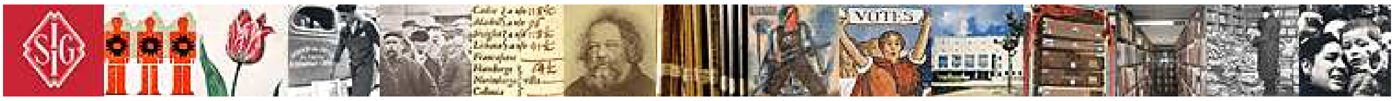

Cognition and History

The Evolution of Intelligence and Culture

The inaugural Science and Society Lecture
Amsterdam, 24 October 1996
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The Science and Society Lectures is an erratic series initiated by the International Institute of Social History and the International Institute of Critical Research, Amsterdam

There is a wonderful complexity to the matter of human evolution, those qualities of the human mind that we call intelligence, and how each has influenced the other. Human intelligence has evolved, and human evolution has been influenced by human intelligence. A crucial, perhaps defining, feature of human intelligence is our unique capacity to enter into that thing we call culture. So we are concerned here also with the evolution of culture and the way in which culture has affected our evolution. These are profoundly important matters in our understanding of what it is to be human and how we came to be so. Central to the scientific understanding of these matters is the issue of history as cause, and so it is there that I begin.

The Causal Force of History

It will come as no surprise to social historians that history matters, to use S.J.Gould's phrase (Gould, 1986). However, this has not always been a universally accepted position in science. Two examples of how causes are framed in science will illustrate different approaches to the issue of history as having causal force. The first is that of the Russian chemist Mendeleev who invented in the middle of the last century the Periodic Table of the elements, building on Dalton's earlier proposal that each element has a characteristic atomic weight. The Periodic Table was a brilliant insight, being based on Mendeleev's understanding that atoms have an internal structure. It is this structure that causes elements to have the properties upon which Mendeleev ordered the elements in his Table; and it is this structure that enabled him correctly to predict the existence of elements, and their properties, not then known. When later they were discovered, the Periodic Table and the theory underpinning it was vindicated and Mendeleev's fame was ensured. Now the point is this. The Periodic Table, a fabulously successful scientific insight, was based on the assumption that the laws of chemistry are absolutely constant and have always held. Had Mendeleev lived and worked 4.5 thousand million years ago, when the Solar System formed, he could have used the same observations and insights then to construct the Periodic table as he did in the 19th century. For example, since the and insights then to construct the Periodic table as he did in the 19th century. For example, since the beginning of time on this planet, when the elements sodium and chlorine have been mixed together they have formed a compound, table salt, which has rather different properties from those of its constituent elements.

This accords with the principles upon which the Periodic table was constructed and as a 19th century chemist, Mendeleev assumed not just that observations that he made of table salt on Monday would be the same on Tuesday and Wednesday, but that he could have made the same observations and drawn the same scientific insights thousands of millions of years ago. He was correct in this, but the general conclusion that was drawn that there is no temporal element to the laws of chemistry, that time in the form of historical antecedence does not have causal force, we now have reason to doubt.

Our second example comes from Darwin, who learned from 19th century geologists another way of thinking about causation. When Darwin visited the Galapagos Islands he observed over a dozen different species of finch, sometimes unique to different islands in the group and each distinctive, especially in their beaks and feeding behaviour. He concluded that these different species were all descended from a single mainland species, individual members of which had sometime in the past found their way to one of the islands, the descendent species resulting from the gradual migration of birds to other islands and the relative isolation of the islands from one another. This explanation of Darwin's finches was just one case, one illustration, of Darwin's wider thesis which asserts that all living things are related because all of life forms a tree-like structure that is descended from a common origin. Darwin's theory included an exposition of the processes that drive evolution, and these processes have the same quality of apparent timelessness as does atomic structure; whenever and wherever evolution occurs, these processes must be present. But the nature of causal explanation of Darwinian theory embraces historical antecedence as cause, and hence is very different from that espoused by Medeleev. In order to understand why a finch has this beak shape now, today, one has to invoke not only those universal and timeless processes of variation, selection and the transmission of selected variants, but also the form of beak that these processes acted upon in the past, yesterday.

It is important to distinguish the "history-as-cause" explanation of evolutionary biology from the covering law model of explanation of the logical positivists, where an assumed general law is applied to specific instances. An example of the latter would be the application of Newton's law of gravitation, which is the covering law, to explain the specific instances of how far golf balls will travel when struck with equal force here on Earth or on the moon. In evolutionary biology, however, historical antecedence as cause asserts that a beak form of a finch in the past is part-cause of the current form of beak; that if the past beak form had been different, then so likely would be its current form. In evolutionary biology, where you are coming from is a cause (not just an instance) of where you are now. The very essence of evolutionary explanations is that history has causal force.

