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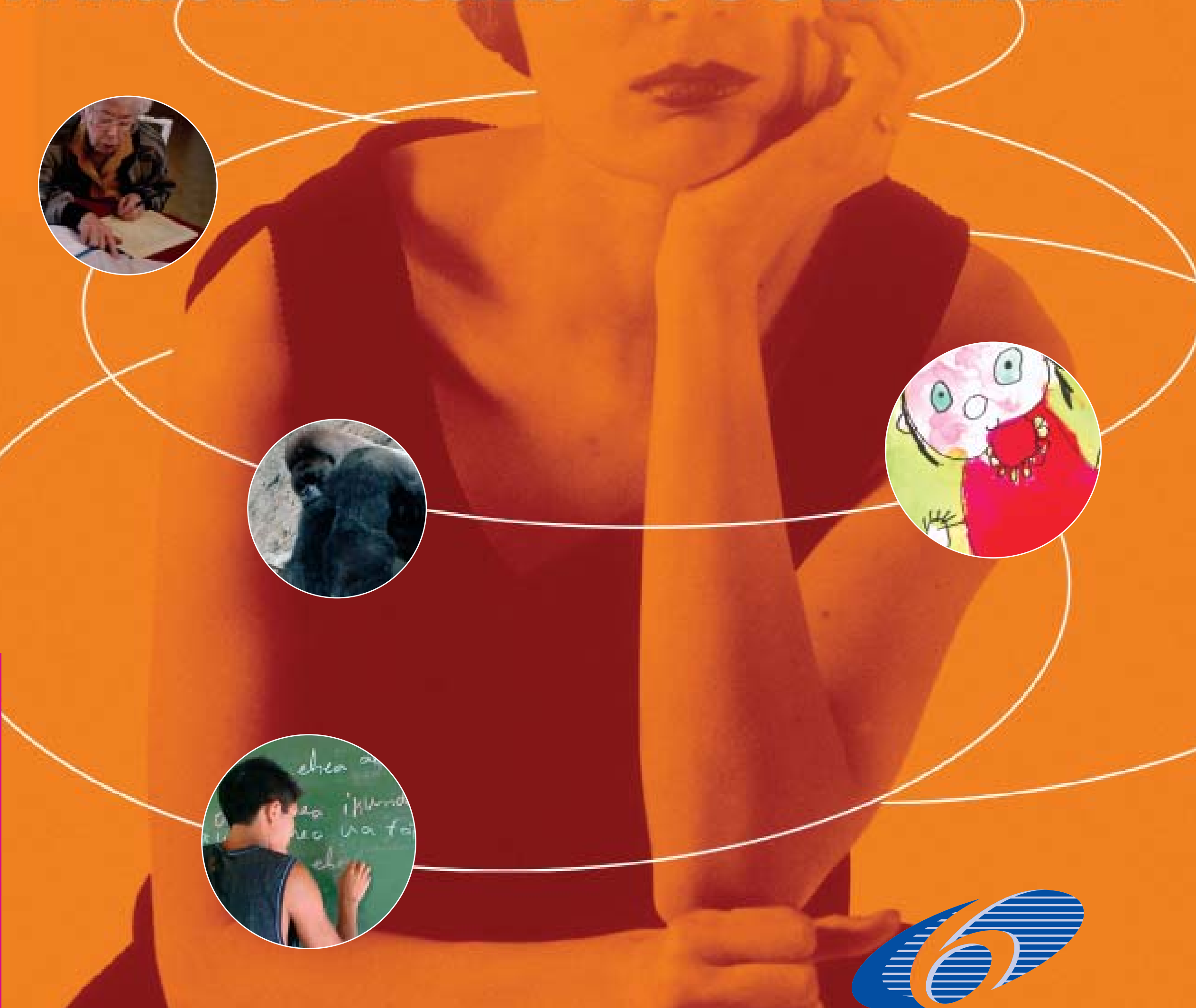
Report of a NEST High-Level Expert Group

What it means to be human



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What it means to be human

Origins and Evolution of Human Higher Cognitive Faculties

Report of a NEST High-Level Expert Group

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EXECUTIVE SUMMARY

The Human Mind Project

"What It Means To Be Human" presents the conclusions of a high-level expert group set up by the European Commission's PATHFINDER initiative to examine the new scientific opportunities arising from advances in our understanding of the human mind. It is a European initiative that aims to assess the potential for a concerted research program in this area and to suggest how this might be achieved through the development of cross-disciplinary and cross-national links.

The report argues that the time has come for a powerful new collaboration, a "Human Mind Project", to pull together and extend the tidal wave of research in this area. Its objectives would be to inspire holistic thinking and encourage and fund collaboration between specialists in many fields from molecular and behavioural sciences all the way to the humanities. New technologies and recent scientific developments mean that within many disciplines, understanding of what it means to be human is growing at an exponential rate. But it is also becoming increasingly clear that it will be essential to build a multifaceted research program if we are ever to gain real scientific insights into critical aspects of human cognition and behaviour. Now is the time for Europe to take up the challenge and realise that opportunity.

This report outlines recent developments in the fields of genetics, neurobiology, cognitive science, human and animal behaviour, paleoanthropology, history, modelling and philosophy, upon which this research program must build. It also suggests areas where there is great potential for integration between disciplines. The opportunities are immense, but research within the Human Mind Project is likely to fall within five broad thematic areas.

§ The genetics of human cognition – how our species, despite its remarkable genetic resemblance to other apes, has evolved and sustains such an extraordinary complex mind.
§ The developing mind – how various life experiences influence the development, maturation and aging of a normal human brain.
§ The process of thinking – new insights into reasoning, learning and memory that will impact on education, communication and the development of intelligent technologies.
§ Motivation and decision making – insights into what motivates people to cooperate or, conversely, to behave with disregard for others, and what factors influence us to make the choices we do.
§ Cultural context – how the human mind manifests itself as culture, how cultures change and how they endure. Which behaviours and ways of thinking are part of our culture and which are part of our nature.

Research within the Human Mind Project will have implications in many areas of public policy from the way we educate our children and motivate citizens to adopt healthier lifestyles, to our ability to cope with issues such as racism, immigration and criminal and antisocial behaviour. In the private sector, it will inform decisions about corporate culture, product design and the manufacture of intelligent machines. Many of the problems, and opportunities, humanity will face in the coming years will not be met simply with technological fixes. We will also need to change our thinking and our behaviour if we want to survive and thrive in the overcrowded, polluted and bustling global village we now inhabit. A better understanding of the human mind and why we have evolved to think in certain ways will help us come to terms with globalisation, demographic transition and even issues such as political corruption and conflict resolution. Research findings coming out of the Human Mind Project will also suggest ways in which we can change our behaviour so as to tackle global warming and to live peacefully in a world of growing demand and shrinking natural resources.

Why now?

For the first time, scientists are now in a position to start piecing together the various parts of the jigsaw to reveal the full picture. With the human genome sequenced, geneticists are starting to work out how environmental factors influence gene expression. Neurobiologists are using new technologies to probe how a brain develops, and see how it is shaped by its social and physical context to become a mind. Increasing computing power is helping cognitive scientists and modellers get to grips with the processes involved in reasoning, learning, decision making, and so on. Students of animal behaviour have started to study traits that were once thought uniquely human, shedding light on their origins. Researchers with an interest in human behaviour are increasingly trying to understand it in terms of our evolutionary and cultural contexts. Those concerned with the history of mankind, both from the paleoanthropological and modern historical perspective, have amassed huge amounts of data about the changing cultural environment in which our ancestors lived. And philosophers are increasingly interested in issues of mind/brain and consciousness. Now is the time to bring all this together.

In the past, researchers from the natural and social sciences have not always seen eye to eye, but attitudes are changing. With our entire DNA blueprint sequenced in the Human Genome Project, many natural scientists are embracing a less reductionist approach to their analysis in order to make sense of the mass of data. Meanwhile, social scientists are emerging from a postmodernist period that emphasised subjectivity and relativity, and are becoming more interested in synthesising and integrating findings from various levels of analysis. Researchers from both camps who are interested in crossing boundaries are finding that new technologies, such as comparative genomics, brain imaging techniques such as magnetic resonance imaging (MRI), and the vastly increased computer power available, offer intriguing, novel ways to test their theories. A Europe-wide Human Mind Project would build on these developments. There is no doubt that it will be a huge undertaking, but it is also clear that there is no alternative if we want to extend the frontiers of our scientific understanding. We cannot know what it means to be human simply by scrutinising individual strands of enquiry because the story of how we acquired our unique nature is exceedingly complex, with many intertwining threads. Who we are, and how we think and behave, is intimately bound up with our evolutionary history and our present physical, social and cultural environment. Only by weaving these together will we start to get a clear view of the rich fabric of our existence.

