, the young child constructs primitive empirical concepts (such as 'dog') by synthesising the reflexes (visual-motor tracking, auditory localisation, tactile-motor, and so on) that have been successfully applied to dogs into a single, multifaceted structure that permanently embodies the notion of dogginess. Once created, such a concept can operate quite independently of the child's experience of actual dogs – it can talk about dogs, draw a picture of a dog, tell you some of the more superficial differences between a dog and a cat, and so on. Furthermore, being synthesised from the infant's own activities, it is neither a direct summation nor a simple generalisation of empirical experience. On the contrary, empirical experience provides the opportunity to develop such structures, but can never define it exhaustively. Still less can experience alone account for the 'logico-mathematical' concepts that synthesise the structures of activity as such (Piaget 2001).

The abstract character of concepts becomes clearer with a higher level 'empirical' concept such as 'mammal'. No one has ever observed a 'mammal' as such - or for that matter 'gravity' or 'natural selection'. Conversely, because they reflect a newly built-in pattern of activity, they inform the subject - rightly or wrongly - that certain structures and relationships apply *necessarily* to any instance of that concept; that radically dissimilar entities may share common properties; that empirically diverse appearances may disguise instances of the same thing; and so on. If these inferences are false, then the effect of applying this new organisation of activity will be a

[2] 'Stage' must be used cautiously in the Piagetian context – stages lie more in the analysis of the subject's capabilities than in dramatic saltations in the subject's abilities, which generally develop fairly continuously.

contradiction between the expected and actual results of activity. But this is not simply failure. Because intelligence operates solely in terms of independent objects, it cannot avoid being presented with the direct expression of its own failure. What is more, the specific nature of the failure, as expressed in the objective result, provides at least indirect evidence of the nature of the original misconstruction. That is, mistakes result not only in failure but also in *contradiction*, and contradiction cannot simply be written off (as failure may be by a non-intelligent organism) but rather 'proves' to subjects who suffer it that there is something amiss with *them*. They *made* this mistake. Hence the peculiarity of intelligence, that it will puzzle at a problem because it is a problem, rather than because its solution will lead to any reward.

Once basic concepts have been established, still higher structures provide intelligence with still more powerful instruments (relationships, systems, methods, and logic and mathematics themselves) that are even more obviously irreducible to empirical or functional action or experience. Yet they provide unprecedented power over the empirical and functional realms. However, there is more to the subject than a growing independence of activity, awareness and authority. As both the logic of its development and the available evidence (outlined below) indicate, none of the arguments being offered here relies on the specifics of human biology – not even on exactly which sensory or motor organs, reflexes, capabilities or appetites are present at the start of sensorimotor development. Rather, the key is the cycle of expression, objectification and internalisation, which relies on entirely general principles. A good deal (perhaps all) of the 'interface' between infant and world needs to be governed by sensorimotor reflexes (in Piaget's very specific sense) for intelligence to develop, but that seems to be all. The resulting development of the subject will be the same, regardless of whether the infant in question is a human being living on Earth with eyes and ears and hands and a rigid skeleton or a species of slug that inhabits deep space, feeds on gamma rays, senses nothing but dark matter and moves by teleportation.

Furthermore, not only are the same kinds of structure (series, classifications, systems, and so on) formed regardless of the specific biological substrate or sensorimotor structures from which they originated, but their development necessarily culminates in a single overall structure that synthesises all aspects of intelligence (Robinson 2004). In short, because the logic of the developmental process described above is not context-, content- or even species-specific, subjects are always and everywhere the same. But if the development of the subject is thus a universal process that can have only one outcome, then variation and selection can neither cause nor affect the nature of subjectivity. Evolution may stunt or hinder (though not deflect) its development or even destroy it completely, but it cannot explain either its nature or its development. Yet both the development of such subject and its outcome are entirely material: there need be no recourse either to Wallace's 'Intelligence' or to a more contemporary Intelligent Designer.

This interpretation of subjectivity is strongly supported by the available data. For example, grossly physically handicapped infants children lacking normal sensorimotor capabilities share a single developmental process, sequence and outcomes with the non-handicapped (e.g., Bebko *et al*. 1992; Kopp and Shaperman 1973; Gottesman 1973; Gouin Décarie in Foss 1969; Eagle 1985). Nor do massive differences in culture, technology and social organisation affect intelligence's nature or developmental stages, though they can greatly affect how fast or in what empirical and functional directions it develops (Hallpike 1979; Robinson 2004). Perhaps most convincingly of all, different *species* appear to develop exactly the same kind of intelligence and develop it through the same stages. Although definitive evidence is lacking, if one takes into account related areas such as tool-making, true imitation and self-recognition, it seems that certain primates, dolphins and birds are intelligent in exactly the same sense and develop their abilities in exactly the same way (e.g., Parker and McKinney 1999; Pepperberg 1999; Bauer and Johnson 1994; Reiss and Marino 2001).

Of course, any intelligent being may be more interested in kinds of object that reflect its biological character: an object that fascinated a human being might leave a bonobo, an Alpha Centaurian or an intelligent machine completely cold. But if one starts from the opposite point of view, from the abstract rules according to which any of these subjects constructs any and every object, then it is difficult to escape the conclusion that, at that level, subjects everywhere are increasingly equivalent, and finally identical. They all seem to construct (produce, act on, organise, define, analyse, transform, and so on) objects in terms of the same universal types of structure.

