DEPARTMENT OF ECONOMICS

UNIVERSITY OF MILAN - BICOCCA

WORKING PAPER SERIES

Cognitivism and Innovation in Economics
Two Lectures

Brian J. Loasby

No. 77 - May 2004

Dipartimento di Economia Politica
Università degli Studi di Milano - Bicocca
http://dipeco.economia.unimib.it

COGNITIVISM AND INNOVATION IN ECONOMICS

Two Lectures

Brian J. Loasby
University of Stirling

Lectures delivered at the University of Milano-Bicocca and at the Bocconi University
on 13-14 October 2003

CONTENTS

INTRODUCTION

This issue of the Department W.P. reproduces two lectures by Professor Loasby organized by the CISEPS (*Centre for Interdisciplinary Studies in Economics, Psychology and the Social Sciences* at Bicocca) in collaboration with the IEP, the *Istituto di Economia Politica* of the Bocconi University in Milan. The first lecture was delivered at the University of Milano-Bicocca on 13 October 2003 and the second was staged the day after at the Bocconi University. The lectures are reproduced here together with a comment by dr. Stefano Brusoni of Bocconi and SPRU.

Two further comments were presented at the time by Professor Richard Arena of the University of Nice and by Professor Pier Luigi Sacco of the University of Venice. Both of them deserve gratitude for active participation to the initiative. Unfortunately it has not been possible to include their comments in the printed form.

In these lectures Brian Loasby opens under the title of *Psychology of Wealth* (a title echoing a famous essay by Carlo Cattaneo) and he develops an argument in cognitive economics which is based on Hayek's theory of the human mind with significant complements and extensions, mainly from Smith and Marshall. The second lecture provides a discussion on organization and the human mind. It can be read independently although it is linked to the former. Indeed, in Professor Loasby's words, "the psychology of wealth leads to a particular perspective on this problem of organization". The gist of the argument lies in the need to appreciate the significance of an appropriate "balance between apparently conflicting principles: the coherence, and therefore the effectiveness, of this differentiated system requires some degree of compatibility between its elements, but the creation of differentiated knowledge and skills depends on the freedom to make idiosyncratic patterns by thinking and acting in ways which may be radically different from those of many other people". This dilemma of compatibility vs. independence can find solution in a variety of contexts, as Loasby's analysis shows.

In his comments Richard Arena had focussed on the rationality issues, so prominent in Loasby's text. For example, he had suggested that the cleavage between rational choice equilibrium and evolutionary order offers ground to new forms of self-organization. Pier Luigi Sacco had emphasized that Loasby's approach breaks new ground on the economics of culture and paves the way to less simplistic conceptions of endogenous growth than is suggested by the conventional wisdom of current models. Unfortunately, as hinted above, is has proved impossible to include those comments in the present booklet along with Loasby's lectures. A special obligation must be recorded to Dr. Stefano Brusoni, who has prepared a written version of his own comment which has been printed in this booklet and can be offered to the reader. Among other participants Roberto Scazzieri, of the University of Bologna, Tiziano Raffaelli, of the University of Pisa, Luigino Bruni of Bicocca, Riccardo Cappellin of Rome 'Tor Vergata' and others were able to offer significant comments during the two sessions of the initiative.

The organizers are particularly grateful to Professor Brian Loasby for the active and generous support of the initiative. Together with our colleagues and students we have been able to admire his enthusiasm and intellectual creativity in treating some of the more fascinating topics of contemporary economics.

THE PSYCHOLOGY OF WEALTH

Brian J. Loasby

Cattaneo's Agenda for Economics

My title is taken directly from the opening of 'Del Pensiero come Principia d'Economia Publica' by Carlo Cattaneo (2001 [1861]); and there is nowhere more appropriate than Milan for a celebration of his work, which has recently been republished together with an English translation. For this audience the presentation of Cattaneo's argument in his essay of 1861 is probably superfluous – except in providing a stimulus to a discussion and development of his ideas in this session; but Cattaneo is not, I believe, at all well known outside Italy, and so some publicity may be as useful as it is deserved.

Cattaneo's purpose was to advocate a fundamental reorientation of economic study. Hitherto, he observed, scholars had successively investigated the contribution to production of natural resources, the work of man (especially as rendered more effective by the consequences of the division of labour), and capital. This analysis Cattaneo described as the physics of wealth; but he noted (as has since been regularly rediscovered) that even if these productive forces were equally available across nations, output could nevertheless differ substantially between them. These differences in productivity he attributed to differences in the application of intelligence and will. It was therefore time for scholars to devote themselves to this new step – to refocus from the physics to the psychology of wealth (p. 49).

It is a depressing commentary on the history of economics, and a salutary reminder of the importance of the ways in which economists have applied their intelligence and will to their own subject, that the call for such a reorientation is still appropriate today – not, I am sure, for this audience, but in relation to the bulk of work in economics, which still seeks to deduce outcomes directly from convenient specifications of the productive forces of land, labour and capital, and to cope with the repeated discovery that apparently similar productive forces can produce very different results by redefining them. 'Human capital' is a very good example, and particularly apposite to this session: it is treated as an augmentation of capital, but the particular ways in which it affects the productive process and the outputs delivered by this process are left out of focus. In particular, no attention is paid to the role of intelligence or will either in the process of decision-making or in the conduct of productive activities. To do so would call into question the analytical reliance on 'rationality', either in the instrumental sense of a precise means-ends relationship or in the now-dominant methodological sense of internal consistency.

Of course, this characterisation of economics does not apply to everyone, either now or in the 140 years since Cattaneo's essay was published; and in this paper and again tomorrow I shall be relying on the work of some extremely distinguished economists, none of whom, as far as I know, drew direct inspiration from him. Cattaneo (pp. 51-3) argues that the reorientation which he is advocating entails a relatively small transition from the work of Genovesi and Adam Smith, whose

recognition of the means by which the division of labour generates improved skills and better practice brings one to the borderline between physics and psychology. However, in observing that Genovesi and Smith were particularly well equipped to cross that borderline because both were philosophers with interests in psychology (which was a familiar combination in their time), he seems to recognise the difficulty of doing so. Why they failed, he suggests, was because they were diverted in another direction by their realisation that increased productivity facilitated the accumulation of capital stocks, which were themselves important contributors to greater output, and by their perception that this relationship was amenable to analysis. The potential for capital formation is the basis of Smith's distinction between productive and unproductive labour, which leaves 'the scholar' on the wrong side, despite the key role that he assigned to 'philosophers and men of speculation' in the discovery of new means of production. As Cattaneo observes (p. 51), every point of view has its limits; every application of intelligence imposes opportunity costs – including applications within economics. That apparently straightforward applications may not be noticed because people are looking in another direction will be a recurrent theme in these two presentations.

It is precisely the opportunity cost of intelligence (or, more generally, of any application of human cognitive powers) that is missing from standard economics. Information may be costly, but everyone knows how to interpret it – including the information that has been rationally forgone. Thus Cattaneo's (p. 59) proposition 'There is no work, no capital which does not start with some act of intelligence' is no more than a platitude in a conventional context; for if all actions are rationally chosen then 'intelligence', like 'utility', has no analytical content. The related proposition, cited from Rusconi, that 'The value of things does not reveal itself on its own. It is the mind of man that discovers it' is in this context, at best, a casual explanation of how the postulated set of goods, and the postulated preference functions applied to them, might have come into existence: causation is outside the scope of standard economics, having been displaced by consistency. (Giocoli (2003) has provided a treatment that is scholarly and incisive.) Menger, however, sought to develop a causal system of economic reasoning, and the foundation of this system is the discovery of how to make something useful as a means, direct or indirect, of satisfying human wants. This may be considered a direct, if unconscious, application of Cattaneo's theme of intelligence and will. However, this application has tended to become submerged within the 'Austrian' theme of subjectivity, which could have provided a welcoming environment, because Austrians have usually been looking in another direction.