We now understand that even the Periodic table and the laws of chemistry that it entails have not been constant in time. Shortly after the origin of the universe no elements existed; the elements emerged over a period of millions of years as the universe developed. Thus, cosmologists and astrophysicists tell us that history has causal force in chemistry too, and that with the exception of the deepest laws of quantum theory, there is no causal constancy in the universe -- 19th century science was just fooled by the slowness of change. But evolutionary change in biological systems is on an altogether different temporal scale. There are now well documented cases, including incidently Darwin's finches, of evolutionary change occurring over just tens or hundreds of years. This is a drop in the ocean of geological time. Much of evolutionary change does, it is true, occur over longer periods, but nonetheless the rate of change is such that it is measurable and hence tangible: you can put your hand on a fossil of early humans, or a stone axe, and actually *feel* the historical causes that have shaped our present existence. We can't do that with physics or chemistry.

Well, Darwin's finches are just one very, very tiny branch on the tree of life that extends back thousands of millions of years. Another, even smaller, branch is that of the Hominoidea, a grouping of apes within the Primate order that includes human beings. Best present evidence, which is molecular, points to the chimpanzee as our nearest living relative, and indicates a common chimpanzee-human ancestor to have lived around five to six million years ago. Of significance to the issue of cognition and cognitive evolution, which is my theme, is what might have happened during the period extending from the first appearance of which is my theme, is what might have happened during the period extending from the first appearance of human-like creatures, which is usually put at about two to two and a half million years ago, to the origins of Homo sapiens, around one hundred and fifty to two hundred and fifty thousand years before the present. In that two million year period the human brain doubled in absolute size and quadrupled in size relative to body mass. Over this same period there was little or no increase in the brain size of any other species of primate -- indeed, there is no known comparable increase in brain size over so short a period of evolutionary time in any other species at any time in the history of life on Earth.

So, whatever else human beings are, we are a relatively recently evolved species and our evolution has involved unprecedented change in the organ system that subserves those mental capabilities that we call intelligence. If we are really to understand the human mind then, it seems to me, we have to take into account the evolutionary, historical, causes that shaped our minds and made them what they are now. There has been, to some degree there still is, a reluctance on the part of social scientists, and other scholars within the humanities, to accept that the human mind is a product of evolution just as is the anatomy of our hands or the way in which we metabolize carbohydrates. This is, I think, a profoundly mistaken, and in effect an anti-scientific, stance. A true and complete understanding of the mind, including intelligence, has to include an evolutionary perspective. We don't yet understand how to do this and what its implications really are, but I will try here to sketch out some of those implications and possibilities.

The Origins of Intelligence

The psychometricians' conception of intelligence as something that people have, that is measured by IQ tests, and which varies from individual to individual, is not the conception of intelligence that I am considering here. There may be some quality of mind that can be measured in this way, but it is an irrelevance to any biological approach to intelligence, and it is this more general conception of intelligence as a biological phenomenon that needs some explanation here. All living things are localized gradients of negative entropy, regions of order and organization, in a universe pervaded by positive entropy, by increasing disorder. The only way in which such states of negative entropy can be developed and maintained is by exploiting energy sources. It takes energy to maintain these negative gradients. Unable to utilize the energy of the sun directly in the way that plants are able to do, which trap solar energy within a complex chemical web, most animals have to make contact with and feed off the energy of organisms that are able to do this. Putting it rather abstractly, animals need to maintain some form of matching relationship between themselves and these indirect solar energy sources, and their principal way of doing this is by moving about in, and acting upon, the world. In order to be successful in maintaining this matching relationship, the behaviour of animals must be guided by information. If the information comes only via genes that direct nervous system wiring such that sensory inputs lead to relatively fixed behavioural responses, then that behaviour is called an instinct. If some of that information comes from memory stores in the brain that have been laid down by individual learning, then the behaviour is intelligent. The internal mechanisms of learning, memory, thought and creativity which have evolved to supply this guidance is what I call collectively intelligence.

In broadest terms, then, it is the source of information guiding behaviour that determines whether we think of it as instinctive or intelligent. Thus defined, intelligence is probably quite ancient, first appearing some five hundred million or more years ago. Obviously, it is not confined just to humans, and it takes many forms. Since information is order, it is energetically costly, and trade-offs between costs and benefits must have evolved. G.C.Williams' (1966) principle of the economy of information which asserts that living things will evolve in such a way as to maintain information in the cheapest form possible is one theoretical expression of such a trade-off. Now, because instincts cost less than learned behaviour both in genetic and nervous system terms, and because the nervous system is one of the most metabolically expensive tissue in our bodies, Williams' principle tells us that there had to be powerful and pervasive forces selecting for the evolution of intelligence. We think we know what the source of these forces are.