Not all intelligent species develop to the same extent, of course. As one might expect, as it reaches its species-specific limits, development tends to break down in species-specific ways (e.g., Antinucci 1989; Langer 1998, 2006 Parker and McKinney 1999). If human and non-human intelligences do eventually part company, this seems to be not because our respective intelligences are qualitatively different but because the limited developmental capacity of, say, a gorilla prevents it from developing beyond a certain level at all. Almost until the end, our paths are almost identical. A chimpanzee has much greater developmental potential than a gorilla, so our respective developments parallel one another for much longer. Conversely, monkeys' developmental trajectories diverge markedly from both, so it is no surprise that they never achieve full object permanence. To the extent that we have any real insight into cognitive development in dolphins and birds, they also follow the 'normal' track for intelligence as such.

If true, this is extraordinary. Primates, birds and dolphins differ not only in their innate sensory and motor organs and capabilities but also at every level of their nervous systems from gross anatomy to detailed cytoarchitecture. Our latest common ancestor with dolphins died out almost a hundred million years ago, and almost certainly exhibited zero intelligence (Marino 2002). With birds, the timescale trebles. At first sight convergent evolution seems a plausible solution, but convergence normally assumes a *variety* of structures performing the *same* functions: bats, birds and bees all have powered flight, but use radically different biologies to accomplish it. However, both the uniformity of the stages through which all intelligent species develop and the consistent nature of the errors committed by undeveloped individuals reinforce the idea that there is only one structure that can be called intelligence, and it pops up everywhere. It is as though bats - and only bats – had evolved among insects and birds as well as mammals. Given the lack of a shared intelligent ancestor, the apparent structural identity of intelligence among dolphins, parrots and primates is inexplicable by any standard evolutionary argument (though see Robinson 2005 for a hypothesis). However, as I hope my preceding argument makes plain, on the ontogenetic level it is perfectly explicable: because the relationship between developmental stages is one of abstraction, not accumulation, the nature of the higher stages is determined not by ancestry but by increasingly general principles of organisation that apes, humans, dolphins, birds, Alpha Centaurians and intelligent machines all share.

This can be illustrated with innumerable examples. For example, object permanence itself arises not out of empirical or functional experience but from the infant's synthesis of its innate sensorimotor reflexes, and is inherently independent of any particular empirical or functional content or context. Indeed, object permanence as such is not 'experienced' at all. Rather it expresses the mutual implication – the literal folding-in – of the various *forms* of sensorimotor activity. Of course, the activity that led to this development had empirical and functional content and context, and object permanence has massive empirical and functional implications. Nevertheless, object permanence as such relies not on specific-specific patterns of sensation or motricity, perception or behaviour, appetites or drives, but on the coordination, synthesis and abstraction of principles shared by *whatever* reflexes are present.

Later, the concept of number arises from a synthesis of the ability to classify objects with the ability to organise them into series (Piaget 1952). Again, it does not matter which specific classifications and series the subject starts from: number is the synthesis of classification and seriation *as such*. As a result, one would expect the same number concept (and number systems) to arise in any species that was able to develop its intelligence to the level where classification and seriation can be merged. So how much less does it depend on the specific organs, nervous system, environment, lifecycle or experience of the developing intelligence. Or again, the diverse history of number systems is well documented (Damerow 1995; Hallpike, 1979: 240ff; Ifrah 1998; Nicolopolou in Cole *et al*. 1997: 212, 219; Nissen *et al*. 1993), but the presence of innumerable pragmatic local variants does nothing to undermine the universal themes the same history also reveals (Robinson 2004).

This process of abstraction has precedents far back in the history of matter, and in a sense intelligence only recapitulates how each new previous level of matter emerged from *its* predecessor. Chemical structures become possible only when the many conflicting physical forces were first synthesised into the 'standing contradiction' of protons, electrons and other particles we know as the atom. This not only stabilises the relationships between these physical forces but also releases a new, specifically *chemical* level of activity. Organic structures then emerge when molecules are organised so as to subsume, and so negate, the normally mutually disruptive reactions of molecules through their transmutation into the standing contradiction between anatomy and physiology we recognise as life. And finally, the generally inconsistent, particularistic, fragmentary and rigid sensory and motor capabilities that typify all complex life are synthesised into the new standing contradiction of abstraction and concretion we call intelligence (Robinson 2005). In a classic dialectical supersession, intelligence achieves its universal capacity for positively comprehending its world by not only synthesising but also subordinating, and so, in that respect, *negating* all its specific positive skills and experience.

In each such case, the new, higher form of matter achieves that higher form by nullifying the conflicts inherent in the lower, and so achieves new levels of both internal integrity and external effectiveness that allow it to assimilate or suppress further changes instigated from the lower level. Of course, its power to do so is limited: atoms are smashed, life dies, reason dissolves into madness and senility. But in each case, each new level of structure reveals new forms of functioning that seem to inhere in the new *level* rather than in any particular concrete *component* that level may include. Thus, just as any physical entity falls under gravity without having any special organ or propensity for falling, so all life shares the same principles of adaptation, heredity and epigenesis, yet these are nowhere inscribed in the organism. Of course, a great deal *is* inscribed. But not everything, and especially not the most powerful and pervasive forces of all.

So abstractions can be material, for abstraction is nothing but the reorganisation of existing material structures and their functioning. Furthermore, because each abstraction is a *synthesis* of the normal functioning of lower level structures, there is no inherent contradiction between the higher and the lower. As a result, although logic and mathematics are so abstract that they often seem irrelevant to practical matters, they can be validly applied not only to any possible expression of intelligence but to all forms of *pre*-intelligent matter too. Hence also the succession of cognitive stages, each constructed by this same process of abstraction (Piaget 2001), without the intervention of any innate 'programming' or specification of the stages or any particular kinds of activity or experience. Of course, intelligence always has a content and context of some kind – otherwise it would not be real. It is always doing *something*. But unlike non-intelligent organisms, there is no specific content or context to which many products of this process of abstraction (such as logic or mathematics) is bound or which it cannot transcend.