Adam Smith had already identified the development of productive knowledge and skills as the prime route to increased productivity; and he would not have demurred from Cattaneo's (p. 65) claim that 'intelligence addresses itself to needs of a mental nature', or indeed to the classification of pomp and vanity (as well as the desire for 'connecting principles' that soothe the imagination) as products of the human mind. That 'the authority of tradition' could inhibit the further development of ideas, and therefore the growth of wealth (p. 67), is also a theme that Smith and Cattaneo share, though Smith was also well aware that tradition was a necessary contributor to order. The interaction between regularity and innovation will become a theme of this paper, and its companion for the second session; it is a natural consequence of the opportunity costs of intelligence as an inherently scarce resource.

Cattaneo had a lively sense of the ways in which the application of intelligence to economic problems is influenced by the environment, and of how this application may itself help to create a situation in which intelligence is no longer directed towards economic improvement. At this point we encounter the second major component of the psychology of wealth: the will, which both orients activity and supplies the determination with which it is pursued. This orientation may be away from

wealth (though, as Cattaneo (pp. 81-3) notes, sometimes with unintended consequences, as when the injunction to seek the kingdom of God led to the clerical ownership of vast estates), or towards the expropriation of other people's wealth and the interdiction of enterprise because of its potential threat to established positions (pp. 87-9); and there is abundant evidence all around us of the obstacles to wealth that are created by human will. But if will can assuredly impede economic development, Cattaneo (p. 101) is confident that 'will directed to wealth must favour the development of intelligence'; it does so both at the level of the individual (where one may think of the combination of intelligence and will that is embodied in Schumpeter's conception of the entrepreneur) and at the level of political and economic organisation, where individual freedom encourages the application of will to find new sources of value and new means to achieve it by the use of intelligence.

In these two presentations I propose to replace Cattaneo's 'will' with 'purpose'. My principal reason for doing so is Edith Penrose's example. She invoked human purpose as a powerful objection to any explanation of economic phenomena that relies on the direct application of biological evolutionary reasoning, from which any hint of purpose is rigidly excluded, either as a source of variation or as an element in selection (Penrose 1952). This negative argument has its positive counterpart in Penrose's (1959, 1995) explanation of the processes by which firms grow, in which human purpose has a crucial role. Like Penrose, I shall be primarily interested in purpose within an organisational context, to which I shall turn in the second presentation; but it is important to note immediately that purpose is not to be confused with the concept of a preference function, or with rationality when that is interpreted either as a precisely defined relationship between means and ends or as consistency. Purpose is to be understood as the intent to achieve some change from the present state in accordance with some objectives; it is related to process, not equilibrium, and this process entails gaining knowledge and developing capabilities. That is why 'will directed towards wealth must favour the development of intelligence'. An important implication is the heterogeneity of economic agents; in the second presentation this will lead to the heterogeneity of firms.

Though the reorientation of economics that Cattaneo called for has not yet been achieved, one may claim that it is under way, and indeed that Italian economists have been the leading contributors; and since the development of ideas is not merely cumulative, but is often assisted by the rediscovery of ideas that have been neglected, or even discarded, we should not be surprised to find, as already noted, that there are several economic giants on whose shoulders we can stand. It is of interest, and a major illustration of Cattaneo's principle that every point of view has its limits, that the most formidable of these giants, Smith, Marshall and Hayek, all developed their psychological ideas before they began thinking about economic issues. All were prompted to do so by their encounters with problems of knowledge; and they each responded by developing explanations of the processes by which knowledge is developed. Moreover they postulated similar kinds of process, leading to the formation of connections within particular domains. Each recognised that such processes cannot deliver proven truth, and so they envisaged sequences of trial and error within particular contexts, leading to the preservation of patterns which appear to correspond with perceived phenomena, until this correspondence breaks down, when a new sequence of pattern formation begins.

Their theories may therefore be categorised as evolutionary, in the broader Darwinian sense of variety generation and the selection and preservation of particular variants; indeed Marshall's and Hayek's are presented as such, while Smith, though retaining the language of design (which neoDarwinians are inclined to treat as a mark of non-evolutionary thinking), rejected the possibility of designing either knowledge or human society, and had a major influence, both directly and

indirectly, on Darwin's ideas about the evolutionary process and the general tendency of its outcomes. It is not therefore surprising that their explanations have similar implications for the quality and reliability of human knowledge, and so call into question the modern fascination with rationality, both as the central assumption about economic agency and as the focus of economic modelling on the internal coherence of equilibrium (see Giocoli 2003). They also have similar implications for the effective organisation of the growth of knowledge; these will be explored in tomorrow's session.

This presentation is organised around Hayek's theory of the human mind, with Smith's and Marshall's theories used to provide complements and comparisons. One reason for choosing a primary focus on Hayek is that his theory is the most elaborate, and explicitly related to neuropsychology (a connection that I propose to exploit); a second reason is that I have recently published an article (Loasby 2002) on Smith's theory of the growth of knowledge as a proto-evolutionary theory, while Raffaelli (2003) has published what may be the definitive account of Marshall's psychological theory and its influence on his economics. The application of Marshall's model of the mind to the organisation of economic activity, in his own work and beyond, receives rather more emphasis in tomorrow's presentation.

Hayek's *Sensory Order*

The problem, which attracted Hayek's attention, was this. 'In order to be able to give a satisfactory account of the regularities existing in the physical world the physical sciences have been forced to define the objects of which this world exists increasingly in terms of the observed relations between these objects, and at the same time more and more to disregard the way in which these objects appear to us' (Hayek 1952, pp. 2-3). Not only have sensory qualities been progressively discarded from this scientific account; they have not been replaced in a way that allows them to be mapped onto the new categories, but by a distinctive ordering. Thus 'objects which appear alike to us do not always prove to behave in the same way towards other objects, … objects which phenomenally resemble each other need not be physically similar to each other, and … sometimes objects which appear to be altogether different may prove to be physically very similar' (Hayek 1952, pp. 5-6). (Note that this problem is defined by the perception of differences.) Hayek accepts the superiority of the physical order as a representation of relationships within the physical world, including the physical properties of human brains, but he does not ask why the human species should have first developed what, from the perspective of the physical sciences, appears to be an inferior classification system, but on which we still rely for everyday living; instead he asks how the sensory order came into existence. 'How' may be thought a more 'scientific' question than 'why', and in this instance it may also be thought to have logical priority: indeed Hayek's analysis provides a basis for explaining why, as we shall see later, without being satisfied with generalities about a natural tendency to progress – which is a seductive but dangerous tendency in evolutionary reasoning. However our initial, and indeed foundational, concern is the value of Hayek's analysis as a general theory of the creation of mental orders – an explanation of how the mind works.

Since the disparity to be explained is that between a classification which is based on the effects produced by external events on our senses and a classification based on their effects on other external events, the focus of inquiry is on systems of relationships, and the key to Hayek's analysis is the hypothesis that 'causal connexions' in either classification are linked to 'structural connexions' within the human brain. It follows that the sensory and physical orders are linked to different neurological networks, and that networks of the latter kind are of relatively recent origin;

Hayek argues that they are nevertheless similar in construction and operation. The essential point to note here is that connections within the brain are selective, and so connections between human perceptions and the physical world (including the physical world of the brain) are also selective; moreover, being selected within the human brain, which as a physical system is capable of sustaining alternative connections, they are 'subjective' rather than 'objective'.