Making it happen

The first aim of a Human Mind Project would be to provide opportunities for researchers who are already breaking down barriers to pursue their ideas. It should also enthuse a new generation to think big and make connections with others outside their own area of expertise. The high-level expert group believes that if the European Commission were to announce its commitment to a European Human Mind Project, this exciting venture would inspire some of the best scientific talent to become involved. By funding a series of summer schools, up-and-coming and established researchers could get together to build an interdisciplinary knowledge base and make contacts for future research projects. A system of medium-sized, grant-funded research projects could then bring together researchers from several different disciplines and at least two European Union countries. Funding would also be needed for some smaller research projects and exchange programs, and to establish a website to coordinate research efforts between networks of laboratories and to provide information about newly published research that will enable individual researchers to keep up to date with developments outside their own field of expertise.

Collaborative work tends to flourish best outside the boundaries of traditional scientific disciplines, and the study of the human mind is no exception. This approach is currently proving fruitful in several fields of inquiry. The study of language is perhaps the best and most well-established, but recent years have seen growing collaboration on other unifying themes such as the study of human economic behaviour and of morality and spirituality. Nevertheless, there are many more possibilities. The Human Mind Project could help focus research efforts in promising areas by funding collaborative studies within a number of thematic strands. Examples of these might include: freewill (exploring the constraints imposed by our genes, neurobiology, physiology, physical and social environment, etc, to come to a better understanding of the extent to which we are "free"); narrative (how we shape and make sense of our cultural and personal world through stories, gossip, propaganda, self-narrative and so on); decision making (exploring how the choices we make are influenced by emotions, rationality, constraints imposed by our physical, social and cultural environment, etc); and "altriciality" (the effect of infant helplessness on the developing brain). The report outlines others and explores one example (altriciality) more closely to illustrate the potential of such an approach.

Committing to a European Human Mind Project will pose some challenges. The problems of bringing together researchers from across the natural and social sciences is surmountable. But the objectives of such a colossal program will always be one step beyond our reach – in contrast to the Human Genome Project, we will never arrive at a point where the study is complete. Still, the potential benefits of establishing a Human Mind Project are very great and surely make it worth the effort. What's more, scientific developments mean that now is the time to act. If Europe does not take the lead then the US or Japan is bound to do so. This is a major opportunity to radically improve our understanding of what makes our species so extraordinary. In the process, it will change the way we think about ourselves and how we live our lives in the 21st century and beyond.

WHAT IT MEANS TO BE HUMAN: Expert Group Report

The principal recommendation of this report is for the creation of a Human Mind Project to complement and build upon the achievements and discoveries of the Human Genome Project. The aim of the Human Mind Project is to promote interdisciplinary research on what it means to be human.

The report is divided into six sections. Section I (The Human Mind Project) explains why a powerful new collaboration is required to advance our understanding of human cognition and behaviour. Section II (Two Cultures?) explains why the time is right for natural and social scientists to collaborate in studying the human mind. Section III (Research at the Cutting Edge and Beyond) highlights important recent breakthroughs in the study of the human mind, and speculates on what could be achieved within the next 10 to 15 years with a collaborative approach. Section IV (Crossing Boundaries) suggests some overarching themes that might form the basis of interdisciplinary studies, and presents a case study to illustrate the potential of research that falls outside traditional scientific disciplines. Section V (Bringing It All Together) outlines the instruments by which the Human Mind Project could be pursued. Section VI (Implications) explains some likely public policy benefits of a Human Mind Project. There is also an appendix (An Extraordinary Brain) outlining distinctive features of the human mind that will be the central focus of research within the Human Mind Project.

I The Human Mind Project

It is a century and a half since Charles Darwin shone the spotlight of science on the question of what it means to be human. His theory of evolution by natural selection put *Homo sapiens* firmly within the realm of nature – defining our species as an animal subject to the same biological laws as any other. Darwin's ideas were radical in his time, and remain so to some. But today, most people do accept that humans are a part of nature, evolved through natural selection, and open to investigation by means of scientific analysis. Nevertheless, most of us also believe – with Darwin – that humans are not quite like any other animal. Our ancestors may have started out as just another ape, but along the way, we evolved an extraordinary mind, capable of self-awareness, of producing tools and language, of worshiping gods, feeling complex emotions such as gratitude, guilt and remorse, appreciating art, proving theorems and creating a marvelous variety of cultures. This mind is the core of our species' uniqueness and the essence of what it means to be human.

Our modern understanding of the human brain and mind has come a long way since the 19th century. We now know much more about the gross and molecular structure of the brain, which particular areas are associated with mental attributes such as emotions, planning, language and our senses, and how brain cells function. In recent decades, advances in technology have led to an explosion of interest in, and understanding about, cognition. Scientists can now watch single brain cells in action. Brain imaging technology allows them to see how the entire brain of human subjects responds in a wide variety of situations. They are able to pinpoint many of the genes involved in brain development and functioning and assess which proteins are being produced in the brain. And rapid advances in computing have been put to great effect in the modelling of many aspects of the human brain and mind, beginning at the molecular level and going all the way up to high level aspects of behaviour and consciousness.

Ironically, while we are starting to understand the unique human mind, it is also becoming increasingly apparent that in many ways our species is not so different from other animals. Our brains are undoubtedly large for an animal of our size, but they follow the same basic structural plan as that of any other mammal. Even more strikingly, our DNA differs from that of our closes evolutionary cousin, the chimp, by less than 2 per cent. Any notions that our unique attributes might be the result of humans having more genes than “lowlier” animals has been conclusively rebutted by the elucidation of the human DNA sequence (or genome). Before researchers in the Human Genome Project published the first draft of our genetic sequence in June 2000, the clever money had bet on humans having around 100,000 genes. It turns out we have a paltry 30,000 or fewer. Working out which stretches of the genome constitute genes (the DNA that codes for proteins) is tricky, but some estimates put the figure as low as 20,000 – which would mean scientists (and the rest of us) have substantially fewer genes than their favourite experimental lab plant, the simple mustard weed. It is clear that human sophistication does not lie in superior numbers of genes. So what is the key?

It seems that it is not what we’ve got but how we use it that counts. Our genes may be very similar to those of apes, but it is becoming increasingly apparent that the way genes work is far more complex than geneticist had expected. A single gene almost never functions except in conjunction with other genes and with the rest of the environment in which it is expressed. The implications of this insight are enormous. Arguments about what it means to be human have traditionally been couched in terms of nature versus nurture – or, more crudely genes versus environment. Indeed, those who believe that individuals become what they are through life’s experiences (the nurture camp) were concerned that efforts to decode the human genome would give the upper hand to those who argue that we are primarily the product of our genes (the nature camp). In fact, the Human Genome Project has taken us beyond genetic determinism, making it apparent that nature and nurture are intimately entwined. Our genome does not dictate who we are or how we will think and behave, because the function of genes is intrinsically bound up with the environmental context in which they are turned on and off.

Such environmental influences are not confined to human genes, all organisms experience them. But the role played by the environment has an added dimension in our species because our unique mental abilities allow us to shape our own world. We live in a world of ideas and artefacts that have been forged in the human mind. To a far greater extent than any other animal, we construct our own environment through culture. In addition, because human babies are born unusually immature and helpless, and because we continue to develop and learn throughout our lives, our physical and social environment is particularly influential. This feedback between our internal and external worlds is central to the human condition. On the one hand, our species has evolved like any other animal through a process of natural selection that favours individuals who are best suited to their environment. On the other, we have evolved an extraordinary mind that allows us to continually create and change our environment. As a consequence, you cannot understand the human mind without considering the environment that it shapes and that, in turn, shapes it.

This realisation is now permeating the study of the human mind in a wide variety of disciplines. Geneticists are starting to work out how environmental factors influence gene expression. Neurobiologists are using new technologies to probe how a brain develops, and see how it is shaped by its social and physical context to become a mind. Increasing computing power is helping cognitive scientists and modellers get to grips with the complex processes involved in reasoning, learning, decision making, and so on. Students of animal behaviour have started to study culture and other traits that were once thought uniquely human, shedding light on their origins and evolution. Researchers with an interest in human behaviour are increasingly trying to understand it in terms of our evolutionary and cultural contexts. Those concerned with the history of mankind, both from the paleoanthropological and modern historical perspective, have amassed huge amounts of data about the changing cultural environment in which our ancestors lived. And philosophers are increasingly interested in issues of mind/brain and consciousness.