The rate at which information can be acquired by a species and stored within the gene-pool of that species is limited by the rate at which individuals can reproduce themselves, that is, the period that extends from individual conception to when that creature is itself reproductively competent. In a small rodent this is a period of a few months; in humans it is in the region of twelve to thirteen years. These are finite periods of time that sometimes occupy significant proportions of the average life-span of an animal. In humans it approaches one fifth of our lives. Any changes in the world that occur at rates higher than this rate of generational time cannot be detected by, and hence information about such changed conditions cannot be incorporated into, the gene pool. If these changes are important to survival, and many, like the spatial position of vital resources or the identity of social allies and enemies, are, then such animals will have evolved additional, individual information-gaining processes that are capable of tracking such rapid changes in their world. In most general terms, this temporal sampling limitation of genetic information-gaining processes is what has caused the evolution of individual intelligence in animals, and maintains it in place despite its high energy costs.

Some Implications

The previous section is a highly condensed form of a rather lengthy argument that derives from a number of sources, which have recently been brought together between single covers (Plotkin, 1995). This thesis on the origins of intelligence as rooted in the need for some animals to track high rates of change has a number of important implications, just two of which are presented here. One is that the *tabula rasa* view of mind and intelligence is untenable; the other is that genetic reductionist accounts of the evolution of any species whose individuals are intelligent are unworkable.

The British Empiricist philosopher, John Locke, argued that the mind is at birth like a blank slate upon which experience writes. Hence he denied the existence of innate or *a priori* knowledge. The notion of a blank slate became an important part of empiricist thinking and has also had a strong following in the scientific psychology of this century. It has been at the centre of most of associationist learning theory and of behaviourism, and it has been applied as much to animals as humans. It has also usually had an appeal to the liberal-minded non-scientist, suggesting as it does that humans as cognitive generalists can learn and think anything; any failure to do so is because of impoverished experience or inadequate teaching.

In the context of the age- old debate about the relative contribution of nature and nurture to human disposition and behaviour, the *tabula rasa* position is a vote for nurture and against nature. The evidence, however, tells us that this is wrong. I will give just two examples. One comes from the study of animals the significance of which is that what we know has been achieved with rigorous experimentation.

We know with the certainty that experiments give that songbirds have to hear the song of their fellow males at a certain age if they are to acquire normal, species-typical song. What is extraordinary is that if they are exposed to the song of another species during this song-sensitive period, they acquire neither their own species' song nor that of their "mentor". They have to hear their own species' song for normal song to be acquired. In other words, these are animals that come into the world knowing what it is that they have to learn. This wonderful contradiction, this paradox for any follower of Locke, is resolved by the realization that cognitive abilities are the products of evolution. All of the processes that we tend to think of as being in the service of nurture themselves have nature, that is, they have evolved, and so cognitive modules are primed or predisposed by information coming from the genes. There are other examples from other kinds of animals, ranging from insects like honey bees to mammals like voles, of similarly constrained learning. As a general rule, animals learn what is good for them, Konrad Lorenz's (1965) great insight, and that can only mean that learning is a product of evolution.

A similar account can be given of human learning and intelligence, but in our case, because of the limitations placed on experimentation, the evidence is less direct. The famous example is language. At birth infants have a pronounced sensitivity to human speech sounds; this rapidly narrows to the speech sounds specific to the linguistic environment in which they are being raised; the pattern and rate of language learning is remarkably uniform across languages, irrespective of which of the world's five and a half thousand documented languages is being acquired; the rate at which new words are learned is breathtaking given that it occurs without formal tuition from caregivers or others; the same extraordinary effortlessness marks the acquisition of syntax and grammar, which again is almost always entirely untutored -- this must be so because few adults are aware of the rules governing their own language. All of this, apart from the sensitivity to speech sound, applies as much to deaf children who are raised within a linguistic environment of handsigning as they do to children with normal hearing who are raised to speak Dutch or Zulu. The fact that language is a human- specific learned trait, and that its acquisition has never been explained using generalist learning principles like those of associative learning, adds further weight to the Chomskian view (see Pinker, 1994 for a recent review) that language is the product of an innate organ of mind, and that learning a language is the result of a specialized, predisposed, cognitive module. In the same sense that I applied the phrase to songbirds, we humans come into this world knowing that language is one of the things that we have to learn.

is one of the things that we have to learn.