The characteristic Austrian emphasis on subjectivity therefore has a psychological, indeed biological, basis; but it is perfectly compatible both with an objective universe and with the possibility of coming to understand it – though not with any final proof of empirical truth; there is nothing improbable about the intellectual alliance between Hayek and Popper. The subjectivity of the human mind is not just a 'veil'which conceals but does not influence objective forces; it has real effects. It allows great scope for error, because connections may be false or incomplete, and for sheer ignorance as defined by Israel Kirzner, because the connections which could have mitigated that ignorance may never have been made; it also allows great scope for imagination and novelty, through the making of new connections. The link between Hayek and Shackle is well founded (though it will receive no more than glancing attention today.) The influences on the formation of connections, and on the possibilities of aligning them with the external world, then become an important field of study, the results of which may be significant for policy. We shall return to these implications later.

Since connections are formed within the brain, and are necessarily highly selective, it might be supposed that individuals could develop patterns of connections which are so diverse that they fail to understand each other; and this is not a possibility that we should ignore. However, Hayek argues that similarities of experience promote similarities of patterns and perceptions, at the level of the individual or the species; as we shall see, there are important differences between the evolutionary processes at these two levels. Smith's (1976a [1759]) *Theory of Moral Sentiments* also rests on such similarities of patterns and perceptions. (As just noted, subjectivity is not unconstrained.) Because of the normal connotations of the word 'experience', it might be more appropriate to speak of 'construing the replication of events', a terminology introduced by the psychologist George Kelly (1963), to whose work we will refer several times. This is indeed an accurate definition of the process that is analysed in Hayek's neuropsychological theory, for what events are deemed to constitute a replication is determined by the interpretative framework that is applied to them, or in physiological terms, by the neurological pathways that they share. In what circumstances people are likely to use similar constructions is an issue that we shall have to consider later, as is the issue – perhaps of greater importance – of the possibility of understanding substantially different constructions which are used by other people, and of using such different constructions within a single coherent economic or social system. Any discussion of such issues must be based on some account of how these interpretative frameworks are formed; and that is the problem that Hayek explores.

Because its conceptual basis is that of a selectively-connected system, Hayek's theory is to be sharply distinguished from general equilibrium models, in which every element is connected to every other. The completeness of these connections (the equivalent of a 'field theory') is the basis both for analyses of the existence and stability of general equilibrium allocations and for claims about their welfare properties; all 'market failures' are to be traced to the absence of some connections. Potts (2000) has produced an incisive argument that the incompleteness of their connections is the crucial fact about all economic systems. The incompleteness of all cognitive systems is also the foundation of Simon's work on human decision-making and organisational design, which is part of tomorrow's agenda; Simon, like Hayek, insists on the importance of

interactions between the external environment and the 'internal environment' (Hayek 1952, p. 109) of the human brain.

Hayek's hypothesis of connectivity also naturally suggests the need for a process-theoretic explanation of the development of selective and systematic connections, and this is what he provides. Suggesting a topological isomorphism between the neural and phenomenological orders (Hayek 1952, p. 40), he argues that instead of direct connections between particular stimuli and particular sensory qualities, the effect that is produced by any stimulus depends, first, on how (or indeed whether) it is translated into an impulse in some nerve fibre (Hayek 1952, p. 10) and, second, on the location of this impulse in relation to other impulses within the network of connections that has already been established within the brain (Hayek 1952, p. 53). 'The transmission of impulses from neuron to neuron within the central nervous system … is thus conceived as the apparatus of classification' (Hayek 1952, p. 52). De Vecchi explores the influence on Hayek's thinking of gestalt psychology, to which Hayek makes approving references. Gestalt perceptions which are derived not from the parts but from the relationships between them; and these relationships are 'the result of a process of organization … performed by the nervous system' (De Vecchi 2003, p. 144), which selects a particular combination of connections.

Any impulse is not a carrier of the initial stimulus but a 'representation', perhaps with some different properties; and this representation is itself interpreted in terms of the relationships which have already been established within the brain: thus 'the qualities which we attribute to the experienced objects are strictly speaking not properties of that object at all, but a set of relations by which our nervous system classifies them' (Hayek 1952, p. 143). Hayek immediately and explicitly draws on Popper's language to emphasise that '*all* we know about the world is of the nature of theories and all "experience" can do is to change these theories'; in other words, we create a different set of connections. All knowledge, including 'knowledge how' as well as 'knowledge that' (Ryle 1949), is constituted by connections; it is a particular set of relationships among many other sets that are technically possible, and any such set is always potentially subject to replacement – though major changes are not easily achieved, as we have already noted.

Every theory is the outcome of a trial and error process in which theories, and the patterns of neural connections which embody them, are tested by the effectiveness of the actions to which they lead or their success in interpreting phenomena. The test, of course, is of sufficiency, not optimality, in relation to what Hayek (1952, p. 19) calls 'the discriminations that we perform', which he associates with Ryle's (1949) category of 'knowing how'. These discriminations may be of many kinds and many degrees of precision (Hayek 1952, p. 71), and so therefore may be their ranges of sufficiency (as Kelly (1963) also notes). The perception that a theory is no longer adequate, as a basis for action or understanding, stimulates a search for a better theory; since criteria of inadequacy are themselves subjective Hayek provides a foundation for 'Carnegie-type' models in which search is stimulated by a disparity between achievement and aspiration, and in which aspiration levels themselves require explanation. It is such a process, Hayek argues, that has gradually led to the supersession of sensory theories by physical theories for some important purposes, which were associated with different kinds of aspirations. As Hayek points out, this gives us some reason (though not a conclusive reason) to expect a closer fit between these physical theories and the physical environment, provided that this environment does not change at a faster rate than the revision of theories – a point to which we shall return when we come to consider alternative versions of this evolutionary process.

However, because we must always use theories to interpret experience before we can use experience to modify theories, existing theories provide the conditions which stimulate, or fail to

stimulate, the revision of theories and also the starting point for any such revision; thus history matters, for the physical as well as the sensory order, though we need not assume that it determines unique paths or unique outcomes. Moreover, since all of these theories 'are generalisations about certain kinds of events, and since no number of particular instances can ever prove such a generalization, knowledge based entirely on experience may yet be entirely false' (Hayek 1952, p. 168). This, we should note, is a restatement of David Hume's objection to induction as a means of demonstrating empirical truth, as well as an endorsement of Popper's position. It is a powerful argument for basing knowledge on a variety of experience, in Kelly's sense: knowledge will be greater if the production and testing of knowledge is dispersed.

NeoDarwinism and neoconstructivism

Hayek's theory of the formation and modification of mental orders is explicitly designed to encompass two distinct processes, one of which 'takes place in the course of the development of the single individual' and one 'in the course of the development of the species and the results of which will be embedded in the structure of the individual organism when it commences its independent life (or when it reaches maturity)' (Hayek 1952, p. 102). The idea of an embedded framework of the human mind which (correctly) controlled human knowledge of such basic and universal concepts as space and time was developed, in a non-evolutionary fashion, by Kant in response to Hume, and it was Herbert Spencer (now so out of favour) who proposed an evolutionary interpretation of such embedding which would preserve Kant's conception of the mind's power of structuring perceptions against the claims of extreme empiricists (Raffaelli 2003, pp. 31-4), thus preparing the way for Hayek's two processes. Hayek (1952, p. 166) extends this interpretation by arguing that 'experience does not begin with sensations or perceptions, but necessarily precedes them … and the distinction between sensory qualities, in terms of which alone the conscious mind can learn anything about the world, is the result of such pre-sensory experience'. It seems natural to ascribe this evolutionary sequence to the species rather than the individual.