We have reached a stage where we are starting to see how the pieces of the puzzle fit together. Many researchers, working in their own separate disciplines, have created a platform from which we can build into the future. Now they must work together to raise a palace from these foundations. What we need now is a powerful new collaboration between natural and social scientists, a “Human Mind Project”, to pull together and extend the tidal wave of research in this area. If we do commit to such a program there is a real possibility that in the next decade or two we will come to a scientific understanding of how, in the evolutionary blink of an eye, the human mind came into existence, and how this mind has shaped the nature of our species and of the world we create and inhabit.

This Human Mind Project will be a very different challenge to the recently completed Human Genome Project. While that endeavour was mostly technical, with machines automatically sequencing the DNA, this new project will require great intellectual courage and ingenuity to integrate what we already know and to synthesise new findings. But an investment now in improving our understand of what the human mind is and where it comes from, will have huge payoffs in the future. Many of the problems (and opportunities) humanity will face in the coming years will not be met simply with technological fixes. We will also need to change our thinking and our behaviour if we want to create a better world out of this overcrowded, polluted and bustling global village we now inhabit. An increased knowledge of the human mind will give us the power to make these changes.

II Two Cultures?

Despite the fact that the natural and social sciences rest on the same fundamental principles of logic and systematic observation of the physical world, strong forces continue to keep the two cultures apart. Changing the status quo is an enormous challenge. But it is a challenge that must be faced if we are to make real progress in understanding how the human mind evolved and what shapes it today. Fortunately, there are signs that the time is ripe for change. Some of the historical differences, as they apply to the study of human nature, are actually diminished by recent developments on both sides of the divide, raising the prospect that the next decade will see real progress on this old problem of integration.

Natural scientists, for example, are very much aware that the reductive program of DNA sequencing needs now to serve as the platform for synthesising activities. Evidence for this change in thinking can be seen in the movement toward “systems biology”, which aims to integrate vast amounts of data about biological systems so as to understand how they work. The change can also be seen in a growing interest in how a human genotype (a person’s genetic blueprint) becomes translated into the phenotype (what that person actually is and does). Another approach that has particular relevance to the study of human behaviour and social interactions is a type of computer modelling based on a branch of physics called dynamical systems theory. Such models allow researchers to link small- and large-scale events by looking for patterns that emerge out of complex and seemingly random interactions. As natural scientists become more interested in building bigger pictures, their approach becomes more attractive to the many social scientists who have problems with the notion of reductionism.

Social scientists, meanwhile, are now in a position to use the new information coming out of genetics, neurobiology and other natural sciences to explore how the evolved human mind shapes and is shaped by the diverse human cultures they observe. A recent move away from postmodernism is allowing researchers to see their studies as part of a larger scientific endeavour. Where postmodernism promoted the destructive theory of subjectivism in historical and social scientific research, the new thinking is more integrative, encouraging analysts to look at large bodies of data and try to synthesise the evidence into a meaningful whole. In addition, the philosophy of mind, is currently one of the liveliest parts of philosophy, in terms both of the amount of work published and of the number of research postgraduates working in the area. It is one of the few branches of philosophy that attracts the interest of the broader academic community and the public as a whole – as evidenced by regular press coverage of debates about the nature of consciousness, the possibility of computers thinking and the relation between mind and brain. Moreover, researchers in several empirical disciplines are coming to realise that the work of philosophers is directly relevant to their own researches.

Accepting the challenge to embark on a truly interdisciplinary Human Mind Project will require courage on the part of researchers, and financial commitment from society as a whole. But both social and natural scientists have everything to gain by breaking their isolation from each other, by starting to believing that science is not a question of choosing one perspective, and then ceasing to listen to the other side. Only then can they hope to integrate the new findings about how the mind works into a comprehensive understanding of human nature and what it means to be a highly social, cultural species.

III Research at the Cutting Edge and Beyond

As a small group with limited time, we cannot hope to give a comprehensive overview of research in this enormous field. What we can do, however, is highlight some of the key breakthroughs in recent times upon which the Human Mind Project would build. We can also speculate on exciting prospects in the next 10 to 15 years, identifying areas that seem ripe for interdisciplinary studies as well as those where insights already gained in one academic field could help to further research in another. The opportunities are immense, but as the section below illustrates, research within the Human Mind Project is likely to fall within five broad thematic areas.

§ The genetics of human cognition – how our species, despite its remarkable genetic resemblance to other apes, has evolved and sustains such an extraordinary complex mind.
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Genetics

The obvious and major advance here has been in the sequencing of the human genome, which was completed in 2003. Now we know the exact order of the 3 billion bases (A, T, C and G) on the 23 pairs of chromosomes present in almost every one of our cells. We have a pretty good idea of which stretches of DNA constitute genes (a mere 5 per cent) and which regions lie outside genes. But the job is far from complete. Even now, estimates of the total number of human genes range between about 20,000 and 30,000. This number will undoubtedly be refined over the next few years through ongoing work sifting through the sequence to look for clues about where genes start and end, and how widely-distributed stretches of DNA might work together to produce proteins. We will also achieve a better understanding of individual genes themselves – at present we only know the proteins that are encoded by half of the identified genes. The regions of DNA outside genes hold even more mysteries. It has become apparent that some are involved in turning genes on and off, but it is far from clear how they interact with other such regions, the genes themselves and the wider environment. A fuller picture is bound to emerge in the next decade. Likewise, there will surely be advances in our knowledge about the function of the rest of the non-coding or "junk" DNA, which constitutes the vast majority of our genetic material.

Genetic analysis is about much more than the sequences of bases. If you want to understand what makes an animal tick, you need to know what proteins individual genes make and under what circumstances the genes are active. Much work is currently being done in the field of "gene expression". One upshot of this is a realisation of the staggering complexity of the process by which sequences of bases on a chromosome are converted into proteins in a cell. It has become clear, for example, that a single gene can produce different amounts of a variety of proteins depending on the circumstances under which it is activated. Ongoing work will improve our understanding of the complex environment in which genes are expressed.

While some geneticists work to improve our understanding of what the genome of our own species means, others continue to churn out data about the genetic sequences of other organisms. Of particular interest here are the genomes of closely related species. Now we have draft sequences of the chimpanzee (our closest living relative, with which we share a common ancestor somewhere between 5 and 8 million years ago) and the more distantly related macaque. Other primate genomes are currently in the pipeline and will be completed over the next few years. Progress in understanding the differences between our own species and other primates will come through collaborative work between genome analysists and researchers studying physiological and behavioural traits such as vision, hearing, language acquisition and social interaction. Comparisons between the human and chimp genomes should allow us to identify most, if not all, the genetic changes that have occurred since our two species went their own separate evolutionary ways. We can then design models of the evolutionary process and find the DNA sequences in our genome that have evolved faster than would be expected. These are the genes we are interested in – the genes that evolved because of the advantage they conferred on our ancestors.

We already know that around half of all the human genes identified to date are expressed in the brain. This knowledge is made possible by a recently developed technology known as microarrays (or genes on chips), which allows researchers to assess whether the particular genes represented on a given microarray are expressed in a given sample of tissue. Development of this approach in the coming decade is likely to allow geneticists to discover the full range of genes being expressed in single neurons. And, provided the techniques can be made minimally invasive, the new technology will allow researchers to build a picture of the physiological processes taking place in the brains of humans, and other animals, while they are in the act of thinking.

Neurobiology

Very rapid progress in understanding how the brain works is being made possible by the development of techniques that allow neurobiologists to look at the workings of single cells *in vitro* and by imaging technologies that give pictures of the brain in action. The brain is turning out to be even more complex than we expected. What is particularly surprising is just how plastic it is, with neurons able to modulate important aspects of both their structure and function. This is obvious during development, but until only a few years ago, experts thought that humans do not generate new neurons after birth. It is now clear that even in the adult brain neurons do divide in a few areas, and that in general the structure is far more dynamic than had previously been assumed. These findings have led to great interest in the study of the mature brain, and in how brains age. In addition, neurobiologists are becoming increasingly aware of the role played by the external (and internal) environment in brain development during maturation and learning. This is an area of neurobiology likely to get increasing attention in coming years, with neurobiologists teaming up with geneticists and experts in human and animal behaviour to study how environmental stimuli affect gene expression and to extend their current knowledge from laboratory animals to humans.

Neurobiologists are already employing new technology to considerable effect. Electroencephalograms (EEGs) which record the brain's electrical activity by means of electrodes attached to the scalp have been around for many years, but advances in high resolution recording from multiple discrete brain areas are now allowing researchers to get a better picture of the brain in action. Analysing the data from such studies is notoriously difficult, but a rapid increase in computational power, coupled with blossoming interactions between neuroscientists and computer scientists promise exciting developments. Progress here is likely also to contribute to the development of a new generation of computational models of neural circuitry.