There is a very similar story to be told for facial recognition, the understanding of cause-effect relations in the physical world, and the attribution of intentional mental states to others (see Johnson and Morton, 1991; Hirschfeld and Gelman, 1994; Sperber, Premack and Premack, 1995 for reviews).
Anyone of these examples destroys the notion of the mind as a *tabula rasa*. But there is yet another reason to doubt the blank slate concept. When we come into the world, it is initially an unlabelled place (Edelman, 1987) which can be partitioned into a virtually infinitely large number of ways. That is, the number of things that we could learn from our quite limited sensory input combined with our ability to move, is huge. We live within this vast space of things we could learn, and if our cognition were not predisposed, if it did not point us into the right parts of this massive search space, the chances of our learning the things that it is important to know are very small indeed. This is because the *tabula rasa* principle says that if you can learn anything, if the slate is really blank, why then given enough time, you will learn everything. But you would have to be given enough time. Learning the important things then becomes a ponderous and chance-ridden process. Yet the very reason why it evolved was because of the need to track rapid change. Slow and haphazard is just what cognitive processes are not because if they were they would have little adaptive value and would not have evolved at all. We know that in those species that have evolved intelligence, cognitive skills are indeed rapid and economical mechanisms that fit with the general life-history style of the learner; intelligence and instinct are closely interwoven to the point that it is not inaccurate or fanciful to think of learning as an extension of instinct. To repeat the point, but the point is so important it bears repeating many times, resolution of the old nature-nurture argument comes with the understanding that nurture itself has nature. In technical jargon, learning is a consequence of the operation of a semi-autonomous information-gaining device that is nested within the larger, more encompassing information-gaining processes of evolution whose products are stored in genes.

In summary, most evolutionists and evolutionary psychologists believe that the correct way to think of intelligence is, first, that it is a characteristic that is highly constrained by a species' evolutionary history; second, that the word is best confined to a generic use; third, that contemporary cognitive psychology is correct in thinking in terms of intelligences which are relatively discrete, discontinuous cognitive skills; and fourth, that neither humans, nor the members of any other species have the capacity to learn and think about anything and everything. One way of saying all this is that the ideal of a rational, free-thinking, human being is a fiction -- or so rare as to be, in effect, a kind of freak of nature. Shakespeare, of course, existed but was probably not very good with mathematics, or might have been less than skilled with his hands. Newton was good with sums but couldn't write sonnets. And most of us are entirely ordinary in all these respects. We humans are not general-purpose thinkers and problem-solvers who can turn our minds to anything. We are very restricted in what it is we can learn and how we think, yet within these limitations we are economical and effective cognitive agents.

The second implication concerns the spectre of a rampant and powerful biological science taking over the social sciences with unstoppable reductionist arguments and explanations, which has been with us for over a century. However, an evolutionary approach to intelligence, which relates closely to its non-*tabula rasa* nature, tells us that such reductionist arguments could never succeed. The counter-argument goes like this. Nature is rather clever in the way that it equips learners with knowledge about what it is they have to know if they are to survive. It does this by feeding information gained *a posteriori*, through history, at the species level to the individual as a learning or reasoning predisposition where it appears, for the individual, as *a priori* knowledge. The empiricist denial of innate knowledge is wrong; the age-old rationalist view is closer to the truth and Kant's notion of the *a prioris* is much closer to the way modern science views these matters. (It is worth noting in passing that science can now adjudicate in such philosophical disputes.) However, whilst Nature is clever, it is not prescient. Indeed, it evolves these semi-autonomous information-gaining devices precisely because it is not prescient. And in doing so, it in effect passes some of the causal responsibility for behaviour onto these semi-autonomous devices. Intelligent creatures construct in their own minds and brains the detailed picture of the world that their genes only hint at, crucial as those hints might be in navigating through to the right place in knowledge space. In so doing, they construct for themselves the causes of their own behaviour. Were this not the case, if the slate were completely written on by genes, then we would be dealing with instinct and the causes would reside in genes and in the developmental processes by which they are translated into action. The fact that we do make life and death decisions concerning who we co-operate with, which resources we exploit, where we

make life and death decisions concerning who we co-operate with, which resources we exploit, where we live, how we move through space, and with whom we choose to reproduce ourselves, all on the basis of information that comes to us through these semi-autonomous information-gaining devices, means that any proper causal analysis of the evolution of species whose individuals are intelligent has to locate some of those causes within the brains and minds of those individuals. Towards the end of this lecture I will give some specific examples.
The general point being made here is that genes and development are not enough. Social scientists and scholars of the humanities quite simply have nothing to fear from a powerful, reductionist biology. What has happened in molecular biology since the genetic code was unscrambled by Watson and Crick over forty years ago has been magnificent. And I don't doubt that it will help in developing the human sciences. But it is never, on its own, going to do the whole job.

The image I would like to leave you with is this: the slate is not blank. Both evidence and argument tell us it is not and cannot be so. But neither is it wholly written upon. The temporal sampling limitation of genes requires that some part of the slate is not filled in at birth. However, because of the operation of Williams' principle, what space is left open for experience to fill in is the least amount Nature will allow, and it will vary with the general life-history and life-style of a species. Nature is forced into this delicate balance in the matter of how much must be written on the slate, but one thing is clear. At birth, something is always written there. We are all possessors of innate knowledge upon which we then build.