This in turn leaves us with an ever widening and deepening grasp of the general *forms* of activity, up to and including *activity as such*. These forms are then applicable to any possible content or context because they synthesise not only all their precursors' specific forms but also (with a little familiarisation and exercise) all *other* forms of that general type. This is why human infants can easily assimilate non-human modes of sensory experience (Bower 1989), some great apes can understand functional equivalence (Russon *et al*. 1998), children can learn rules for conjugating French verbs, concepts such as democracy or equality before the law make any sense or the reader of this essay can evaluate its argument without having had the experiences from which its ideas were derived.

This must seem a very bold claim. If we know anything about organisms, it is surely that they are subject to any number of species-specific predispositions, constraints, quirks, appetites, closures and limitations. And, considered strictly as organisms, it must be accepted that this is equally true of intelligent species. In particular, intelligence is instantiated above all in the human central nervous system – an indisputably biological structure – so surely it too must be subject to evolutionary pressures? Certainly, yet intelligence's freedom from innate, functional and experiential constraints and propensities that is conferred by the process of abstraction is equally fundamental.

But surely this is a contradiction? We can't be both subject to the vagaries of biology and the rigours of intelligence. Seemingly, the dilemma could hardly be more fatal to the present argument. Apparently we must accept either that the structures Piaget describes are instantiated in the organic structures of the central nervous system or that they are purely theoretical abstractions devised to support experiments and school tests. If the former then they are necessarily subject to evolution at some level (not to mention every other biological vicissitude), and if the latter, then they are only *not* subject to evolution in the trivial sense that no theoretical entity is subject to evolution – true but wholly irrelevant to the question of whether intelligence itself evolves.

It is tempting to reply that this is a kind of 'category error' – that my hypothetical critic is making essentially the same mistake as any reductionist who asserts that, as all organic processes are implemented exclusively in chemical pathways, they can all be reduced chemical terms. In other words, the indispensable insight into the element of higher level organisation, on which the present argument also rests, is completely ignored, and the reductionist's argument is invalid. Unfortunately, the status of intelligent activity is not so well established that simply drawing this analogy answers such criticisms. There is after all no shortage of people who would deny that explaining intelligent functions in neural terms would be a reduction. However, there is an alternative that preserves the present argument.

No, there are no formal operations in my head. But neither are there adaptations in organisms or mechanisms for falling in rocks. Just as life is a function of structures (such as DNA) that are not themselves alive, so intelligence is a function of neural (and many other) structures that are not intelligent in themselves yet whose collective effect is no less distinct from the merely alive. Falling is governed by laws of which the rock knows nothing and for which it is no way physically prepared in any specific way. Yet it falls. Rather, it is the absence of a positive structure that *prevents* it from falling (stickiness, the presence of anti-gravitons, and so on), and so makes transparent the operation of a universal physical factor that affects all matter, everywhere and always, namely gravity. Likewise, once an organism has been liberated from the positive inclinations to act in species-specific ways imposed by its biology by the development of subjectivity, it does not have to have logico-mathematical structures built into it to be able (indeed compelled) to follow them. Just as gravity is a universal force that applies to all matter *as such*, and so requires material entities to possess no special structures to give it effect, so the logical and mathematical principles that typify subjectivity represent the most general rules for activity *as such*, and require no internal structures in the nervous system to give them effect. There are many things in our heads without which intelligence would be impossible, but a prescription for intelligence as such is not one of them. So the rules that apply to the contents of my cranium – evolution among them – need not define - or even impinge on - the intelligence with which they cause us to act, any more than the particular features of a ball or a rock or a hippopotamus alter the general laws that govern their falling. Like life, intelligence is the effect of many structures, some of which reside in the brain and some of which do not; it is not their cause.

At the same time, it is this process of abstraction from the particular nature of this or that intelligent being's organic substrate and the subject's resulting capacity for 'activity as such' that explains some of the most remarkable features of intelligence itself. For example, it accounts for 'the unreasonable effectiveness of mathematics' (Wigner 1960), and why logic and mathematics can be used to construct any possible object and articulate any form of activity, be it physical, chemical, organic or intelligent. We are capable of all this not because we have such insights built into our thoughts (be it by programs, modules, Platonic reminiscence, learning or divine spark) but because the process of abstraction, by coordinating many diverse and very concrete instances of a general *type* of activity into an internalised insight into *form*, both actively synthesises these all pre-existing concrete structures *and* subordinates every positive prejudice each such structure may harbour about how activity should be organised to an increasingly multi-dimensional awareness of activity in general. With that, all pre-existing types of activity are combined, their mutual implications revealed, their mutual contradictions shorn away and yet higher syntheses accomplished.

In practice, of course, even subjects nominally operating at a relatively high (e.g., formal operational) level make mistakes, misunderstand and generally fall short of their own subjective norm. After all, the mechanisms by which all these syntheses and abstractions take place are biologically instantiated, rely on empirical knowledge and are exercised with partial knowledge in pursuit of functional goals and in complicated contexts. We are also perfectly capable of denying the logic of a situation or intention out of fear, vanity, self-doubt, arrogance and innumerable other psychological factors, or out of interest, ideology or any number of social attachments and impulses. In fact complete rationality has often been postulated as an ideal (especially by warriors and mystics) but usually only at the cost of either abandoning or superseding all unrationalised commitments. Such states of mind are conspicuous only by their absence from most human existence. Yet we are always *capable* of applying rational criteria to our activities, however uncomfortable they may make us. In fact that is exactly what acting intelligently means.