However, Smith had already gone further in observing how 'the ideas of the imagination' could overthrow 'the evidence of the senses', which we might now interpret as the ability of 'the development of the single individual' to override the results of 'the development of the species'. The significance of this capability can hardly be overemphasised; though its evolution is susceptible to a biological explanation, its effect is to make possible a human history that is not determined by biological mechanisms, and so to create space for social sciences which go beyond biological models. In particular, it allows the fundamental principles of evolution to be more broadly interpreted. In contrast to the neoDarwinian prescription, social and economic evolution may include many selection processes, deliberate as well as natural (though since deliberate selection is not based on rational expectations it may have unintended consequences) and it may incorporate direct influences of environmental change on the search for novelty, although such novelties cannot be directly derived from environmental change. Cattaneo's twin human attributes, intelligence and will, are products of evolution but also help to shape it: the wealth of human societies is a product not only of physics and biology, but of psychology also.

Since Hayek's specific objective was to explain how the sensory order could differ from the physical order, it was reasonable for him to leave open the application of his unifying principle to the distinctive systems of individual and species development – as Smith left open the application of his unifying principle of the division of labour to the distinctive systems of firms and markets; but it is now difficult to ignore the important differences between them. Hayek's presentation in terms of individual development, which was – and for many of us still is – easier to connect with

our own established schemes of ordering, carefully avoids any discussion of these differences (Hayek 1952, pp. 102-3), and this presumably explains why his theory of species development is so often overlooked. Some neoDarwinians, however, are very sensitive to the implications of proposing two distinctive evolutionary processes. They would argue that Hayek's theory of development within the lifetime of an individual includes no account of any process by which a newly-developed order could be transmitted across generations, whereas the neoDarwinian transmission mechanism of genetic inheritance can be readily applied to a theory of the development of species-specific patterns of behaviour.

> Hayek's account of development within the individual may be interpreted as driven by experience, in Kelly's sense of the constructions that are imposed on a sequence of events, through experimentation with new connections and choosing among them – both of which may be subjectively influenced; but in species development the role of 'experience' is not to stimulate experimental changes in mental ordering but only to select (objectively) among changes which have occurred by random mutations. The double helix is a device for accurate reproduction, and so all mutations must be technically regarded as mistakes in copying; and although environmental factors may be allowed to influence the frequency of mistakes it is a fundamental principle of neoDarwinism that it cannot influence the kind of mistakes that are made. 'Experience' can therefore make no contribution to the generation of modifications, but is strictly confined to selecting among modifications that are unrelated to experience; instead a very small fraction of these mistakes turn out to enhance fitness, and these are preserved by accurate copying to succeeding generations. Experience-led learning by individuals is regarded with suspicion by neoDarwinians, and it cannot be inherited; our mental orders are genetically adapted to some past environment, with the era of hunter-gatherers being a current favorite (see Cosmides and Tooby 1994). 'Intelligence' and 'will' are demoted from the status assigned to them by Cattaneo to the role of instrumental variables.

Indeed we may now observe an emerging conflict for supremacy in the social sciences between the rival unifying theories of rational choice equilibrium and neoDarwinian evolution. The two stand in a curious relationship. Both are theories about selection between alternatives and the preservation of what is selected; and in both, selection is based on the consequences of those alternatives which are presented for selection. However, rational choosers, being equipped with rational expectations, know these consequences in advance, and having made the correct choices they naturally have no wish to change them, but remain in their equilibrium state until there is some shock to the economic system. (Their cognitive system, being already fully connected and therefore perfect, never changes.) In the neoDarwinian model, by contrast, no-one knows the consequences of the available alternatives, and any attempt to design alternatives in order to produce desirable consequences is a pretence that is unworthy of science; but if neoDarwinian processes can discover the best answer that is currently available only after trying all existing (though not all possible) alternatives, nevertheless the best currently available answer will be discovered, and once discovered it will be conserved in the genetic code, which may then be observationally indistinguishable from an equilibrium allocation. By appropriate allowance for the costs of this process one may even be able to make claims for optimality along similar lines to the claims for optimality, subject to information and transaction costs, that are sometimes put forward in economics. Thus assumptions which appear to be polar opposites can, with a little sleight of thought, support identical outcomes.

Now deriving equilibria from the initial data is analytically simpler than tracing processes, because the stages of these processes are not themselves full equilibria and are therefore difficult for the modeller to control in a non-arbitrary fashion, as has been discovered by those economists who attempted to provide a model of equilibration that would conform to the established criteria for modelling general equilibrium. Partial equilibria can be devised, but any particular partial equilibrium is always open to objection – particularly by those who believe either in rationality or in the long-term power of neoDarwinian processes. (The standard isolation of game-theoretic models from the wider environment raises dual questions about the appropriateness of this assumption of environmental irrelevance and the applicability of these models in a wider domain, which modellers do not always address.) So we should not be surprised that some evolutionary theorists are attracted by the relative simplicities of equilibrium modelling; and one particularly attractive application is the direct attribution of particular medical conditions or behaviour to specific genes. The explanation of performance by structure is a favourite theoretical principle across many disciplines, and a direct link between final outcomes and the initial data has the dual appeal of simplicity and plausibility, especially when the initial data can be identified as a specific gene sequence.

However, there is some resistance to the dominance of this strategy among neuropsychologists; and the combination of argument and evidence which they have produced should have particular resonance among social scientists of an evolutionary inclination, especially those who are impressed with Hayek's reasoning. The following account is based on a series of papers, some jointly-authored, by Professor Annette Karmiloff-Smith, Head of the Neurocognitive Development Unit at University College London, and an acknowledged leader in her field. In a lecture to mark the Centenary of the British Psychological Society (Karmiloff-Smith 2002) she argues for the significance of individual development in shaping the outcomes of genetic endowments. Her starting-point is the use by neoDarwinian geneticists of evidence from adult neuropsychological patients and children with genetic disorders to support claims that the human brain is organised into specialised modules which are directed by specialised genes. She offers a fundamental methodological criticism that will appeal to all Austrians: an exclusive focus on the relationship between initial conditions and end-states may lead us astray, and a better understanding of causation requires attention to the processes by which these end-states are produced.

Her central example is of a genetic disorder, the Williams Syndrome, which is clearly associated both with the deletion of 17 specific genes and with a specific set of physical consequences in adults, including a smaller brain volume, an abnormal size, orientation and density of neurons, and atypical proportions of several regions of the brain, together with psychological consequences of low IQ and low spatial skills, with the notable exception of unimpaired proficiency in facial recognition. This combination appears to supply strong *prima facie* evidence for an exclusively genetic explanation, and has been cited (e.g. by Pinker 1997, 1999) in support of a theory of the direct determination of behaviour, including altruism, aggression, intelligence, spatial cognition and language, by specific genes or specific sets of genes (Karmiloff-Smith 2002, p. 526).