The Evolution of Culture

The evolution of individual intelligence as an adaptation for tracking rapid change and adjusting to it, powerful and effective as it is, nonetheless is like any other kind of adaptation in that the consequences of individual intelligence, the memories and the products of reasoning and thought, remained confined within each individual organism for hundreds of millions of years in all but a single species, or perhaps the species of the single genus Homo. Any population-level effects came about only by the adaptive consequences of having the capacity for individual intelligence feeding back into changes in gene-pool constitution by the usual route of overall individual fitness gains and reproductive success. The precise form or content of the adaptations formed by intelligence -- this food is safe, that face is not to be associated with -- could not be transmitted to others and remained locked within each intelligent creature that had gained the information. In the context of major evolutionary events (Szathmary and Maynard Smith, 1995), the appearance of individual intelligence was not a major transition in the history of life on Earth, on a par with, say, the evolution of self- replicating molecules or multicellularity. Individual intelligence was, however, a necessary precursor to what was an evolutionary watershed, a profoundly important event in the history of life the consequences of which we are seeing unfold before us -- this was the evolution of culture which, among extant species, is unique to Homo sapiens.

Literally hundreds of definitions of culture have been offered over the last 150 years, which can be classified in a large number of ways (Kroeber and Kluckholm, 1952; Keesing, 1974). Many revolve around the products of culture, be they artefacts, ideas or behaviour. A better approach, I believe, is to define culture in ways that make for an analysis of the phenomenon in terms of processes and mechanisms. For that reason I define culture simply as shared knowledge. If you can share what you know with others, and are able to acquire knowledge from others, then you are a creature capable of entering into culture. There are documented cases of a few other species, like bees, songbirds and chimpanzees, being able to acquire information from one another. There are, though, several features of the human capacity for learning from others that make human culture different from anything that birds and bees can do (Tomasello et al, 1993). Primarily, these differences concern the way in which, pathology apart, literally every member of the social group shares in knowledge, and that knowledge is of many different things -- linguistic, dietary, dress, and abstract beliefs amongst many other forms of knowledge. By contrast, in chimpanzees for example, only a limited number of individuals will share a small number of isolated behaviours; and in bees, while most members of a hive are able to share information about the location of resources, that is all that is shared. The sheer astonishing richness of the range of what humans share with one another marks culture out as different from anything seen in any other species.

A second unique feature of human culture is incessant, cumulative, modification of knowledge and practice over generations. Tomasello calls this the "ratchet effect". The conservation and elaboration of stone tools over hundreds of thousands of years is one example; the growth of the form and use of computers in the over hundreds of thousands of years is one example; the growth of the form and use of computers in the last four decades is an example of a spectacular ratchet effect. Furthermore, human culture is marked by an extraordinary specificity and detail of shared knowledge which no other animal exhibits. What this all means is that the richness, the precision, the range, and the durability of human cultural knowledge is such that if one is looking for insights and understanding of culture from biology, comparisons with other living species will not help.

Szathmary and Maynard Smith consider language to be a major evolutionary event, and the reason for their choice is that with the appearance of language came, for the first time in evolutionary history, the means of transmitting large quantities of information between individuals which do not involve genetic transmission. This truly is a major evolutionary event, but language cannot be the only crucial psychological process that was necessary for culture to appear in humans, and it does seem to me that it is culture, not just language, that is the major event, with language being one of the necessary component processes of culture. The other processes necessary for culture can, perhaps, be gleaned by considering one of the most important characteristics of human culture, which is the existence of social constructions like money, marriage and justice. All social constructions are based on agreement. It is only because we agree that a fifty Guilder note has sufficient value that it can be exchanged for enough goods to make a meal, or for the purchase of a book, that it has that value. In itself, the piece of paper has miniscule intrinsic worth. And it is only because we agree in societies like our own that fairness should underpin our notion of justice that our beliefs and practices with regard to justice have the characteristics that they do. The notion of fairness as central to justice is not some immutable, inexorable consequence of human biochemistry and present in all humans. Some cultures have quite different social constructions of justice based on social status, revenge or religious precepts. Justice is what it is in Holland or England because we agree that it should be so, and for no other reason. Put simply, some things exist only because we all agree to think that they exist. Parenthetically, some biologists are sceptical about the existence of social constructions and suggest that they are part of the mythology of the social sciences. This is a curious stance to take because it is manifestly the case that social constructions have real causal force. People live in the manner that they do, and die as they do, often in large numbers in wars, because of them.

Now, language alone cannot explain social constructions. I agree with Searle that "what is special about culture is the manifestation of collective intentionality and, in particular, the collective assignment of functions to phenomena where the function cannot be performed solely in virtue of the sheer physical features of the phenomenon" (Searle, 1995 pp 228).