Magnetic resonance imaging (MRI), is probably the best known technique for brain imaging. It has provided many fascinating insights into the workings of the human mind/brain in the past decade and is likely to remain an important tool, particularly when employed in conjunction with animal studies. MRI indicates, for example, that a type of brain cell called a mirror neuron, discovered only a decade or so ago, plays an important role in our ability to empathise. But MRI has its limitations. The images it produces are not a direct representation of activity in brain cells, but instead measure the amount of blood flowing to various brain regions. Blood flow is considered a proxy for activity because the more active a neuron, the more blood it will need to provide oxygen to generate energy. The downside of this indirect approach, however, is that MRI is neither fast enough nor accurate enough to pinpoint neural activity when and where it actually happens.

There will doubtless be improvements in MRI resolution in the coming years, but more promising still is the prospect of advances in imaging technologies that measure neuronal activity directly. At present such techniques are highly invasive, but developments could allow them eventually to be used in higher animals and even humans to record millisecond-long events at the level of a single neuron. This would have two extremely important consequences. First, it would provide a whole new way of directly investigating specific brain functions such as memory. Comparative studies between humans and other animals would be essential here to identify similarities and differences. Second, such technology would allow “real time” analysis of complex processes such as the ever-changing connections between neurons.

A final important field where neurobiologists are likely to achieve progress is in the imaging of well characterised brain pathologies. In many cases the importance of such studies is purely medical. Others, however, offer new opportunities to understand developmental and structural properties of the brain. Studies of people with ADHD (Attention Deficit Hyperactivity Disorder), for example, give insights into decision making and risk taking. And imaging the brains of people with autism could tell us much about the neural basis of social and antisocial behaviour.

Cognitive Science

A distinctive feature of cognitive science is that it entails modelling at many different levels, forcing researchers to address the operations of whole systems as well as analysing their parts. In recent years there have been great advances in computational agent modelling, in which communities of agents have to communicate with each other. One important question that arises is at what stage this communication approaches the kind of communication of which we are capable. Human communication requires that we recognise each others’ intentions, and interpret each others’ communications in the light of them. As a result, humans are capable of complex mixtures of cooperation and competition. Existing agent systems have contributed many insights to this question but they have not yet incorporated this recognition of intentions. This will be an intensive area of research in the coming years.

Another area of cognitive science that lends itself to modelling is reasoning. Here information engineering approaches, such as artificial intelligence, interact strongly with analytical cognitive science and neuroscience. Traditionally, classical logic treats reasoning as a single homogenous process. A more recent and alternative perspective is that there are many logics for many reasoning purposes (reasoning about what is the case, what ought to be the case, and what possibly can be the case, for example). These non-traditional logics do not simply indicate how we ought to reason but also describe how we actually do reason. A multiplicity of logics raises the issue of the multiplicity of human interpretation – the very same sentence can have a multitude of meanings and the hearer must divine what the speaker is trying to achieve. Models based on multiple logics offer a way of imposing constraints on interpretations. By identifying strong constraints within each type of logic, they may reveal how we decide which interpretation is most reasonable. Researchers who engineer computing systems that process language have taught us much and will continue to provide new insights in this area.

A related issue in current cognitive science is the debate over whether human cognition is domain specific or domain general. The “specificity” camp sees human evolution as the addition of a thousand new modules each reasoning in its own way depending on what we are thinking about. We have one module for doing reasoning about exchange, one for reasoning about danger and precautions, one for folk biology, another for folk physics, and so on. But evolution usually progresses through adjusting the purpose of something that is already there, so the idea that whole new modules have been added over time is rather implausible. What’s more, the domain specific view doesn’t fit with the observation that human cognition is characterised by making connections and thinking about the same problem in a variety of ways. The alternative “generalist” view is that we do have many ways of reasoning, but that each is abstract (not dependent on what we are thinking about), based on earlier ancestral abilities, and not necessarily implemented as separate modules. This debate is set to run and run because it has important practical implications. It is, for example, very closely related to educational policy. Does each academic subject fit within a separate domain, or are there key reasoning skills that cut across them and can aid in learning new ones? The rhetoric tends to be of the latter kind; the practice of the former.

Cognitive scientists have also been concerned with the question of whether there is some central overarching system of reasoning about how to reason. In other words, when faced with a variety of ways of thinking about a particular situation, how do we choose a good one? The answer, it seems, is not that we have a homogeneous generalised higher-order logic, but rather that extensive learning of a lot of representational skills allows us to transform new problems into ones that we know how to solve. Understanding how we do this, has far-reaching implications. Much of human reasoning can be thought of as finding good representations of problems. We tend, for example, to design our environment using representations of problems that make them easy to solve – from bus timetables to equations. The potential gains in understanding how people reason and learn about how to represent things are huge.

Human Behaviour Sciences

Modern psychologists have provided insights into a wide range of human behaviour from celebrity worship and consumerism to racism and the ways in which we deal with our knowledge of mortality. Many of their experiments are ingenious and rigorous, providing a wealth of data about the human condition. These findings are, however, rarely considered within an evolutionary context – questioning how and why we came to think in certain ways. That has been left to the evolutionary psychologists, a group derided in some quarters because of their discipline’s associations with modular mind theories (see Cognitive Science, above). In Europe, however, many researchers have abandoned ideas of modularity in favour of mental connections and cultural and ecological influences on human evolution. And, at their best, evolutionary psychologists take a truly interdisciplinary approach to understanding how we became human. They have been instrumental in bringing together teams including anthropologists, psychologists, archeologists, geneticists, linguists, economists, mathematicians and others. This trend is particularly striking in the UK, where there are several large collaborative ventures including the British Academy Centenary Project, “Lucy to Language" and the Centre for the Evolutionary Analysis of Cultural Behaviour, which aims to be a global "hub" for the evolutionary analysis of culture.

Neuroeconomics is another new approach fostering integration between the social and natural sciences. Economists have long realised that people are not always motivated by a desire to get the biggest possible payoff, now neuroeconomists have started to investigate what really does motivate us. They often use a branch of mathematics called game theory. Experiments based on playing highly orchestrated games for real money have, for example, been used in cross-cultural studies to show that what people perceive as "fair" is not universal – as had previously been thought – but depends on the cultural context in which we live. Game playing is also being used to probe the uniquely human trait of strong reciprocity (giving without any prospect of return) – which in turn has led to evolutionary computer modelling to investigate the purpose of human altruism and how it might have evolved. Game playing experiments are being combined with brain imaging (MRI) to see what's going on in the brain when we behave in different ways. For example, the reward centres of the brain have been found to light up when we cooperate. And one very recent study combined this approach with the a physiological experiment to reveal that people given a sniff of a naturally occurring hormone called oxytocin become more trusting.

Such research is not without its detractors. Some people describe scientists who use brain imaging to probe human behaviour as the "new phrenologists", others fear that they will develop sinister forms of mind control. Certainly, for real enthusiasts, the radical prospect for neuroeconomics lies in identifying factors that influence and motivate us, and working out how these motivators are affected by a wide variety of environmental conditions, such as an individual's emotional state or cultural background. Although this could point to ways of influencing people's decisions and actions, the shear complexity of the human mind makes fears of mind control unfounded. Nevertheless, in the future, findings from neuroeconomics may help policy makers interested in persuading people to adopt healthy lifestyles, improving industrial relations, encouraging children to learn, or even minimising institutional corruption.

Another approach to understanding human behaviour that has become increasingly influential in recent years stresses the importance of "fast and frugal heuristics" (mental shortcuts that provide quick and usually satisfactory solutions to problems). Research into heuristics brings together insights from various disciplines. The mental short-cuts themselves are based on distinct mental biases, long recognised by psychologists. There is also a strong emphasis on the environmental factors that affect decision making, combined with an evolutionary perspective of why the human mind works well in certain situations and not others. Studies in heuristics highlight the important role played by emotions in decision making. They also suggest why we often make good choices based on very little information, why we tend to be very bad at interpreting statistical information, and even why our limited short-term memory helps us think well on our feet. The heuristics approach may offer practical solutions to problems such as the best way to persuade people to invest in pensions and how to present public information so that it will be meaningful to people.

Animal Behaviour

Perhaps the most exciting development in ethology in the past decade has been the move to analyse aspects of animal behaviour that were previously thought to be exclusively or largely human. New inroads have been made, for example, in understanding cultural variety in primates and in other animals including cetaceans (whales and dolphins) and social birds. Nobody is arguing that non-human animals have high culture – as exemplified by our music, literature, art and so on – but the most intelligent and social ones do have certain aspects of culture that are helping us define human culture and understand the processes involved in becoming cultural and sustaining culture. While studying animal “proto-culture” researchers have also come across instances of innovation, which provide insights into how cultures change, and how they endure – key concepts in understanding our far more complex human culture.