And that is the point. Whereas even the most highly adaptive but non-intelligent organism is unable to guide its actions *in terms of* their adaptiveness, any intelligent subject is capable of planning, regulating and evaluating its own actions in terms of its current ideal structure, which is to say, its current level of abstraction. Beyond a certain quite low developmental level we are likewise perfectly capable of knowing that we are making a mistake (or telling a lie, allowing self-interest to colour our perceptions, and so on). However, this ability does not require any specific talent or circuitry or 'module' for spotting errors, deceptions and omissions. Rather, it demands only the ability to apprehend contradiction, and the ability to articulate the rules (another class of object, of course) that define it. And contradiction itself requires only that the subject be able to recognise conflict between objects. The sophistication with which we do this depends on our current level of development – a young child has yet to build rules, goals and ideals in the object-form familiar to adolescents and adults - but generally speaking the subject consists not of specific neural pathways for transitivity or the law of the excluded middle, but rather of whatever structures are needed to detect, objectify and evaluate conflicts between and within objects.

For example, the logico-mathematical capabilities that characterise formal operations are only the most abstracted form of this capacity for objectifying self-knowledge and the ability to apply that knowledge to our actions – which was, of course, the definition of intelligence from which I started. However, these structures do not reside *in* intelligence, but rather are constructed and reconstructed every time they become relevant to an action or experience currently in train – as objects that represent relationships between other objects. Conversely, where they do not already inform an individual action or experience, the need and motivation for them to be constructed will be revealed by the conflicts, errors or omissions that appear between the objects our actions and experiences themselves create.

So, the ideal logico-mathematical structures that define, say, formal operations do not reside in the individual (or, *a fortiori*, in that individual's brain). But an individual, even one instantiated in the most biological of brains, *is* intelligent by virtue of their ability to construe and objectify contradictions within and between the objects that constitute (at various levels) their action, organisation and experience. As that subject matures, the contradictions they are capable of recognising and exploiting take increasingly sophisticated forms, including reflections on its own intentions, goals, values and nature, reflections on the process of reflection, and so on, and the progressive construction of increasingly abstract and universal principles of activity, objectivity and existence. By the time it reaches a truly formal level, intelligence is inherently systematic and explicit as to the validity of its own formal structure and requirements (Inhelder and Piaget 1958, Robinson 2004). So all expressions of, say, formal reasoning (formal logic, bureaucratic systems, the rules of chess, theories of the evolution of intelligence, and so on) objectify basic models of formality, validity, systematicity, and so on. And it is against these 'objects' that formal operational activity is implicitly validated, for if it contains errors, conflicts or omissions, these will be expressed in failures, gaps and contradictions in the results at this level. Of course, we frequently fail to observe these faults, but they are always available in principle, even if recognising them sometimes takes a lot of effort. That is why it is always possible to appeal to, say, conscience, ideals or just logical coherence. But no amount of effort will tell a sunflower why it is tracking the sun or a wolf why it is howling at the moon.

Certainly there need not be specific cognitive adaptations acquired through the processes of evolution, instantiated in particular neural circuits and subject to yet further selective pressures.

Has gravity evolved because rocks and planets found 'better' ways of falling? Indeed, the presence of positive inclinations and biases would also imply equally positive prejudices, which would militate against intelligence's evident capacity for dreaming up any number of ideal standards, forms and controls for its own action, including such conspicuously non-biological ideals and values as justice, truth, honesty, integrity, validity, and so on. As with intelligence itself, none of these need reside in itself or even in its practical creations. Rather, we are constantly 're-minded' of them by the natural tendency of a truly abstract structure such as the subject to strive for a synthesis (i.e., joint objectification) of the things, situations and events that collectively define the *content* of its activity, the *nature* of that activity (method, technique, rules and wider ideals and goals), and the converse *objective* presence of failures, conflicts, gaps and contradictions. But all this is possible only by virtue of intelligence's *lack* of predetermined direction or closure.

As I have already shown, this is not simply a philosophical argument. The empirical evidence makes it perfectly clear that the same structures are shared across the biological spectrum, among primate, cetacean and avian species who anatomical differences and lack of evolutionary relatedness make it inconceivable that their shared capabilities are the fruit of either homology by common descent or functional convergence. What is more, their shared radical subjective openness implies a further, equally radical corollary that each of these species also supports, albeit in ways that are limited by their respective biological capacities. For such an open intelligence must – and evidently does - possess an equally radical capacity for development. If the structures by which intelligence is guided are not embodied in the individual (or, *a fortiori*, in the intelligent brain) but constantly being constructed and re-constructed, yet they enable intelligence to construct in objective form perfectly real tools such as goals, ideals, meanings, values, norms, standards, and so on for defining, guiding and evaluating action, then the ultimate reference points for intelligence's development lie not within its own (inherently limited) biology or in the structure of its niche but in the structure of universe as a whole and in the logic of activity as such.

On the other hand, placed in the context of the massively developed social and symbolic systems that a society of (largely) formal operational individuals is capable of creating (the Athenian agora, the modern university, business or government, and so on), there does not seem to be any empirical evidence for insurmountable limits. A little over three centuries from the Newton's *Principia* and two from the start of the Industrial Revolution, we are seriously talking about quantum computers, genetic engineering and a global society. Who knows where we will be up to two or three millennia from now.

6. The world made by intelligence

The mass of objects the subject makes of, inherits from, co-produces with and shares with other subjects is far more than simply a collection of discrete entities. The words I am writing now are created in a specific context not only of other cultural artefacts – theories, journals, disciplines – that give them a specific meaning but also of a wide range of electronic technology that makes the dissemination and debate of that meaning possible. Indeed, not only are all objects invariably created in specific relationships to other objects but their material independence of their producers and their embodiment of a more or less broad range of physical, chemical, biological and intelligent structures – in a word, their very objectivity - mean that they spontaneously organise themselves into relationships and systems that not only develop, unite and oppose them to one another but frequently transcend anything any purpose their producers may have had in mind. By any account the world 'our' objects form is enormously more than the sum of its parts.