The power of money does not lie in the coin, nor that of justice in the buildings that house our courts or the people that operate the system. "Collective intentionality" is where the power lies, and this is a very difficult thing to explain. In the last 18 years or so, centre stage in developmental psychology has come what is known as "theory of mind", which is the understanding that other people have minds as well as ourselves. We now know something of the way in which children come to understand that intentional mental states like wanting and knowing exist in the minds of others; and we have also come to understand the catastrophic consequences for normal social function when the ability to attribute mental states to others fails to develop. We now believe that the development of a theory of mind is one of the most important features of human cognition, because it lies at the heart of social causation -- we understand people as causal agents by way of the attribution of intentional mental states. Although the phrase theory of mind was first used in a classic paper with regard to chimpanzees (Premack and Woodruff, 1978), there is no evidence whatsoever that any other species is able to attribute intentional mental states to other indiviuals. It is, like language, a human-specific characteristic,and it must have a crucial role to play in establishing agreed or "collective" intentional states. It must be the case that the capacity for attributing mental states to others is a necessary prerequisite for the capacity to recognize that one's own mental states match those of others. The kind of agreement that social constructions require can only come into being between individuals who possess a theory of mind.

Another important aspect of human psychology that is necessary for culture has been known to social psychologists for many years. Social forces such as conformity, obedience and cohesiveness are known to operate with real causal effect to establish or shift intentional states, and the direction of shift is usually towards some social norm, towards an agreed or "collective" intentional state. The classic studies are those of Muzafer Sherif, which were carried out in the 1930s.

I am suggesting that, at a minimum, the extragenetic transmission of information, a theory of mind module, and the evolution of a responsiveness to social force, were the elements necessary for the module, and the evolution of a responsiveness to social force, were the elements necessary for the appearance of human culture. Whether through co-operation, coercion or education, we establish agreed mental states and values on matters that relate in large part to the existence and continuing function of the social group. Culture is truly a population-level or group-level phenomenon. In my view it is impossible to understand it in any other way, and this is another reason for believing that biologists armed with reductionist strategies cannot succeed in explaining the social sciences. It must be added for those who are knowledgeable about the problems raised in the past for the notion of group selection by evolutionary theory that there is now an increasing acceptance that the concept of group selection can be defended (Wilson and Sober, 1994)

It should also be noted that I have been referring to extragenetic transmission of information at times rather than language. This is a caution born of our not knowing, and perhaps we will never know, the order in which these essential components of culture that I am advocating here appeared in human evolution. There are some experts on human evolution, for example Tobias(1995), who advocate the view that a form of language may even have existed in our australopithecine ancestors, the ape- human creatures that mark the beginnings of hominid evolution some four to five million years ago, and certainly existed in Homo habilis, the earliest known species of the genus to which modern humans belong; and others, for example Lieberman(1984) who believe that language first appeared when Homo sapiens evolved, in the region of two hundred thousand years before the present. Yet even if Lieberman is correct, two hundred thousand years is a long time. Nobody suggests that human language appeared suddenly and in one single step.

A rapid evolutionary event for something as complex as language is probably to be measured in thousands, perhaps tens of thousands, of years. It almost certainly was preceded by the evolution of protolinguistic and paralinguistic signalling such as gestures, grunts and cries of varying intonation and intensity. It must have evolved alongside imitation and mimesis and would have formed, across a not insignificant period of time and many generations, an increasingly complex and effective collective system of communication involving hands, ears and eyes. Entangled somewhere within this complexly evolving set of communication skills is the cognitive module that allows the attribution of mental states to others. It is likely that developmental studies will tell us more about the dependencies of language, imitation and theory of mind, and give us some glimpse into the evolution of the human capacity for culture, but I would not hold my breath on it. Lacking any evidence from other existing species, I suspect that these are going to remain issues about which we can only conjecture.

The Causes of Human Evolution

I want here to flesh out the argument presented earlier that genetic-developmentalist reductionist accounts of human intelligence and evolution are, literally, untenable. The argument, remember, is that the evolution of the cognitive modules that make up the semi-autonomous information-gaining device that is intelligence resulted in a diffusion of the causes of intelligent behaviour into those modules; and that if intelligence has had a causal role in the evolution of our, and others, species, then the argument has to be extended.

Reductionist accounts of the evolution of intelligent species are no more tenable than are reductionist accounts of the behaviour of intelligent individuals. This is because if a choosing intelligence affects survival and reproduction, then that intelligence is one of the causes of the changing gene frequencies in that species, which means that intelligence becomes one of the causes of the evolution of that species.