Ethologists working with social animals have also made considerable progress in understanding the sorts of cognitive abilities required for group living. Play, for example, seems to be crucial for the mental development of social animals. Studies looking at the simplistic “morality” of non-human animals highlight the importance of rules and mores in establishing cohesive groups. Investigations of animal “personalities” indicate the costs and benefits of different behavioural strategies – bold animals for example may get more food and better mating prospects, but they are also more likely to be eaten – providing a springboard to understanding why evolution favours behavioural variety rather than conformity. Studies of the emotional lives of animals encourage us to reassess the role played by our complex emotions – such as love, disgust, grief and shame – in our successful functioning as the ultimate social animal.

Another key area of progress in ethology is in the study of theory of mind or “mindreading”. This ability, to understand that another individual can have different beliefs, desires and intentions to your own, develops in human infants at about the age of three or four. Experiments with chimps suggests that they too understand this by the time they reach adulthood – although the findings are contested by some. Even accepting that chimps do have theory of mind, their mindreading abilities are minimal compared with those of humans. Animal studies are revealing that theory of mind is central to many distinctly human traits including language, deception and cooperation. Without it there would be no movies, theatre, literature or visual arts.

One potentially fruitful development in the work on theory of mind is its extension to include the study of dogs. Compared with chimps, dogs brains are much smaller and much less similar to ours. Yet, dogs are often better at mindreading than primates. What dogs do share with us (and have done for perhaps 135,000 years) is the domestic environment – both species have undergone similar selection pressures to survive and thrive in the same largely man-made physical and cultural environment. Dogs’ skills at some of these cognitive tasks indicate that the social environment is crucial in the evolution of theory of mind. Although dog brains are very different from human brains, the way we think can be remarkably similar. It seems likely that in coming years, comparative studies between humans, dogs and chimps will give new insights into the evolution in our ancestors of cooperation and other traits connected with sociability.

Collaboration between ethologists and geneticists will allow them to identify genes associated with particular behaviours, and look for genetic variation between humans and other primates, and between primates and other animals with which they share behavioural or cognitive abilities. Brain imaging also presents exciting prospects for cross-disciplinary studies. In the next decade it seems likely that researchers will use imaging technology to compare the active brains of human children and adult chimps. Ethologists working with economists and game theorists will devise experiments to test and compare the cognitive abilities of humans and animals, looking at behaviours such as cooperation, trust, deception, learning and memory. With improved technology, imaging might also throw new light on the differences between humans and other animals in their modes of thought. It could help us understand, for example, how the human mind excels at creativity, formalisation, making connections and concentration.

Paleoanthropology

Recent years have brought some exciting new fossil finds, as well as major advances in our knowledge of past environments and the chronology of human evolution. This progress in field research has gone hand in hand with a revolution in analytical technology and, in particular, the rise in the past two decades of what is now commonly called "virtual paleoanthropology". Here, medical imaging techniques such as X-ray computed tomography and industrial imaging technology are increasingly being used in conjunction with stereolithography and other 3D printing methods, to create virtual representations of specimens. This has opened new possibilities for the analysis the remains of individuals from our family tree, the hominins.

The new technology is allowing the systematic study of the anatomy of fossil hominins using virtual representations rather than by scrutinising the original specimens. Researchers can reconstruct virtual body parts even from damaged or distorted fossils. These methods have also been used in the analysis of inaccessible internal structures and organs, which can then be compared with similar structures from extant humans and primates. To date, such studies have including analysis of the intricate working of the inner ear, and the recreation of entire brains based on scans of the inner contours of skulls. In addition, virtual representations can be manipulated using mathematical models to yield further information about structure and function (including the stresses that various body parts would have experienced during life), and to build up time series' showing how they would have developed and matured.

In coming years research is set to focus more on the biology of our ancestors. Already there is much interest in the differences among various hominin and primate species in the timing and pattern of growth and development processes throughout their lives. The best way to assess these life history traits in extinct species is through detailed analysis of growth markers in the microstructure of ancient teeth. Such studies provide a powerful mechanism to understand evolutionary change and have become increasingly popular in recent years. They are illuminating many aspects of hominin life history, including the evolution of the teenage growth spurt, prolonging of childhood, the post-menopausal stage in women's lives and longevity in general. Paleoanthropologists are also becoming increasingly interested in prehistoric demographics because of what population structure and size say about the biological and social adaptations of ancient species, and about the role of learning and cultural transmission of knowledge.

Another way to study the lives of our ancestors is through the chemical analysis of fossil remains. There have been considerable advances here, too. Most of the work involves the extraction of organic molecules, with DNA and the protein called collagen being the main targets for researchers to date. Analysis of stable isotopes such as oxygen, nitrogen and carbon in collagen extracted from bones provides essential information about the environment and diet of these individuals during their lifetimes. Analysis of ancient genes is more problematic because DNA does not preserve well – sequences tend to become totally undecipherable after a few tens of thousands of years. Nevertheless, paleogenetics has added an entirely new dimension to the analysis of relationships among fossil hominin species, revealing for example that Neanderthals are a side branch in hominin evolution rather than a direct ancestor of modern humans. New approaches to analysing fragmented genetic remains will doubtless turn up more surprises in the future.

To make sense of the fossils they find, paleoanthropologists take a keen interest in human variation. Working with geneticists and population biologists they are building a picture of how various human anatomical features vary with age, sex, geographic origin and so on. But, while focussing on human variation, their primary interest is in our shared origins. As such, findings coming out of paleoanthropology have the potential to be used to fight intolerance, prejudice and racism in the coming years. These findings also have very practical potential to inform the way we design our world. It seems likely, for example, that paleoanthropologists will increasingly collaboration with business, using their understanding about evolved human anatomy to contribute to the ergonomic design of cars, clothes and machinery.

History

Since the late 1920s the two dominant traditions of thought in historical research have been the Marxist and the Annales (or French) schools, the later being derived from the former, with an additional influence from late 19th century anthropology. What they share is a desire to understand the causal relationship between the way humanity is influenced by "material" processes on the one hand, and social, ideological, political and psychological processes on the other. Both schools stress the importance of material conditions in shaping human destiny. But Annales historians emphasise the endurance of physical and geographical conditions as an explanation of stability and continuity in social phenomena, whereas the Marxist school has tended instead to focus on the significance of social and economic relationships as an explanation for long-term change.

During a postmodern interlude in the 1980s and 1990s many historians abandoned not only materialism but also any attempts to synthesise, seeing them as more or less fictional "master narratives". Recent years have seen a return to these issue, but now in a wider and far less doctrinal perspective than before. Worth mentioning in this context are so-called "world-system theories" which represent the amalgamation of the Annales and Marxist schools. Meanwhile, other historians less influenced by Annalism and Marxism have highlighted other material processes of crucial importance to human life. Some put the spotlight on microorganisms, others argue for the importance of climate change, and still others point to the geophysical conditions that were required to bring about the change from a hunter-gathering to a sedentary, agrarian lifestyle, such as access to plants and animals that would lend themselves to domestication.

One of the most important and influential achievements of the Annales school has been the notion of different tempi of social, economic and political change. Habits and manners that depend on climatic and environmental conditions (pastoral life, for example) change very slowly; socio-economic change is slightly faster; and political life changes most rapidly of all. By introducing this new perspective the Annales school has contributed to the reorientation of historical research from its concentration on rapid political change to slower economic and social change, and from a primary interest in élites to ordinary people. Marxist historians had made a similar mental leap, but where the Annales school differed was in adopting the anthropological idea of "mentalité" – the inertia of collective attitudes among ordinary people. So, while Marxist historians spent much of the second half of the 20^{th} century considering matters of economic and technical change, social processes and class struggles, Annales historians have expanded their interest outside the realm of economics. And by considering both the forces for continuity and those for change, Annales historians stress that to be human is not simply to be able to adapt to ever changing cultural conditions, but also to be constrained by them. In other words, in order to survive humans, like all organisms, must be flexible, but no too flexible.

In the next 10 to 15 years historical research on what it means to be human will have to focus on evolutionary processes of cultural change and continuity, on the historical mapping of cultural traits, on interplay between natural and cultural processes, and on the relation between innovation and learning for the understanding of how we build culture. This can only be done in collaboration with geographers, evolutionary biologists, archaeologists, evolutionary anthropologists and others.

Such a collaboration might, for example, allow researchers to use their shared interest in human diversity to compile a chronology of cultural accomplishments. Historians have documented wide variation between cultures in such areas as religious practices, political institutions, judicial and tax systems, aesthetic ideals, war technology, writing culture, and so on, recording both cultural change over time and variation between different societies at any given point in time. Evolutionary biologists and paleoanthropologists have tried to trace the emergence of such cultural practices and work out how they have changed the human evolutionary environment, so influencing further cultural and biological evolution. Only collaboration, however, will allow the systematic mapping of this knowledge. Mathematical modeling then offers a way to discover whether some of the observed paths of cultural evolution follow certain patterns representing a set of rules or laws of cultural evolution – analogous to the Mendelian laws of genetic evolution.