Living in such a world entails a good deal more than simply learning to deal with random variation and natural selection more effectively. In fact, that particular accomplishment is a very secondary issue from intelligence's own point of view – a prerequisite of and platform for building its own values, goals, systems and processes achieving intelligence's proper goals, but no more able to explain them than the Earth's gravitational field. Even as far as our strictly biological adaptation is concerned, our intelligence is no more encapsulated in the individual, the brain or even groups of organisms than adaptation is to be found in the molecules that make up the body. In fact, the content and context of intelligent activity, organisation and experience increasingly consist of intelligence's own arrangements, products and organisations. If the reader doubts this, I suggest that they estimate how long any significant aspect of their lives would continue without the non-organic artefacts by which they are surrounded. The fact is, intelligence is less and less embodied in biology. Perhaps one day it will have no biological basis at all.

The significance of this progression is clear. "The organisation of the higher unit does not simply interact with the external environment, it is also the agent of selection on the lower unit. To the extent that control over replication of the lower unit is required for effective interaction with the external environment, organisations must appear in the higher unit to limit the origin or expression of variation at the lower unit… In each case the lower unit may replicate, but only within bounds set by the influence of this replication on the higher unit's effectiveness in its interactions with its external environment" (Buss 1987: 171-172). In other words, human intelligence's progressive transcendence of human biology obliges the biological systems and processes that define us as organisms to respect, and perhaps even subordinate themselves to, requirements imposed by intelligence, rather than *vice versa*. As evolution has little power over most of its objective conditions and constraints, it is again excluded from many aspects of the development of intelligence. It is quite inadequate to describe this as an 'extended phenotype': the biological principles that define and determine phenotypes of all kinds are quite incapable of explaining the origins, nature, functions and operations of a bank, a nation state or the internet.

Of course, much of the structure needed to make intelligence work currently resides in our individual nervous systems, as does a huge store of internalised experience and implications. So from a strictly psychological perspective it is proper (if narrow) to describe the formation of intelligence in terms of the progressive reconstruction of the neonate's sensorimotor reflexes, and through that the central nervous system as a whole. Yet not even subjectivity, the internal organisation of intelligence, can be regarded as bounded by our crania or our psyche: structurally 'internal' is not the same as empirically 'inside'. Rather, the internal organisation of intelligence increasingly resides in cultural and technological structures embedded in our collective world. If I were looking for the place where the most important decisions are made in most of my life, I would look not to individual brains but to great bureaucratic systems that embody the rules whereby corporations and governments come to their dubious conclusions. These systems and institutions organise activity, experience, relationships, knowledge, resources, instruments, capabilities and much else on our behalf. We must know how to access and operate these structures, so to speak, but exactly how they do what they do may be quite hidden from view, and quite beyond the grasp of any single individual.

So the world is intelligence's substitute of the organic environment. But does it exceed the environment in the ways that subject and object transcend their counterparts?

One of the most remarkable corollaries of and autonomous subjectivity and permanent objects is the unlimited interest they give us in our 'environment'. What is more, as the very practice of biological science constantly demonstrates, this interest is quite independent of any functional interest we may have in them. If we can appreciate the existence of things, situations and events independently of any biological (or any functional) interest we may have in them, we may (and must) also be concerned that they may have spontaneous, latent, potential and unplanned effects on our interests, quite independently of any biological relationship we may have with them. That is, in a sufficiently developed subject, objectivity confers an increasingly explicit grasp both of *possibility* and *contingency*, and with it a potential interest in the nature of absolutely anything that *may* impinge on our existence in any way we deem significant, regardless of whether it *actually* does so right now, or indeed may do in any foreseeable future. It also engenders a whole range of existential concerns that arise from our ability to grasp our own place in the universe, regardless of any discernable functional concern, and so to raise questions about our own nature, status, origins, significance and fate.

Putting these points together, it is clear that, on the one hand, we are fully capable of constructing an infinite variety of environmental niches that are increasingly determined by the direct and intentional products of human activity; and on the other, the specifically intelligent aspects of our concrete 'nature' are so little predefined by our biological heritage that we are equally able to develop into savannah hunters, pyramid builders, factory workers, peasant farmers and evolutionary biologists – a collection of 'niches' so diverse that they would surely mark their occupants out as members of different species did we not know otherwise. At the same time, we are equally able to accept and reject the conditions in which we exist and develop by virtue of the values, goals, concepts, relationships and systems intelligence itself produces, and so to increasingly directly and intentionally drive our own further development.

As ever, the contrast with organic environments could not be more stark. As Brandon has suggested, biological environments can be analysed into three interacting tiers (Brandon 1990). On the highest level, all organisms have a common 'external' environment consisting of all entities, structures and processes that are objectively present, even though they lack any biological impact, up to and including the entire universe. Below that level, an organism's 'ecological' environment comprises the fraction of the external environment that actually bears on the lives of its members, including their ability to reproduce themselves. The fraction of the ecological environment that affects reproduction *differentially*, and so provides a platform for natural selection, Brandon calls the ‘selective’ environment.

These tiers are by no means static or impermeable. In fact, any notable shift in development and evolution transforms their boundaries. However, intelligence seems to represent a much more radical break. If Brandon can draw such distinctions and we can collectively modify or replace any of the systems and processes involved at all three levels – which, given the preceding account of subjects and objects, we can – then for intelligence his boundaries do not really exist. Unless our researches in quanta and quasars have reproductive implications of which we are not yet aware, the outermost, external environment is especially irrelevant to any study of intelligence, but the others are equally questionable. So the real scientific problem posed by intelligence’s ‘environment’ is neither to question Brandon’s categorisation or to locate external, ecological and selective boundaries for *Homo sapiens*, but to understand what it is about intelligence that renders all such boundaries and conceptions obsolete.