Such an exclusive explanation is then confronted with further evidence. First, patients who lack a subset of these 17 genes do not exhibit corresponding subsets of the symptoms. (Though the sample size is small, universal claims, such as that for exclusive and specific genetic determination of end-states, may logically be refuted by a single counter-example; questions about the evidence must be questions about the experimental procedure which has generated an apparent counter-example, not about its logical status.) Second, in response to the claim that the apparently unimpaired proficiency of people with Williams Syndrome in facial recognition demonstrates an intact face-processing module, careful experimentation revealed that these people were processing faces feature by feature, whereas the supposed 'face-processing module' relies on overall

configuration. (Of particular interest is the observation that control subjects were equally reliant on featural processing when they were presented with inverted faces; the implications of this will be considered in the second presentation.) Differences between experimental and control subjects were also found in the means of producing some other supposedly-intact skills; thus the 'pattern of intact versus impaired modules formed from intact versus mutated genes', which the theory of purely genetic determination requires, is removed by '[d]ifferentiating between superficial behavioural scores and underlying cognitive processes' (Karmiloff-Smith 2002, p. 536). Third, experimentation with infants revealed substantial differences from the results with adults, while the use as controls of infants with Down's Syndrome had the incidental effect of demonstrating notable differences between the infant and adult states of those affected by this syndrome also; such changes in response during the course of development, implying a reconfiguration of neural networks, is not consistent with nativist claims that directly link impaired modules with adult states (Karmiloff-Smith 2002, p. 538).

These results do not, of course, overthrow the conception of a genetically driven evolutionary process, or indeed the argument that many human physical and behavioural characteristics are genetically determined; but the modified theory that is offered by Professor Karmiloff-Smith, in conjunction with other cognitive neuropsychologists, allows scope for 'complex pathways from gene-to-brain-to-cognitive-processes-to-behaviour' (Karmiloff-Smith 2002, p. 526). Genetics, and the neoDarwinian model of which they are the focus, retain a major role, both directly and by supplying the potential for the development of alternative pathways; but there is nevertheless considerable space for social scientists to develop evolutionary explanations of a somewhat different kind, for which genetic constraints may provide an appropriate baseline, such as all evolutionary explanations need. This kind of permissive linkage between disciplines appears to correspond to Ziman's view of science. Though commending 'weak' reductionism – the search for underlying commonalities – as a research strategy, Ziman (2000, pp. 323, 326) objects to 'strong' reductionism – the unification of knowledge by the universal application of fundamental principles, precisely because no such principles can explain 'the spontaneous emergence of novel modes of order in complex systems'; and these selective connections produce 'a *simplification* of nature, and of human cognition as naturally evolved, that actually makes scientific research possible'.

Explanations of the emergence of order, in human brains and in human societies, are therefore not confined to random mutations and natural selection, though neither is excluded, but can incorporate the search for novelty, through making new connections, and choices that are made for what appear to be good reasons, because they embody plausible connections. They may go beyond this to suggest why particular reasons may be thought to be good (even sometimes when they are not) and why searches may be undertaken in particular circumstances and may proceed in particular directions. Thus such explanations are not restricted to explaining how people may get things right, but may also help to understand how they may go astray – and an understanding of the reasons for failure may have practical uses. The drastic simplifications of assuming all economic agents to be hard-wired optimisers who are extremely well informed (and if confronted with asymmetric information know precisely what are the implications of what they do not know), which excludes the need for any process other than Bayesian updating, will, however, not suffice. The kind of psychology-based social science developed by Hayek, on the other hand, is highly congenial.

In fact, the final sentence of Karmiloff-Smith's lecture would serve as a present-day introduction to Hayek's *Sensory Order*: 'The contrasting view [to the static model of genetic determination of adult states] presented in this lecture is that our aim should be to understand how

genes are expressed *through development*, because the major clue to genotype-phenotype relations is not simply in the genes, or simply in the interaction between genes and environment, but in the very process of development itself' (Karmiloff-Smith 2002, p. 540). In other papers she argues that 'on the gene side, the interaction lies in the outcome of the interacting, cascading effects of interacting genes and their environments and, on the environment side, the interaction comes from the infant's *progressive* selection and processing of different kinds of input. … The child's way of processing environmental stimuli is likely to change repeatedly as a function of development, leading to the progressive formation of domain-specific representations' (Karmiloff-Smith 1998, p. 390).

In a jointly-written paper advocating 'an emergentist solution to the Nature-Nurture controversy', she and her colleagues emphasise 'the extraordinarily plastic and activity-dependent nature of cortical specialisation'. Because 'cortical regions are likely to differ from the outset in style of computation, which means that they will also differ in the variety of tasks they can perform best', there may be widespread dispositions to convert domain-relevance into domain-specificity; nevertheless any particular pattern of domain-specificity is a consequence of development (Bates et al. 1998). The argument that the localisation of mental functions does not imply localisation in any particular part of the cortex, and that alternative pathways may be developed in response to specific damage, had already been made by Hayek (1952, pp. 147-8), citing Lashley's (1929) account of 'vicarious functioning' and 'equipotentiality'.) Though much is genetically determined and the remainder is genetically constrained, nevertheless in important respects 'the brain progressively sculpts itself, slowly becoming specialised over developmental time' (Karmiloff-Smith 2002, p. 527).

'The expression of genes through development', rather than entirely by programming, may itself be given an evolutionary explanation, as Karmiloff-Smith (1998, p. 390) notes: 'although evolution has pre-specified many constraints on development, it has made the human neocortex increasingly flexible and open to learning during postnatal development. In other words, evolution is argued to have selected for adaptive outcomes and a strong capacity to learn, rather than prior knowledge. Within such a perspective, it is more plausible to think in terms of what one might call domain-relevant mechanisms that might gradually *become* domain-specific as a result of processing different kinds of input.' There has been some evolution away from genetically specified domain-specificity towards a genetically-enabled multi-specific capability for creating domain-specific skills through development, in what we shall presently characterize as a Smithian evolutionary process. Domain-specificity – the division of labour – is a general characteristic, but some domains may be genetically specified and others may become specified during the course of development.

Present-day humans therefore embody a partial shift from 'evolution in the course of the development of the species' towards 'evolution in the course of the development of the single individual' – a shift which has been confirmed by natural selection, but which entails other forms of selection (for a discussion of some of these, see Loasby 2001). This process of learning works through the creation and modification of connections within the brain, for selective connections are the key to human cognition. If two stimuli are experienced differently, 'this difference must be reflected somewhere in the brain. Every new piece of learning changes the structure of the brain in some fashion, however minor' (Bates et al., 1998). This is precisely how learning is modelled by Hayek. The development of a new system of connections that constitutes a physical order, and which at first supplements and then increasingly supersedes our sensory order in many contexts, may be seen as a consequence of this major trend in selection within the human species. This evolution of the evolutionary process deserves some further consideration.

> That specialization on a particular range of activities would result in a progressive movement from relatively undifferentiated potential to domain-specific knowledge and capabilities, which could confer distinctive advantages, was Adam Smith's great idea. It was applied to the world of nature by Milne-Edwards (1827, p. 534) to explain the great variety of species, and this gave Darwin the principle which governed the direction of evolution. We may now draw on our knowledge of genetics to argue that the detailed specification of a limited range of behavior for each species provided evolutionary space for very many different species to demonstrate that their evolved domain-specific behavioral regularities conferred sufficient comparative advantage within their specific environment to allow them to survive, though any comparative advantage may be extinguished by changes in this environment, including the evolution of other species. Only in the human species is this specialization associated with exchange, though the principle of complementary specialization is manifest in social insects and in many specific inter-species relationships – plants and pollinating insects provide the largest class of examples – and in a broader sense in ecology.