Modeling

From its origins on the fringes of science, modelling is increasingly becoming part of mainstream research. It is essentially about synthesis, making it an ideal tool with which to investigate the human mind. Modelling encompasses different levels of analysis from the neurobiological or network level, through the behavioural level, and the social level, to the evolutionary level. In recent years, it has become more abstract and conceptual – looking at how beliefs, desires and intentions influence behaviour, for example. Models of decision-making are increasingly popular. Another new development is models that link different levels of analysis.

Cognitive scientists have been at the forefront, embracing modelling and formalisation in their attempts to understand how we think. One approach is to use symbolic models to help in visualising various mental processes, rather than aiming to map what is actually happening in the neurons. Symbolic models have been used with particularly effect in efforts to understand cognitive architecture. They also include knowledge- and logic-based models created to simulate mental processes involved in the acquisition of knowledge and in the manipulation of knowledge during complex tasks. Non-symbolic models, on the other hand, work through a lower level analysis, aiming to represent more detailed processes. They include the so called "connectionist" and "neural net" approaches – models that represent information through a connected network of units. Non-symbolic modelling has developed strongly over the past 15 years or so, with the network approach playing a particularly important part in efforts to understand natural and adaptive processes and learning. More recently, another modelling approach has arisen based on a branch of physics called dynamical systems theory, which can be applied at many levels to model cognitive phenomena as state-determined dynamical systems.

The behaviours of individual people can be conceptualised at different levels of abstraction. At a high level, for example, they might be described in terms of goals or desires and plans or intentions. This is the level that deals with concepts such as emotion, feelings, consciousness, decision making and freewill, and it is also the one with which most people identify. The problem for modellers is that it is difficult to model concepts at this level of abstraction in a precise way. At a lower level of abstraction there have recently been major advances in our conceptualisation of physiological and neurological processes, stimulated by progress in scanning techniques. Modelling of interactions at the molecular and biochemical level is also developing rapidly. The challenge modellers face over the next decade is to see whether they can integrate insights gained at lower levels of abstraction to create models of high level processes that are solidly grounded.

When modelling social interactions, the outcome of such interactions depends crucially upon the behavioural characteristics that the modeller bestows on individuals. At the moment, these are kept rather simple and do not reflect any specific mental capabilities. This may change as we learn more about the cognitive, physiological and even genetic factors at the root of certain behaviours. For example, recent developments show that criminal behaviour correlates with many concrete attributes such as an individual's diet, brain function, genetic makeup and formative relationships. By incorporating such factors modellers can build bridges between the individual's internal processes and social interactions. The prospects of improving our understanding of how humans behave within a social framework make this an exciting area for future collaborative research.

In the past decade, modellers have developed techniques to simulate evolutionary processes. These include genetic algorithms, the computational equivalent of genes, and evolutionary methods such as "natural selection" whereby only the most successful or "fittest" individuals or algorithms make it into the next generation. In nature the process of evolution is about optimising the design of organisms to meet the changing requirements of their physical environment. As a consequence, these models are concerned with optimisation, and their potential has been recognised in many fields from product design to pharmaceuticals development. In addition they can give new insights into the evolution of human traits and behaviours. Increasingly, evolutionary models are also being used to investigate interaction between populations – how changes within one group initiate changes in another, and vice versa. Developments in this area will help to integrate the evolutionary perspective into the broader picture of what it means to be human.

Philosophy of Mind

In recent years, philosophers have made important contributions to the way in which we conceptualise issues of the mind and consciousness. The philosophy of mind and philosophy of psychology are among the most vibrant areas of the discipline, and there are increasing links between these areas and researchers in the cognitive and behavioural sciences. Research in this interdisciplinary domain has also begun to capture the public imagination and to be covered in the media. Capitalising on this momentum and interest in a way that will contribute to the Human Mind Project requires overcoming a number of institutional obstacles.

First, philosophy of mind and philosophy of psychology have become fragmented into a range of different traditions and approaches pursued largely independently of each other. Some theorists overlap to a large extent with the theoretical aspects of cognitive psychology. Others explore the structure and character of common-sense thinking about the mind. And yet others focus on the metaphysics of the mind – on general questions of how the mind relates to the brain, whether the mind is a different type of thing from the brain, and how what goes on in the mind can bring about changes in the physical world. These different approaches need to be brought into dialogue with each other. Second, the scope for philosophical study of what it means to be human is much broader than "philosophy of mind" and "philosophy of psychology" as usually conceived. Current research in other areas, such as moral philosophy, philosophical logic, and the philosophy of language is highly relevant. Again, a suitable framework is required if the relevant connections are to be properly brought out and pursued. And finally, more philosophers need to become aware that to seriously tackle some questions central to what it means to be human they must take detailed account of current research in the neurosciences, empirical psychology and cognitive science.

Despite these obstacles, the benefits of collaboration are clear. The following example illustrates how philosophy can make contact with other disciplines in the human and natural sciences to pursue issues directly germane to the question of what it means to be human.

Philosophers generally accept that many aspects of conscious mental life are guided by standards of correctness and rationality that are fundamentally different from the laws that govern the behaviour of physical objects. But what exactly are these standards? It seems plausible that the basic principles of deductive logic, together with some combination of decision theory and game theory, serve in some sense to define rational thought and behaviour. But little attempt has been made by philosophers, or indeed cognitive scientists, to investigate whether accounts along these lines are psychologically realistic. One challenge in doing this is to accommodate the extensive experimental work on recurrent errors in human reasoning and the non-standard reasoning heuristics that often explain them. Another challenge is to investigate whether these accounts of rationality contravene the computational constraints binding upon any psychologically realistic conception of rationality. A third challenge arises when one asks how theories of individual rationality can be applied in social situations. Considering the possibility of a model of rationality that meets these challenges will require bringing together work from the fields of computational complexity theory, decision theory, evolutionary theory and experimental psychology.

Other areas where similar collaborative research might prove fruitful include:

§ The relation between philosophical models of consciousness and explorations of different types of non-conscious awareness in scientific psychology.

§ The deployment of philosophical models of interpretation and psychological understanding to clarify debates about mind-reading in young infants and non-human animals.

§ Comparisons of the nature of explanation in folk psychology and scientific psychology.

§ The implications of philosophical work on the logic and epistemology of qualitative states (such as colour experiences) for the scientific study of these states.

§ The interplay between philosophical accounts of the norms of cognitive functioning and the ways in which those norms break down in psychiatric disorders.

§ The extension of philosophical accounts of the nature of thought to the types of non-linguistic thinking attested to by cognitive ethologists and developmental psychologists.

IV Crossing Boundaries

To get the best possible cross-fertilisation of ideas between the natural and social sciences, researcher must step outside the straight jacket of their traditional disciplines. One obvious approach in furthering our understanding of what it means to be human is to focus research efforts towards trying to understand one of the many characteristics that is either uniquely or distinctly human (as outlined in the Appendix). This is already paying dividends in certain areas including language and, more recently, studies of economic behaviour and of morality and spirituality. But with a little imagination it is possible to come up with a whole range of less obvious themes that might form the basis of productive collaborative research as part of a wider Human Mind Project.

These themes could include: adaptability/plasticity (exploring the limits of human neural, behavioural and social flexibility); the "phenotypic problem" (understanding how *H. sapiens*, a species that shares over 98 per cent of its genes with chimps is nevertheless so very different from its closest primate cousin); narrative (how we shape and make sense of our cultural and personal world through stories, gossip, propaganda, self-narrative and so on); freewill (exploring the constraints imposed by our genes, physiology, physical and social environment, etc, to come to a better understanding of the extent to which we are "free"); migration/colonisation (investigating the ways in which our species has been shaped by our move out of Africa, followed by world domination and now globalisation); demographics (how population size and structure has, and continues to, pose problems and opportunities to which we must adapt our behaviour); decision making (exploring how the choices we make are influenced by emotions, rationality, constraints imposed by our physical, social and cultural environment, etc). Below we outline an example of how one such overarching theme can integrate methods and insights from across traditional academic boundaries.