In short, intelligent worlds are quite different from organic environments. But at the same time, they divorce us from the truly natural environment to a quite astonishing degree. So successful have we been in interposing cultural and technological systems between ourselves and the natural environment that, especially in industrial societies, it is hard to find any aspect of human activity, organisation or experience that is not primarily determined and constituted by intelligence’s own products. Every factory, every office, every piece of paper is of course composed of purely natural materials; but practically never do they actually impinge on our lives with a form, fit or function that is not fundamentally intelligent. As a result, both our collective relationship to nature and our personal lives are so absorbed in the struggle to render intelligible the representations, demands, opportunities, obligations and contradictions of industry, commoditisation, mass media, industrialisation, bureaucracy, money and so on, that it takes an exceptionally well informed effort to detect, let alone encounter nature in natural form (Robinson 2004: Chapters 4-5). Even the recurring cult of the wilderness is expressed more through romanticism, documentaries and tourism than any direct acquaintance, and increasingly mediated by profiteering, regulation and romanticism (Teich, Porter and Gustafson 1997).

With few exceptions, the massively collective and artificial character of the contemporary human world is almost wholly ignored by would-be scientific studies of intelligence, which commonly limit themselves to cognitive, phenomenal and individualistic frameworks. But this is to limit intelligence to extremely narrow aspects of what is in fact a world of immense social and symbolic, cultural and technological complexity and depth. It is fully equivalent to eliminating the study of evolution and heredity from biology, leaving only the isolated organism. As a result, the actual objects, processes, relationships and systems through which intelligence operates to the historical scale have been universally neglected, at least by students of intelligence as such. Indeed, history itself is seldom seen as the product of human intelligence, and although human activity and experience are widely accepted as being the products of history, only in quite narrow sections of the social sciences (e.g., the sociology of knowledge) do the implications of this fact have any impact.

Nevertheless, from an evolutionary point of view, it is the world of intelligence that delivers on object permanence's promise to supersede evolution and the intelligent subject's potential to rise above biology altogether. This it does in a variety of ways. For example, intelligent beings create, share and develop a huge range of systems for action, organisation and evaluation through their ability to share a common world. These very words can be shared between author and reader not because human biology provides mechanisms of direct communication in the manner of birdsong but because they are embedded in and mediated by systems (languages, disciplines, organisations, production, communication, etc.) that rely absolutely on our shared capacity for object permanence.

However, by far the greatest implication of intelligence's creation of the world is the corollary to which I have alluded several times, namely *history*. For any world created by collective intelligence is capable of radical transformation and development without any change in the underlying structures of either individual intelligence or its biological underpinnings. Had the cave painters of Chauvet been born three hundred centuries later, they would have felt as much (or as little) at home in modern industrial society as we do ourselves, even though the vast difference between their actual lifestyle and our own would, in non-intelligent organisms, would (from a biological point of view) qualify them as members of another species, if not a different genus. It is this historical character that has let so many generations take for granted a higher starting point than their parents, to disregard the burdens and threats that absorbed so much of their predecessors' effort, and to find quite new opportunities open to them – and all without any significant biological alteration.

By contrast, a biological niche is seldom dominated by the organism's own products, and even when it is – in a termite mound, for example – the product in question is typically rigidly determined by changes in the organism's biology that are no more open to the organism's understanding or control than the weather. But for human beings, not only all government and all organisations but art, philosophy, the social sciences and a great deal else assume the ability to recognise that we create our own world and may actively develop any aspect of it further. In short, intelligence's creation of history ensures that the human 'niche' is indefinitely self-expanding. Unlike the niche and environment of any other species, our 'niche' is ultimately identical with the human environment as a whole, and the human environment is ultimately identical with the universe.

So it is the world that is the arena of the unlimited development referred to earlier, and history is its medium, its realisation and, increasingly, its explicit inspiration and chosen proving ground. As social, political and economic policies grow more ambitious and the scope and power of our collective cultures and technologies expand both our impact on nature and our mutual relationships, history is increasingly the conscious product of our collective intelligent activity and increasingly organised into structures that embody logico-mathematical rules, rational methods and quasi-intelligent systems.

As I have argued elsewhere, the analogy between individual intelligence and the structure of history as a whole began as soon as history itself, and it is not difficult to detect the resemblances between the familiar stages of individual cognitive development and major historical formations such as feudalism, capitalism, and so on (Robinson 2004). That is not to say that history is individual development writ large. The individualism of most research into intelligence makes it easy to misinterpret the idea that intelligence is the author history in this way (Allen 2006; Eller 2005; Robinson 2006), but the reality is that the individual and historical development and structures of intelligence are quite distinct (and often quite different) corollaries of the generic model of intelligence outline above (Robinson 2004). Epigenesis, evolution and heredity are likewise all aspects of life, but only on the most abstract level is there any direct parallelism between these different and equally elementary aspects of life.

Not that the analogy is quite exact. History is only possible (beyond the simplest level) when the individuals who act it out internalise at least some of the structures that inform, determine and regulate it – an insight that is triggered with the first intimation of lineage or heritage. In other words, history proper presupposes that its inhabitants possess at least a modest theory of history (even if it is clothed in theology, philosophy or superstition). There is no need for any non-intelligent organism to have the least inkling of how evolution or epigenesis works or how the organism itself is changing from one generation to the next, whereas the concepts of deliberate social change and of remaining true to certain goals or values must both be present for history to 'happen'. Without at least some personal apprehension and mastery of how social and symbolic systems work, the progressively greater conscious control historical intelligence exercises over its own activity, development and direction would be quite impossible. With some such apprehension, however, not only can artefacts, opportunities and lessons be deliberately passed on and more effective systems and processes built, but the very rules, methods, instruments and techniques whereby such structures are built, operated and judged (and such lessons learned) can also be abstracted, improved and institutionalised, and historical change thereby accelerated.