However, speciation is only the first stage of differentiation. The growth of the pre-human brain allowed for an increasing range of behaviour within each individual; but what appears to have been a crucial change resulted from a very rapid increase in brain size between 500,000 and 100,000 years ago. Because it followed the change to an upright stance, which inhibited enlargement of the birth canal, this increase could be accommodated only by the birth of infants at a very early stage of brain development; this made them extremely vulnerable to both accident and predation for an exceptionally long period, and could therefore have been selected for only if it was associated with some great advantage. This advantage, we may now conjecture, seems to have been precisely the ability of this new genetically-endowed cognitive capacity to form better representations of each individual's local environment as it was encountered, and to develop more appropriate skills to deal with it – which is the kind of adaptation cited by Karmiloff-Smith. For this purpose 'the unusually slow period of human postnatal brain development' (Karmiloff-Smith 1998, p. 394) is actually an advantage, for the connections in the brain are being formed while the child is interacting with the environment. With an appropriate genetic endowment of programmable rather than programmed capacity, domain-specific skills can be developed within individuals as well as through the evolution of species; and this new variant of evolution can cope with faster environmental change than reliance on the selection and diffusion of fortuitous genetic mutations, and also with movement into an environment that has not previously been experienced by that individual. Hayek's model of development at the individual level applies.

This interaction between the growing brain and the environment could not have happened if the development of this larger brain were strictly genetically determined; but the extraordinary increase in the size of the brain entailed a far greater proportionate increase in the number of potential connections, and it is very hard for a non-specialist to see how the programming capacity of the genome could have increased sufficiently to cope with this increase. Specialists appear to share this view. 'On mathematical grounds, it is difficult to understand how 10^{14} synaptic connections in the human brain could be controlled by a genome with approximately 10^{8} genes, particularly when … humans share approximately 98% of their genes with their nearest primate neighbours' (Bates et al. 1998). Hayek (1952, p. 185) applied his proposition that 'the capacity of any explaining agent must be limited to objects with a structure possessing a degree of complexity lower than its own' to the human brain; it is no less applicable to the programming capacity of the genome. Instead, 'brain development in the higher vertebrates appears to involve massive overproduction of elements early in life (neurons, axons and synapses), followed by a competitive

process through which successful elements are kept and those that fail are eliminated' (Bates et al. 1998); this is a non-genetic application of neoDarwinian evolution which introduces a different evolutionary process.

The diminution of genetic control has allowed cognitive development to be shaped by interaction with particular environments at the level of the individual, on evolutionary principles of variation and selective preservation. Thus the evolutionary process has itself evolved, as genetic determination has been supplemented by genetically-enabled capabilities, in a way that increases adaptation – at least in the short term, in relation to the time scale of genetic evolution (though even within a human lifetime, as Adam Smith realised, the development of domain-specific skills and habits of thought may lead to dangerous reductions of adaptability). The evolution of the evolutionary process, though not precisely so expressed, is also a feature of Adam Smith's psychological theory of the growth of knowledge, in which specialisation between individuals, in both knowledge and capabilities, is a later development that enhances the effectiveness of the powerful motivation to create mental models of puzzling phenomena (Loasby 2002). The principle that greater diversity requires a relaxation of central control is familiar in studies of organisational design and innovation; and it is, of course, a central principle of Austrian economics. (It is not good news for economists who rely on general equilibrium modelling.) That this diversity within the human species should apparently be an unintended consequence of the increase in brain size (even though to a neoDarwinian all consequences are unintended) should also appeal to an Austrian mindset.

Smith and Marshall

At this point it is appropriate to observe the similarities, and the differences, between Hayek's analysis and the psychological theories that, as noted towards the end of the introduction, were developed early in their careers by Adam Smith and Alfred Marshall. As we have seen, it was the sensory order that Hayek set out to explain; in his exposition of 'the principles which lead and direct philosophical enquiries' Adam Smith (1980 [1795]) had sought to account for the development of mental representations of the physical order. Smith was familiar with Hume's simple proof that there could be no procedure for deriving universal laws from observation or experiment, and consequently no impregnable basis for deductive reasoning about phenomena. He accepted Hume's recommendation that we should turn our attention to the processes by which people came to treat empirical propositions as if they were unquestionably true; but he seems to have been dissatisfied with Hume's argument that people were 'excited by nature' to believe in 'constant conjunctions' (Hume 1875, p. 41), and developed an explanation which gave distinctive roles both to the innovative human mind and to human emotions.

He suggested that it is characteristic of human nature to be uncomfortable when unable to make sense of a particular phenomenon, especially when that phenomenon is repeated; people therefore try to invent 'connecting principles' that will collect unexplained phenomena into categories and provide an acceptable explanation of these categories. Satisfactory explanations are a source of positive pleasure, especially if the solution is aesthetically pleasing, and are likely to be widely adopted by those encountering such phenomena. The discomfort resulting from a subsequent failure to accommodate some new phenomenon within an established pattern then provides the stimulus to create a new interpretative system by a rearrangement of connections, which may also entail a rearrangement of categories (for example, the set of 'planets'). In relation to Hayek's analysis, Smith may be interpreted as explaining how a physical order may emerge – and diverge – from a sensory order, and showing how sensations guide this process.

That Smith, like Hayek, had a conception of knowledge as a set of replaceable theories is most strikingly demonstrated by his insistence that Newton's theories were the product of Newton's imagination, not a direct perception of the truth. As Smith noticed, its general acceptance is to be explained by the rhetorical appeal of its unifying principle, which unites terrestrial and cosmological phenomena. Smith (1980 [1795], p. 77) even noticed that people's desire for theoretical comfort could be powerful enough to override the evidence of the senses, such as the overwhelming sensory evidence of a stationary earth, 'in order to preserve the coherence of the ideas of their imagination'. Though this supersession of sensory evidence was clearly a major element in the problem that Hayek attempted to resolve, his explanation is focused on the physiological mechanisms and does not incorporate the motivational issues that were so important to Smith.

Because psychology was at that time closely associated with philosophy, it is not surprising that Smith did not attempt to provide a physiological underpinning for what we may now call his evolutionary theory of cognition. He did, however, extend that theory to explain how the division of labour promotes the growth of knowledge. First, science emerges as an identifiable category of knowledge with its own practitioners, and then, as scientific knowledge expands, specialisation between the sciences simultaneously increases the range of study within the scientific community and the attention to detail within each sector. At each stage this closer focus accelerates the perception of anomalies which, by causing intellectual discomfort even when they appear to have no practical significance, stimulate the invention of new 'connecting principles' that may accommodate them. (That practical significance may play no part in very powerful motivations is amply demonstrated by Giocoli (2003); this is a theme that will not be developed in either of these presentations.) Then Smith (1976b [1776]) transferred his theory of the growth of knowledge from science to the economy through his fundamental proposition that the division of labour, because of its powerful effects on the growth of knowledge, is the primary instrument of economic growth; in the process the emphasis switched to the importance of attention to detail as a problem-generator, the solution of productive problems providing sufficiently obvious motivation. (For an extended account, see Loasby 2002).

It was this application that attracted Marshall's attention, and not Smith's underlying psychological theory, which Marshall may never have read. However, Marshall had already recognised the possibility of a conjunction between contemporary associationist psychology and Darwin's ideas (which, as has been noted, owed much to Smith's emphasis on the advantages of differentiation), and in the process provided a physical equivalent of Smith's cognitive theory. Marshall's encounter with the problems of knowledge has been explored by Butler (1991), Groenewegen (1995), and Raffaelli (2003); it may be sufficient to note here that this encounter was prompted by a major intellectual controversy about the possibility of demonstrating religious truths, which coincided with Marshall's own religious doubts.