A case study: Infant helplessness

"Altriciality" refers to a distinctive aspect of human biology, namely that human babies are born helpless and at an early stage of development compared with other primates, so that they must spend many years as "apprentices", maturing and acquiring the skills needed to survive and thrive. This one biological characteristic has many and far-reaching consequences, both for the development of the human mind/brain and for the behaviour of individuals within society. The very earliest stages of brain development after birth, for example, include a period in which the newborn bonds with its carer – a process that is essential for the baby's future socialisation. Poor attachment at this stage has been implicated in antisocial and criminal behaviour later in life. Early influences on the developing brain also shape the way we see the world, affecting the way we think, reason and acquire language, and perhaps even the uniquely human trait of spirituality. As a result, a better understanding of altriciality has implications for learning and teaching. More generally, since our biological fate is to have a brain shaped by the environment in which it develops, research in this area helps to identify how social and physical environments interact to affect brain development.

No other animal is so helpless at birth as the human baby. While most animals are born when their brain reaches full adult size, human babies come into the world a full 12 months before this occurs. A newborn human's brain is just 25 per cent of its fully mature size. That may sound like a problem, but in fact it is a useful biological adaptation, which allowed our narrow-hipped bipedal ancestors to produce offspring with big brains and highly flexible behaviour. The fossil record of hominins, our own ancestral line, shows that there has been a tendency for adult brain size to increase over evolutionary time. But it is only after about 500,000 years ago, in our own species, that we observe a rapid increase in adult brain size in the absence of corresponding body size increases. How this came about, is a question that researchers might successfully begin to address in the next decade.

Technological advances within paleoanthropology are likely to give new insights into the steps involved in the evolution of a life history where infant helplessness is central. They will also help in identifying the environmental and cultural changes that accompanied this biological change. Because altriciality is a biological characteristic, evidence of its evolution will be in our genes, giving a record of what sorts of changes in growth rate, length perameters, etc, were involved. Progress in the analysis of genomes, and comparative genetic studies between humans and other animals are likely to provide key information here. It is also possible that analysis of ancient DNA from fossil hominins could play a part. Another approach is for researchers to consider the evolution other big-brained creatures including the cetaceans (whales and dolphins) and non-human primates. One potentially fruitful avenue of research would be a comparative study of brain evolution in hominins and cetaceans. Another is to find out more about some of the environmental conditions that were common to lineages that have evolved big, slow developing brains (omega-3 fatty acids, for example, which are important for brain development and come mainly from marine sources).

Comparative studies between humans and other extant animal species, looking at the size and developmental patterns of various brain regions, might help reveal what is unusual about brain development in modern humans. The shaping of brain (and mind) functions by the environment is a key issue in neurobiology. Here progress comes from classical approaches such as integration of animal and human studies, and from studies of human pathology including analysis of discrete diseases, temporary impairments of brain function and studies at the boundaries of normality. Over the next decade imaging techniques may improve to such a degree that they can be used to test, in humans, ideas arising from animal studies. Eventually it may even be possible to analyse the specific effects of various environmental stimuli on developing brains. Collaboration with modellers is likely to play an important role in understanding how maturation and learning work together to shape the developing brain. The process entails a complex mix of wiring up and pruning back of connections within the brain, which is likely to be affected by changes in the timing of brain development – as happens with altriciality. By extending and integrating their existing models of brain maturation and learning, modellers will start to reveal the consequences of human infants being born with such premature brains.

There is no doubt that infant helplessness has profound implications at the cognitive level – in explaining the way we think. A focus on altriciality, for example, may help in understanding how language evolved. Recently, several lines of evidence as varied as brain imaging and linguistic/logical analyses have suggested that language grew out of our ancestors' capacities for planning motor actions. Complex language requires the ability for recursion (the mental capacity to stack and unpack clauses so as to make and interpret complex sentence structures). The logic of action planning also demands recursion (for stacking goals instead of clauses), suggesting that the parts of the human brain that do language planning are an outgrowth of the parts of the ape brain that do action planning. What is novel is the our ability to externalise plans, allowing us to understand the communicative intentions of others. Altriciality played an important role in this final development because it produced an environment in which the interests of a mother and her infant are genetically aligned to encourage cooperation – an environment in which there is intense pressure to understand and predict each other. Human mothers and infants have biologically highly distinctive capacities for achieving joint attention, which in turn has dramatic impacts on learning.

The most important implications of infant helplessness are social, because the environment in which our brains are shaped are human environments. If the first thing a baby sees is a smile, and if social cues are central to its survival, this will shape the way it learns to think about the world. An infant with a very long period of helplessness experiences social control before it experiences much physical control. It learns to control adults by the use of its voice, before it can systematically control even its arms. The brain development mechanisms responsible are operating in an external world and a social world, where their counterparts would have been operating in the womb in our early ancestors. Philosophers at least since Nietzsche have suggested that many human uniquenesses from anthropomorphism to religion stem from exactly this changed situation of human infants. It is entirely possible that these speculations may be cashed out in precise characterisations of novel human maturational and learning mechanisms in the next 10 to 15 years.

V Bringing It Together

Even with a growing appetite for collaboration, there are still some very practical problems to overcome. Institutes and university departments are rarely multidisciplinary, and when they are, they tend only to integrate adjacent areas of investigation. As a result, mutual understanding among different areas of research can be very superficial and based primarily on indirect information. The problem of getting researchers from different disciplines into physical proximity is compounded by cultural clashes between disciplines. Scientists are inevitably focussed. Their background, criteria, tools, etc, are almost always quite different, so that scientists from different areas have problems understanding each other. Rapid progress within a discipline means high competition, which requires precise focussing on discrete problems, to be tackled using well known technologies. Studies outside familiar niches of knowledge are therefore discouraged. Evaluation of research for grant applications is made by specialists, who are usually reluctant to commit to projects that extend beyond their own knowledge and understanding. And funding is often precisely allocated to research within specified disciplines.

It will undoubtedly be a challenge to bring together researchers from different disciplines to pursue a European Human Mind Project. What is the best way to meet that challenge? One option is to set up new research institutes dedicated to cross-disciplinary studies into various aspects of what it means to be human. The benefits of creating successful centres along the lines of the Max Planck institutes are apparent. But such an approach is very expensive and rather inflexible, which is why we believe it is an option best considered at a later date when the Human Mind Project becomes more established in Europe. For now, instead, the aim should be to cultivate interest among the best scientists, to provide forums in which they can come together and to instigate funding initiatives that help them do collaborative research.

A series of conference – or even round-table discussions within conferences – on the subject of “What it Means to Be Human”, will spark interest in a collaborative European Human Mind Project. Once enthusiasm starts to grow, summer schools can be established to bring together international groups from a variety of disciplines. The obvious problem here is in securing the participation of good, senior faculty to run seminars and give lectures. The obvious solution is to make it worth their while both intellectually and financially. The result then will be a creative environment in which both established and up-and-coming researchers can share knowledge and ideas and make contacts outside their core disciplines.

Progress within the Human Mind Project will then best be served by a system of medium-sized, grant-funded research projects that bringing together researchers from several different disciplines and at least two European Union countries, for a finite period, with clearly defined aims and outcomes. Such a collaboration might take the form, for example, of a five-year project employing full-time postdocs and supporting a number of graduate students working with several senior faculty, seconded either part-time or full-time from their home institutions. It will also be helpful to fund a scheme of smaller research projects, involving perhaps just two or three researchers working together. Exchange programs that cut across disciplinary boundaries provide another channel for getting researchers together, although these will work best if they are structured and focussed. The internet can be used both to coordinate research efforts between networks of laboratories and to provide information about newly published research that will enable individual researchers to keep up to date with developments outside their own field of expertise.

Efforts to disseminate research arising from the Human Mind Project will be particularly important, not only because scientists who undertake publicly funded research should be accountable, but also because the subject of what it means to be human is of intrinsic interest to non-scientists. It is crucial that journalists, who act as go-betweens linking researchers with laypeople, do not distort the facts in pursuit of a good story. An effective way to educate mainstream journalists about the subtleties of scientific research and the scientific culture that produces it, is to get them into the lab to witness the processes in action. The Human Mind Project should consider funding such a program. Of course some journalists are extremely well informed already, and if they can be enthused by the idea of a Human Mind Project, they will be powerful allies in furthering the endeavour. Such commentators can not only increase public interest in the venture and understanding of its findings, but they can also keep policy makers informed about research relevant to their work.

VI Potential impact

Throughout the history of our species, advances in science and technology have continually changed our ideas about what it means to be human – and that process is speeding faster than ever into the 21st century. Some of these changes have been very rapid, yet we seem to have adapted with ease. Many of us cannot imagine going back to the days before the internet, for example. Other changes, such as genetic modification and nanotechnology, make some people distinctly uneasy. Likewise, a Human Mind Project will doubtless generate anger and alienation in some quarters, particularly among the increasingly vocal minority who reject Darwinian theory altogether, and among the many people who fear what science has to say about their thoughts and behaviour. Recognising this, we will need to be particularly careful about engaging with the public as we launch into this exciting phase in the development of our understanding. Scientists working within this program must accept that their research will have a strong social resonance that imposes an extra responsibility upon them to choose their objectives wisely and ensure that their findings are not distorted. Nevertheless, the prize that humanity can gain through a better understanding of itself is worth that added care. This area of science is particularly intriguing, important and beneficial precisely because it impacts on our everyday lives.