The consequence of viewing the role of intelligence in this way is to make evolution a much more dynamic and complex process. The history of this kind of approach is to be found in Richards (1987) and Plotkin (1988a), and the details of evidence and theory in Laland (1992) and Plotkin (1988b).

Here I will offer just a few examples. Imprinting is a phenomenon first described in birds by Lorenz, and now understood to be present in many sexually reproducing species (Bateson, 1983). In broad terms, imprinting refers to the way in which exposure to particular individuals affects later choice of mating partner. Imprinting is not an absolute and irreversible outcome of development. In many species of bird and mammal imprinting looks like other forms of learning in occurring repeatedly and hence in being reversible. Imprinting is a form of learning. Now, no behaviour more directly affects what genes are propagated and in what combinations than does mating behaviour. If choice of mate is an outcome of learning, then learning is entering in a direct causal fashion into the determination of the genetic constitution of sexually reproducing species that imprint. Here is a form of learning that does indeed have causal force in evolution. The same argument can be run for birdsong, which we know is learned and which causal force in evolution. The same argument can be run for birdsong, which we know is learned and which has been shown to affect subsequent mating behaviour and mate choice.

The conclusion is stark and simple. In some species there is clear evidence that intelligence is one of the causes of evolution. Does this apply to our own species? There is an enormous body of anthropological data about the way in which human mate choice is determined by cultural injunctions in many different kinds of societies. As argued in the previous section, culture is a human-specific trait that derives from certain human-specific cognitive characteristics. The causal force of culture in Homo sapiens is massive and pervasive. No-one is surprised at the notion that cultural injunction constrains human mate choice; yet few social scientists are comfortable with following through on the implications of this -- that since culture can only be explained as an outcome of human intelligence, then intelligence is directly implicated in human mating patterns, including assortative mating, which have been causal forces in human evolution. In this sense, it is the social scientists who should and must intrude into the biological sciences.

There are other examples apart from reproductive behaviour. The case of lactose tolerance and intolerance is becoming famous for the way it demonstrates the interweaving of culture and biology (Durham, 1991). Approximately two thirds of all people in the world have varying degrees of difficulty in digesting lactose, a sugar found in mammalian milk. Prior to weaning, the enzymes that allow lactose absorption are present in the alimentary tracts of all people. Around the time of weaning these levels decline in most people, and the illness that results from drinking milk in those who are lactose intolerant can be severe -- in the nutritionally stressed, or those suffering from other illnesses, it can be fatal. Most people from Africa and south and east Asia are lactose intolerant, whereas 95% of Scandanavians are lactose tolerant. Across Europe there is an especially marked gradient in the ability to absorb lactose, being high in the north and declining to the south and east. Correlating with this gradient are customs of milk and milk product preparation such that in northern Europe there is consumption largely of unprocessed milk and its products like cream which are lactose rich, whereas as one moves towards the Levant, processed milk products like yogurt and kefir, which have greatly reduced lactose levels, become common. Accompanying the dietary and food preparation practices are culturally propagated myths about milk consumption, such as it being the food of the gods. It is now widely accepted that lactose tolerance is caused by a mutant gene which became fixated at high levels in populations that combined high nutritional stress with vitamin D deficiency, the latter being prevalent amongst people who live in regions of low sunlight levels (unless they have other components of their diet that make good this deficiency, but this is a detail of a much more complicated story than there is space for here). The peoples of northern Europe benefitted in significant ways, life-saving ways, through their ability to consume milk without it making them ill, and so the mutant gene was strongly selected for in certain populations; however, the important point is that the engine driving this evolutionary event was not the mutant gene but the invention and propagation of animal husbandry and dairying practices, part of the agricultural revolution.

The agricultural revolution, as the word demonstrates, was one of the most significant achievements of human culture in all of human evolution. The final example of how human intelligence and culture might have affected human evolution is rather more tentative, but no less fascinating for that. Earlier I mentioned the doubling (or quadrupling in relative terms) of brain size during human evolution. In fact, the increase has not occurred gradually and smoothly. There have been periods of relatively rapid expansion in brain size and longer periods of stasis. One of the periods of most rapid increase occurred in the middle Pleistocene epoch, around six to seven hundred thousand years ago, and it coincides with evidence for the first use of fire in food preparation. The significance of this according to Aiello and Wheeler (1996) is that cooking is essentially an externalization of the digestive process. As the controlled use of fire spread and became commonplace amongst archaic humans, and it could only have done so by cultural innovation and transmission, so the need for the large digestive systems that characterize the great apes was reduced. Earlier in human evolution, the switch to high energy foods, notably meat consumption in quantity, coincided with another period of accelerated increase in brain size. What links these two organ systems, brain and gut, is that they are the metabolically most expensive organ systems in our bodies. Raise dietary quality or invent cooking and gut size can be reduced allowing brain size to increase. The controlled use of fire was a landmark event in human evolution. It is most likely that the practise spread culturally, and if Aiello and Wheeler are correct, then this is an exquisite example of human evolution having been significantly affected by human intelligence. Many other examples, drawn from warfare, genocide, science and medicine, would all tell the same story.

genocide, science and medicine, would all tell the same story.