His response was clearly shaped by Alexander Bain's (1864, 1865) major reorientation of psychology from philosophy towards physiology, which had the unintended effect of making it readily accessible to Darwin's ideas, as Marshall quickly realised; he had read *The Origin of Species* by March 1867 (Groenewegen 1995, p. 119). He did not think of connections between neurons (which was a later pattern of thought), but wondered how far the psychological processes of knowledge development could be represented by a mechanical system, and devised the most elaborate model of his whole life in order to investigate this question (Marshall 1994). In doing so he was consciously following the example of Charles Babbage, who (we may note in passing) had been inspired by the decision of the French mathematician Prony to organise the production of

mathematical tables on Smith's principles of the division of labour (see Raffaelli 2003, pp. 52-3). The possibility of reducing biology to physics is not a recent idea, and the problematic relationship between mechanical and biological concepts which pervades Marshall's economic analysis seems to have its origin here. (This relationship is another topic to be excluded from the present discussion.)

Marshall's 'machine' is first conceived as a combination of a 'body', which is capable of receiving sensations from its environment and performing actions in that environment, and a 'brain', which has no direct connection with the environment and therefore must operate, as in Smith's and Hayek's theories, by forming selective connections. Marshall indicates this by restricting the brain to operating with 'ideas of sensations' and 'ideas of actions'; it works by linking the idea of an initial sensation received by the body with the idea of an action which the body performs in response, and then linking the latter with the idea of a sensation that is interpreted as a consequence of that action. If the latter linkage produces a pleasurable sensation, then the linkage from initial sensation to action is strengthened, and if the sensation is unpleasant it is weakened. The suggested mechanism, possibly inspired by Babbage's conceptions of analytic engines and automata, to which Marshall refers, is of wheels connected by bands, which may become tighter or looser in response to the sensation experienced. This cumulative trial and error process, which forms associations of contiguity or similarity, is consistent with Bain's account of the physiology of mental phenomena; and Marshall shows how the process could produce complex patterns of relationships. The basic mechanism, including the importance of sensation, also corresponds quite closely with Smith's mentally-focussed account of the growth of knowledge, though it would correspond even better with an elaborated account of the process by which the division of labour fosters the development of capabilities. Indeed it should be noted that in Marshall's presentation action is essential to the formation or dissolution of associations; this was to become an important element in Marshall's theory of economic development. Not only does every action start with some act of intelligence, as Cattaneo observed; actions favour the development of intelligence.

Over time such a machine may develop a range of closely connected sensations and actions, which we might now call routines; these routines are not the result of anticipatory choice but of environmental selection among actions which, by Marshall's intentional specification of his model, cannot originate in consequential reasoning. Although the imprint of his mathematical training is unmistakable in the conception and structure of his 'machine', he has already moved away from the axiomatic method as the appropriate way of deciding what to do. To be precise – and this may sometimes be very important, though Marshall does not say so – selection depends on the environment as it is perceived by the machine. In the elaboration of his model this environment contains other machines that operate on similar principles, but because of differences in initial perceptions and initial actions and the selective reinforcement of what appears to work they may develop different connections. Thus a population of machines constructed to a uniform design may generate the variety which is essential for any evolutionary process.

Marshall continues his evolutionary sequence by postulating the emergence of a second level of control within the brain, which uses similar mechanisms for different purposes (an early example of exaptation as a postulated evolutionary mechanism). Ideas of sensations received which have not been linked to any idea of satisfactory action can now be referred to this higher level, which may generate the idea of a novel action and associate it with the idea of a sensation produced by its effects. Expectations appear; but they appear as conjectures. A pleasurable linkage of contemplated ideas is then transferred to the lower level, where it directs bodily action; and if the action produces the anticipated sensation the corresponding link between initial sensation and action

forms a new routine. This is a crucial development: it introduces imagination and the possibility of trial and error within the mind which may improve the chances of success in the environment, thus opening the path to modern practices of research and development. Since both the conjectures generated at this level and the internal selection processes applied to them are not random but oriented to problems, the course of development is influenced by human intelligence and human will. This does not conform to modern neoDarwinian principles of variety generation; but it does not conflict with the broader Darwinian principle of selection at the practical level, as in Darwin's own example of selective breeding.

Marshall's formulation has substantial virtues as an evolutionary model which conforms to a basic economic principle: certain regularities of behaviour are selected and reinforced by their success in extracting benefit from their environment, by a procedure which operates at low cost in mental energy. Another economic principle may be discerned in Marshall's distinction between two categories of evolutionary sequences, which we may now distinguish, in Hayek's terms, as the development of the species and development within the individual: this is Smith's principle of the division of labour, which accelerates the growth of knowledge. The evolution of the brain is clearly a biological phenomenon, though the sequence may be explained by the application of basic economic principles to biology. The second level, which is much more energy intensive, requires the prior development of the first as an effective survival mechanism and subsequently as a problem-generator; with this precondition it becomes an important source of potential improvement in the machine's performance, achieved at low overall cost in mental energy by the separation of levels and specialisation between them. The additional effort of generating and checking ideas is undertaken only when the existing set of routines has proved inadequate, and does not disturb those elements in the set which appear to work well; any improvements in performance are stored at the lower level, and thus cease to require active supervision. It is an efficient mechanism for making local adjustments, a precursor of Marshall's partial equilibrium analysis.

These improvements in performance exemplify evolution at the level of the individual, which is made possible by the evolution of the relevant capabilities at the level of the species, and we may suppose that this partial switch from programming behaviour to programming the potential – from fully-specified to imperfectly-specified systems – was itself naturally selected because of its superiority over genetic modification in adapting to changed circumstances (as argued in the earlier section on neuropsychology). Smith's foundational proposition applies to the division of labour between evolution at the level of the species and evolution at the level of the individual. Though Marshall does not argue in these terms – that is hardly to be expected at this date – he clearly distinguishes between the capabilities that are built into a machine and the particular connections which that machine develops, and he assigns different roles to them.

Marshall and Hayek have much in common, but also some useful differences. Both explain the growth of knowledge by the creation of selective connections, and both are concerned with mechanisms that make this possible, though Marshall is content with what we would now call a constructive existence proof (explaining how it could be done) while Hayek seeks to explain how it is actually done. On the other hand, whereas Hayek's explanation deliberately avoids any differentiation between development of the species and development at the level of the individual, Marshall uses this differentiation (though without explicit reference to machines as a species) to account for the evolution of the brain's capabilities. In addition, both examine two processes within the brain, which are built of similar elements but produce different results; this common source of differentiated outcomes is a feature of evolutionary thinking. However, whereas Marshall's processes, though relying on similar mechanisms, necessarily operate at different levels of the brain,

Hayek presents the processes of creating the sensory and physical orders as if they operate within the same level.

Marshall's model can be used to supplement Hayek's theory: the sensory order can be produced by pure mechanism, but the physical order requires the imaginative capabilities of the higher level. On this interpretation the physical order, though developed at the level of the individual, requires capabilities that result from further development at the level of the species. Smith's psychological theory of knowledge also assumes the capabilities that Marshall assigns to the higher level; and the motivational basis of this theory can be invoked to explain why the selection criteria that are used to construct the physical order, which are directly linked to the imagination, may lead to patterns that conflict with the sensory order. Neither order is directly imposed by phenomena; both are constructed within the brain, by similar methods but at different stages and within different possibility sets. As Hayek observed (quoted earlier) '*all* we know about the world is of the nature of theories'.