Findings from the Human Mind Project will have implications in almost all areas. For example, an increased understanding of how children learn and respond to different teaching methods, can be used to put education systems on a more scientific footing. A greater insight into what motivates individuals will present new, more direct ways to encourage people to change their habits. This will be crucial in tackling some particularly pressing problems such as how to persuade people to adopt a healthier lifestyle, or to investing in their own future through personal pension plans, for example. A deeper knowledge of our shared evolutionary history and our common human nature also has the potential to influence the way citizens think about themselves and others, making them more tolerant of people who seem superficially different from themselves, and so easing the tensions caused by racism and immigration. In addition, this collaborative research project will have an impact on society's attitudes towards criminal and antisocial behaviour, and allow policy makers to create more effective laws that are less at odds with our evolved human nature.

In the private sector, research within the Human Mind Project will inform decisions in the boardroom. CEOs keen to create a thriving corporate culture will benefit from multidisciplinary research looking at the ways in which the most successful human cultures handle information, motivate individuals to work together, and create rules that reinforce our better nature. Product designers will be able to capitalise on an increased understanding of evolved human psychology and neurobiology. Some companies are currently employing anthropologists to help them design technologies that are more user friendly. As we increase our understanding of how the human mind works, such input will become increasingly invaluable, particularly in the creation of intelligent machines. Improved models of how humans actually perform cognitive tasks will pay dividends in the design of new technologies, in our understanding of the human-computer interface, and, eventually, in the production of technologies that can be used to augment the cognitive capacities of individuals.

On a wider scale, a better understanding of the human mind and why we have evolved to think in certain ways, will help us come to terms with some of the most pressing issues humanity faces today. Technological fixes will not provide all the solutions, we will also have to learn to change the way we think and behave. Findings from the Human Mind Project will, for example, help us to identify and adopt the changes in behaviour that are necessary to address the biggest problems of all, such as global warming. They will also help us make the most of a shrinking world, so we will be able to benefit from our increasing interdependence with other people whose lives are very different from our own. Inside the global village, we can extend our natural empathy to a far wider group of people, improving our chances of living peacefully in a world of growing demand and shrinking natural resources. A more holistic view of human psychology within a cultural context will also improve our abilities to combat political corruption and resolve conflicts. And this research can help the developed world come to terms with the demographic transition that will result in increasingly older populations, not least because a better understanding of the aging brain is crucial if we are to successfully treat age-related illnesses such as Alzheimer's disease and dementia.

The successful collaboration between researchers who study the many aspects of the human mind, will have a profound impact on the way we live our lives and see ourselves. This research program is set to shake things up in the 21st century as much as Darwin's ideas did in the 19th.

APPENDIX

An Extraordinary Brain

A central objective of the Human Mind Project will be to increase our understanding of characteristics of the human mind that are either unique or qualitatively different from those found in any other animal. The most striking of these are:

§ Learning and memory – Our superior ability in these areas is not simply a factor of our big brains, it also depends on the way in which our neurons are connected. Brains are much more complex and plastic than we had expected. At present, neurobiologists have only preliminary information about how we learn and remember. Unlike other animals, most of human brain development occurs after we are born. This means that the way we think is shaped in large part by the environment in which we live.

§ Symbolism – Earliest evidence for symbolic thought – the ability to ascribe arbitrary meaning to things – comes from the Blombos caves in South Africa where, more than 100,000 years ago, people seem to have used red ochre as a body paint in rituals. The ability to understand the meaning of symbols, and to create representations of things that are not present, is essential for of complex language.

§ Language – Complex language is unique to humans, and the foundation of many other attributes. We still have little idea when it evolved – indeed scientists from different disciplines often have very different ideas about what exactly it is. Some experts think the capacity for complex communication originated with our own species, *Homo sapiens*, perhaps as early as 200,000 years ago. Others argue that the first real evidence for language comes just 50,000 years ago with the cultural revolution in Europe characterised by the original surge in human creativity, including cave painting and tool production.

§ Consciousness and self-awareness – Experts cannot agree on exactly what consciousness is, let alone whether we are the only beings that possess it. It seems likely that consciousness did not emerge *de novo* in our own species. But animal consciousness must surely feel different from human consciousness, and we may be the only species that experiences the mental sensation of self-consciousness – the feeling of being the protagonist in the film of our own life.

§ Innovation and creativity – Most animals evolve slowly, primarily through biological changes (genetic mutations) but humans are different. Our skills at creative problem solving mean we can adapt quickly to changing environments and, in turn, change our own world. Through imitation and learning we can transmit new ideas and techniques down the generations. This is the basis of cultural evolution.

§ Mind reading – Understanding that another individual may have beliefs, intentions, feelings and desires that differ from your own is central to being human. Other primates may be able to do this to a limited extent but they have nothing like the human ability to see the world from another's perspective. This is at the root of all our social interactions and is particularly important for the characteristically human attributes of empathy and sympathy.

§ Morality and spirituality – Highly social animals may have mores to help smooth the cogs of group interaction. Elephants even seem to have death rituals. But emotions such as guilt and regret are our preserve. In addition, our spiritual life is built on language, symbolism and the ability to envisage the world as other than we find it, and no other animal has these capabilities.

§ Trust and deception – Most human social interactions depend on trust. It plays a central role in everything from business and banking to sexual relationships and play. Although trust is a dominant force in human society, cheating can benefit individuals. Our species has a highly evolved ability for social manipulation known as “Machiavellian intelligence” which allows us to detect deception in others and sometimes to try to cheat the system of trust ourselves.

§ Reciprocity, altruism and cooperation – Economic life is based on our strong sense of reciprocity – you scratch my back and I’ll scratch yours. But humans also seem to be the only species on Earth that gives freely to non-kin without any prospect of a return. There is much debate about why we should do this – whether it serves some purpose in its own right (to consolidate group affiliation, for example) or whether it is an evolved trait that once had survival value but no longer does in our modern world.

FURTHER READING

Robert Axelrod, *The Evolution of Cooperation*, Basic Books (1984)
Robert Boyd and Peter Richerson, *Culture and the Evolutionary Process*, Chicago University Press (1985)
Luigi Cavalli-Sforza, *Genes, People and Languages*, Berkeley University Press (2000)
David Christian, *Maps of Time*, Berkeley (2004)
Patricia Churchland and Terence Sejnowski, *The Computational Mind*, MIT Press (1992)
Vilmos Csanyi, *If Dogs Could Talk: exploring the canine mind*, North Point Press (2005)
Daniel Dennett, *Darwin's Dangerous Idea: evolution and the meanings of life*, Simon and Schuster (1996)
Daniel Dennett, *Consciousness Explained*, Back Bay Books (1992)
Frans de Waal, *The Ape and the Sushi Master*, Allen Lane (2001)
Jared Diamond, *Guns, Germs and Steel*, W. W. Norton and Company (1999)
Robin Dunbar, *The Human Story: a new history of mankind’s evolution*, Faber and Faber (2004)
Gerald Edelman, *Wider Than the Sky: the phenomenal gift of consciousness*, Yale University Press (2004)
Paul Ehrlich, *Human Natures: genes, cultures and the human prospect*, Shearwater Books (2000)
James Gleick, *Chaos*, Heinemann (1988)
Clive Hamilton, *Growth Fetish*, Pluto Press (2004)
Eric Kandel *In Search of Memory: the emergence of a new science of mind*, (2006)
Kevin Laland and Gillian Brown, *Sense and Nonsense: evolutionary perspectives on human behaviour,* Oxford University Press (2002)
Stephen Pinker, *The Language Instinct*, William Morrow (1994)
Michael Posner and Marcus Raichle, *Images of Mind*, Scientific American Library (1994)
Matt Ridley, *Nature Via Nurture: genes, experience and what makes us human*, Fourth Estate (2003)
Joseph Tainter, *The Collapse of Complex Societies*, Cambridge University Press (1988)

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EUR 21795 — What it means to be human - Origins and Evolution of Human Higher Cognitive Faculties - High-Level Expert Group Report on a NEST PATHFINDER Topic

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The NEST PATHFINDER initiative on « What it means to be human » was launched in 2003. Following two calls for proposals, 17 projects have been selected for funding. These projects investigate the origins and development of human's higher cognitive faculties from a comparative and evolutionary perspective.

A High Level Expert Group was established in 2005 with the aim to examine, forecast and describe this emerging scientific field, its potential impact and future support needs of the research involved in this initiative. The present report summarises its findings and recommendations.

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