It is primarily by virtue of the immensely densely interlocked economic and political, cultural and technological, ideological and scientific systems that result that the question of human evolution has become a practical non-issue. If, as I argued in connection with object permanence, our general capacity for objectivity allows us to defend ourselves against the forces of variation and selection, it is the human world by which we surround ourselves that is the actual defence.

Of course, the world is far more than that. I have already mentioned some of our more immediate defences against biological variation and selection: health education and public health systems, medical science, epidemiological research, mass sanitation, improved nutrition, a scientific attitude to disease, and so on. One could easily add other defences against natural selection such as flood barriers, fire brigades, international aid (such as it is), swamp drainage and buildings capable of resisting earthquakes, not to mention disaster recovery for when all else fails. However, we are also the authors of far more powerful structures and systems whose evolutionary impact goes far wider and deeper than simply protecting us from infection, famine and natural disaster. Far from simply creating barriers, channels, vehicles and other mediators between the human world and the natural environment, human economies have progressively invaded, transformed and revolutionised nature itself. For better or for worse, human activity increasingly defines and directs not only the *relationship* between intelligence and the rest of nature but also what the rest of nature actually *is*. Through the spread of massive urban agglomerations, the conversion of huge tracts of wilderness to agriculture, pastoralism, mining and tourism, our impact on fish stocks, eutrophic algal blooms and the marine environment generally, pollution on a literally industrial and then global scale, and innumerable lesser actions, we have transformed the face of nature as a whole and changed or destroyed the niches of countless other species.

This brings me to my final argument in support of Wallace: that the organisation of human intelligence into a planetary-scale world means that, far from intelligence being subject to evolution, evolution is increasingly subject to intelligence. Sometimes this is intentional, as when breeding programmes are explicitly designed to create heritable differences more adapted to the selective pressures of markets. More often it is accidental, to the point where capitalist industrialisation has triggered off one of the worst extinction crises ever. However, as we come to appreciate the nature and consequences of our actions, the balance between the accidental and the intentional appears to be shifting. Hence not only the growing predominance of intelligence over non-intelligent nature but also its likely irreversibility. This has several strands.

Firstly, the sheer magnitude of the forces human beings now wield ensures that human beings are among the most important environmental factors for every other major vertebrate species. Through the food chains at whose heads the latter often stand, a huge number of other species is also impacted. Secondly, unlike the rest of nature, its intelligent inhabitants are capable of *intending* that variation and selection should occur, right down to specific genetic and developmental mechanics and precise inherited forms. And thirdly, it is in the direct interests of human beings that they *should* assume direction and control of the natural environment, not only because of the residual threats posed by disease, famine, earthquake, flood and so on, but also because the opportunity to extend our reach will not be resisted, so we should take care to do it 'properly'.

This argument may seem to smack more of Victorian triumphalism than a realistic analysis of the contemporary human condition. A huge proportion of nature remains all but untouched by human activity; there are forces in nature that are vastly more powerful than anything human beings can muster; and the ecological problems human beings seems to be inflicting on *themselves* hardly suggest that we will be mastering nature at any time soon. But these arguments are not as convincing as they first seem.

The argument that nature remains largely unaffected by human beings assumes that intelligence’s pretensions will always be defeated by the sheer scale of the non-intelligent. However, if one compares the level of human influence on this planet today with our far more puny presence only three centuries ago, and then projects even a fraction of that rate of change and development onto the next few millennia, there seems to be little reason to believe that intelligence will never be able to operate on a truly planetary scale. It may well be that the current rate will not be sustained, but any plausible rate of development, even with setbacks of Dark Age proportions, is likely to be enough to transform the entire planet eventually.

The second argument, that there are forces in nature that are vastly more powerful than anything human beings can muster, is again empirically correct. For example, every day the Earth receives the equivalent of perhaps 160 trillion tons of TNT in solar energy alone. But the issue here is not the magnitude the forces but how they are arrayed. Untamed nature is organised into the ecosystems on which human beings, like all living things, rely. However, if we could only learn how to operate such systems, they would not resist rearrangement into forms that suit human beings better. So even the most hostile of natural forces might conceivably be co-opted to the human ‘side’. Indeed, there is only one ‘side’ in this struggle: as intelligent beings, humans care about the outcomes of environmental changes and can organise to do something about them, whereas non-intelligent nature remains wholly indifferent both to human beings and to itself. If we wanted to restore the Sahara to the green and pleasant land it was some millennia back, the enormous forces we would need to reorganise to achieve this would not decline to be involved.

Finally, it is true that the ecological damage we are currently inflicting on the planet hardly suggests that we will be capable of any such control in the foreseeable future. If, as Bacon said, if nature is to be commanded, first it must be obeyed, we do not seem to have mastered nature’s most basic rules, and we certainly are not good at putting them into practice. We have not only scarred the face of the environment but also reduced its stability in the face of our actions, which is likely to exacerbate this problem before it is ever solved.

But what is the underlying problem? Simply a matter of technical competence to manage large-scale environments? Probably not. This is largely a self-inflicted problem, induced by the nature of the economic and social systems through which our relationships with nature are defined and controlled. Essentially, all political and economic systems are systems of *interests*, and as such will require considerable adjustment – if that is the word – before they support a constructive relationship with nature. Our dominant economic system, industrial capitalism, cannot be directed by our existing political mechanisms, and its accelerating invasion of nature is by no means motivated by a sense of disinterested ecological responsibility (Panitch and Leys 2006). So even if human beings can solve the enormous scientific and technological problems of creating a rational ecology, that is no reason to be optimistic about the outcome, which will have to be delivered by political and economic means. We may ultimately learn to manage nature as a sustainable totality, but that is not to say that the learning will be a pleasant experience. On the other hand, it is not as though we have any alternative: it is after all the sheer magnitude and power of these same systems and interests that mean that we cannot *not* assume responsibility for our relationship with the rest of nature, or that assuming that responsibility can be done without a radical re-evaluation of our existing economic and political values, goals and systems.