I began this lecture by pointing to the wonderful complexity in the relationship between intelligence and evolution: intelligence evolves, then in turn drives on the process of evolution. It brings to mind the image of a complex causal dance in time in which effects become the causes of effects which themselves become causes. To social historians who study the causes and consequences of successions of cultural selection filters in the process of cultural evolution, this kind of image is, I should imagine, a familiar one. You people have always known that history matters. I hope that I have shown you that an extension of that view to human intelligence, culture and evolution has important consequences for understanding ourselves, and demonstrates how links can be forged between the biological and the social sciences.

A footnote

I am honoured by the invitation to present the inaugural Science and Society Lecture. I am grateful to Dr Kloosterman and his colleagues at the International Institute of Social History who have given me the opportunity to present this material in this way.

September 1996

References

Aiello, L.C. and Wheeler, P. (1996) "The expensive-tissue hypothesis: the brain and the digestive system in human and primate evolution." *Current Anthropology* 36, 199-221.

Bateson, P.P.G. ed. (1983) *Mate Choice*. Cambridge, Cambridge University Press.

Durham, W.H. (1991) *Coevolution: Genes, Culture and Human Diversity*. Stanford, Stanford University Press.

Edelman, G.M. (1987) *Neural Darwinism: the Theory of Neuronal Group Selection*. New York, Basic Books.

Gould, S.J. (1986) "Evolution and the triumph of homology, or why history matters." *American Scientist* 74, 60-69.

Hirschfeld, L.A. and Gelman, S.A. eds. (1994) *Mapping the Mind: Domain Specificity in Cognition and Culture*. Cambridge, Cambridge University Press.

Johnson, M.H. and Morton, J. (1991) *Biology and Cognitive Development: The Case of Face Recognition*. Oxford, Blackwell.

Keesing, R.M. (1974) "Theories of Culture." *Annual Reviews of Anthropology* 3, 73-97.

Kroeber, A.L. and Kluckholm, C. (1952) "Culture: a critical review of the concepts and definitions." *Papers of the Peabody Museum of American Archaeology and Ethnology* 47, 1-223.

Laland, K.N. (1992) "Learning and evolutionary rates: a critical review." *Evolution and Cognition* 2, 63-78.

Lieberman, P. (1984) *The Biology and Evolution of Language*. Cambridge Mass., Harvard University Press.

Lorenz, K. (1965) *The Evolution and Modification of Behaviour*. Chicago, Chicago University Press.

Pinker, S. (1994) *The Language Instinct*. London, Allen Lane.

Plotkin, H.C. (1988a) "Behaviour and Evolution." In H.C.Plotkin (ed) *The Role of Behaviour in Evolution*. Cambridge Mass., MIT Press. pp 1-17.

Plotkin, H.C. (1988b) "Learning and Evolution." In H.C.Plotkin (ed) *The Role of Behaviour in Evolution*.

Plotkin, H.C. (1988b) "Learning and Evolution." In H.C.Plotkin (ed) *The Role of Behaviour in Evolution*. Cambridge Mass., MIT Press. pp 131-164.

Plotkin, H.C. (1995) Darwin Machines and the Nature of Knowledge. London, Penguin Books.

Premack, D. and Woodruff, G. (1978) "Does the chimpanzee have a theory of mind?" *The Behavioural and Brain Sciences* 1, 515-526.

Richards, R.J. (1987) *Darwin and the Emergence of Evolutionary Theories of Mind and Behaviour*. Chicago, University of Chicago Press.

Searle, J.R. (1995) *The Construction of Social Reality*. London, Allen Lane.

Sperber, D., Premack, D. and Premack, A.J. (1995) *Causal Cognition: a Multidisciplinary Debate*. Oxford, The Clarendon Press.

Szathmary, E. and Maynard Smith, J. (1995) "The major evolutionary transitions". *Nature* 374, 227-232.

Tobias, Ph.V. (1995) "The communication of the dead: earliest vestiges of the origin of articulate language." Zeventiende Kroon-Voordracht. Amsterdam, Nederlands Museum voor Anthropologie en Praehistorie.

Tomasello, M., Kruger, A.L. and Ratner, H.H. (1993) "Cultural Learning." *The Behavioural and Brain Sciences* 16, 495-511.

Williams, G.C. (1966) *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought*. Princeton, Princeton University Press.

Wilson, D.S. and Sober, E. (1994) "Reintroducing group selection to the human behavioural sciences." *The Behavioural and Brain Sciences* 17, 585-608.