This leaves human beings in a profound quandary. We are a long way from possessing the intellectual, technological or social tools needed to accomplish this ultimate feat except in trivial and risky ways, yet it is a task that cannot be avoided or shirked. And if it cannot be avoided then we must embrace it. We need not be optimistic about when, if ever, we will get it right: there is after all a natural limit to this challenge, namely the point at which the human environment is so completely impoverished that we are unable to continue taking action on a problematic scale. If we reach that limit, so much the worse for us. But if we can instead create a truly rational ecology, then intelligence will be a little closer to the apotheosis we can scarcely yet imagine, yet for which we must certainly hope.

However, even if the worst comes to the worst, it still does not imply that it is not intelligence that leads evolution rather than *vice versa*. Even if the whole planet is reduced to an uninhabitable desert – not a scenario that any scientist seems to be contemplating at the moment – we still differ from previous victims of evolution's vicissitudes in being able to recognise the dreadful thing we have done.

7. Conclusions

I have advanced three general arguments for the hypothesis that intelligence is immune to evolution. Firstly, our capacity for object permanence (even when interpreted weakly) enables us to recognise and intervene in, nullify, deflect or undo the forces of natural selection. Secondly, both the common process and product of the many ways intelligence has come into existence means that its internal structure – the subject – is the same for all forms of intelligence, so there is no basis for variation and selection. Finally, the building of a full-scale rational world progressively, although extremely problematic, reverses the relationship between intelligence and evolution, leaving evolution subject to intelligence rather than *vice versa*.

But ultimately there is a single very simple reason why intelligence is immune to evolution. Variation and selection exercise control only to the extent that there are no internal connections between the sources of change and the process through which that change is judged. In short, the functioning of organic structures is divorced from judgments as to its functionality. Every organism actively short-circuits this divorce to some extent, for evolution itself ensures that every organism, even the most primitive, incorporates mechanisms whereby activity is preformed to be specifically suited to specific functional 'purposes'. That is what selection means. Especially among birds and mammals this internalisation of control comes to rely more and more heavily on hereditary adaptability, structural versatility and developmental individuation. All intelligence does is take this to its logical, natural and historical limit (Robinson 2005). On the other hand, once achieved, intelligence initiates forms of activity and organisation that are not only biologically unprecedented but also wholly indifferent to human biology.

So what does all this mean? In brief, intelligence is immune to evolution, and if intelligence is immune to evolution, then one of the most fundamental assumptions made by a very large number of scientists in the study of human nature is simply false. Likewise, the languages of adaptation and information processing are radically inappropriate for intelligent activity and development. I would certainly agree that intelligence originated by an evolutionary route (Robinson 2005), but it does not follow that intelligence shares the status of the lion's claw or the horse's hoof. If intelligence is a truly universal and invariant structure, then it is hard to see how it could be open to further biological variation and selection, any more than Planck's constant, the periodic table or the value of *pi*.

As I understand it, this is quite consistent with contemporary evolutionary theory, even if researchers into intelligence and comparative psychology do not draw on this fact. Eigen (1992), Prigogine and Stengers (1984), Kaufman (1993), von Bertalanffy (1950), Goodwin (1995) and others could all be called upon to support the notion of abstracted structures that resist (and often drive) the pressures of variation and selection, and it is hard to see what complexity and chaos theory mean if it is not that such structures are extremely widespread. All I am arguing is that, in intelligence, awareness of this situation is recognised and put to active use by the very organisms under study – most especially, of course, ourselves.

Evolutionary psychologists may be tempted to reply that the uniformity of the developmental process and stages Piaget identified are evidence for their control by species-wide genetic factors. But even the most rigid genetic straitjacket (whatever, in the face of developmental systems theory, that may mean – Oyama *et al.* 2001) leads to far more vagueness and imprecision than would ever be countenanced by a typical product of intelligence such as, say, mathematics or bureaucracy. This is not because intelligence is somehow perfect or 'above' matter; rather, intelligence has principles of rigour and precision built into it that oblige it to act with increasing clarity and exactitude. Indeed, if this were not the case, then it would be impossible to articulate these such criticisms with anything like the rigour on which science itself absolutely relies.

Beyond that, it is clear that the human sciences need not consider themselves ultimately subordinate to the needs of human biology, or that human beings should consider them as 'really' or even as first and foremost organisms rather than persons. It is likely that the same could be said of a variety of dolphins, other primates and birds. As a result, the human sciences are under no obligation to seek evolutionary or adaptive explanations for the things human beings do. To reiterate, intelligence of all kinds must be compatible with evolution, even if only in the minimal sense that it must achieve rates of biological reproduction that ensure the continued existence of intelligent beings. But that no more obliges one to look for biological explanations than the fact that organisms must obey the laws of gravity or thermodynamics means that adaptation is 'really' a physical concept.

There is of course a great deal more to be said about the relationship between intelligence and evolution (Robinson 2005). However, the fundamental logic seems to be inescapable. One can only regret that Wallace's view that our immunity to evolution reflected a *qualitative* break (Wallace 1870; Berry 2002 *passim*) was never followed up adequately, and that Wallace himself succumbed to the widespread mysticism of his day (Oppenheim 1985; Robinson 2004: Ch. 7). The nature of human and non-human intelligence and its unique relationship to biology might so easily have been grasped much earlier. But then, perhaps the reason why this did not happen was that Wallace, like most of science from his day to ours, had no clear definition of terms like 'mind', 'intellect' and so on. Hence the need for Piaget's interpretation of intelligence, with all its portentous implications.

8. References

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