We may conclude that Smith, Marshall, and Hayek collectively offer a good basis for analysing the psychology of intelligence as a source of wealth, and this theme will be developed tomorrow in the particular context of organisation. We should also note that all three were also interested in the factors that Cattaneo included in the category of 'will'. No Smithian scholar is likely to underrate the importance of 'moral sentiments' in Smith's scheme of thought, and much of Hayek's later work was devoted to the institutional and political support for both freedom and prosperity. However, since choices must be made, we shall deal only, and that briefly, with Marshall, because his treatment was closely linked with both psychology and economics, as Raffaelli (2003) has shown.

It is well known that Marshall contemplated a specialisation in psychology, and towards the end of his life expressed at least a passing regret that he had not done so. His primary reason for preferring economics to psychology was the 'increasing urgency of economic studies, as a means towards human well-being … not so much in relation to growth as to the quality of life' (Whitaker 1996, II, p. 285); and the quality of life was crucially dependent on mental as well as physical factors. Better knowledge was a primary source not only of increased productivity (as mainstream economists have rediscovered) but also of better patterns of consumption (which is still neglected); for Marshall, preference functions, like production functions, were a product of the economic system. However, to understand behaviour it was necessary to go beyond knowledge of what was available and of its possible effects, to what Marshall called character. In sketching the breadth of potential for his machine he concluded by describing it as 'a moral being' (Marshall 1994, p.129), and perhaps of particular significance is that when, in an earlier section, he used Babbage's suggestion of a chess automaton to illustrate how his 'machine' might choose between alternatives he observes that '[w]hen a man is playing at chess, just as when he is doing anything else, his character is displayed in the way in which he grasps at immediate advantages or, on the other hand, tries to look further' (Marshall 1994, p. 122).

Raffaelli (2003) argues that it was because Marshall was both so concerned with improving the quality of life for most people and impressed with the effects of the economic system on this quality, and especially on individual character, that he was not prepared to follow John Stuart Mill's prescription that economists should deduce the necessary general laws of economic activity and leave to psychologists the study of individual variations and their consequences. The 'escape from psychology' that economists achieved during the twentieth century (Giocoli 2003) was not for him – and he would not have been surprised by some of its consequences. Economics was

> on the one side a study of wealth; and on the other, and more important side, part of the study of man. For man's character has been moulded by his everyday work and the material resources which he thereby procures, more than by any other influence unless it be that of his religious ideals. … his character is being formed by the way in which he uses his faculties in his work, by the thoughts and the feelings which it suggests, and by the relations to his associates at work
>
> Marshall 1920, pp. 1-2

Marshall therefore gave particular attention to the effects of economic organisation on the use of talents and the development of character, which he believed were aspects of the same process; and since progress depended on variation the differences between individuals should not be suppressed either in economic analysis or in economic systems.

It is, of course, possible to include 'character' (as it is possible to include 'moral sentiments') in a formal preference function, but that would not be an innocuous move. The modern preference function has become detached from the idea of human agency, and a prime reason for that, as Giocoli (2003) shows, is that choice theory has been reduced to a demonstration of consistency; the actual process of choosing is no longer discussable. It is in this process that character, or will, becomes important; rather than forming part of a preference function, its effects are better discussed in a category such as Herbert Simon's 'decision premises', which should be extended to include decision procedures. When Marshall (1920, pp. 216-7) is discussing the provision that parents make for the education of their children, he writes of 'moral qualities' and 'a certain habit of mind'. This is entirely in accordance with Marshall's theory of the mind, which is a theory that depends on the interplay between automatic and novel connections.

Smith, Marshall and Hayek all built their systems on the fundamental economic principle of scarcity; but what is scarce in their systems is human cognitive capacity and the energy that is necessary to drive it. These are precisely the only resources that are assumed to be freely available in most formal models in present-day economics, which thus ignore the most fundamental of all allocation problems that human beings face. It is ignored by the familiar Chicago objection to regulation, which rests on the assumed abundance of entrepreneurship; the Austrian objection is more soundly based on the importance of incentives to expand the supply (Audretsch, Baumol and Burke 1999, p. 620). Smith, Marshall and Hayek also effectively, if unintentionally, provide the framework for explaining why the assumption that cognition alone has no opportunity costs is maintained by most economists; it is essential to underpin the concept of rational choice equilibrium (as Herbert Simon often pointed out), and thus, in Smith's (1980 [1795] p. 77) words, already cited, 'to preserve the coherence of the ideas of their imagination'. Smith's, Marshall's and Hayek's psychological systems rely on routines and institutions which economise on cognition, and so do the economic systems that they later considered and which are populated by human beings who are equipped with such systems. The economizing properties of ecological rationality provide the theme of Vernon Smith's (2003) Nobel lecture, in which Hayek is appropriately cited; and for him as for these earlier authors the preservation of such established structures is an important economising principle. The practice of mainstream economists naturally exemplifies a reliance on rules and institutions in doing economics, and the consequent preservation of existing structures, rather than the principles of global rationality which are apparently embodied in their models.

> The routines and institutions within Smith's, Marshall's and Hayek's psychological systems have the additional merit of focusing attention on the issues for which they are inadequate at any particular time; consequently these are systems in which the

> evolutionary sequence of variety generation, selection, and the preservation of selected variants in the form of modified or novel routines and institutions is a natural occurrence. Indeed, one can say that there can be no evolution without routines. This evolutionary sequence may be handled, in somewhat different ways, at several levels; these may include, for example, genetic and neurophysiological structures, ideas, and organizations, formal and informal, which link together clusters of routines and institutions and provide both the framework and the problems for continuing innovation.

Some implications

Let us now consider some of the implications of these psychological theories, in the light of the general corroboration and specific refinements suggested by neuroconstructivists. We shall also exploit the similarities with George Kelly's (1963) theory of personality, which focuses particularly on the problem of preserving the internal coherence of an individual's 'interpretative system' while simultaneously maintaining a satisfactory correspondence with the events that are encountered by that individual or precipitated by her actions, and in doing so provides a powerful line of enquiry into persistent biases and obstructions to learning. Apparently-relevant evidence may be ignored, and locally-effective explanations may be dismissed, because they appear incompatible with ways of making sense that have become indispensable – even in the hardest of sciences, as Ziman (1978) observes. The pathological imperative to impose such coherence on the theoretical systems of modern economics without empirical warrant or even empirical reference, which Giocoli (2003) has clinically examined, is a particularly suitable case for Kelly's treatment.

Hayek's conclusion to his investigation into the problem of psychological explanation is that, because of the limits of any apparatus of classification, 'no explaining agent can ever explain objects of its own kind, or of its own degree of complexity, and, therefore, that the human brain can never fully explain its own operations' (Hayek 1952, p. 185). Although we can hope to understand the principles underlying our own mental processes, 'mind must remain forever a realm of its own which we can know only through directly experiencing it, but which we shall never be able fully to explain or to "reduce" to something else' (Hayek 1952, p. 194). Human cognition is inevitably bounded, as Simon also insisted. Hayek also draws attention to the impossibility of achieving a full explanation of the world around us, while simultaneously supplying a principle of organisation for the human brain and for human societies; and this is the starting-point for the following discussion.

Hayek's impossibility theorem warns us that our knowledge is necessarily fallible and incomplete, but it also suggests, as do Smith's and Marshall's theories, how it may be improved and tested, and what kinds of opportunity costs are likely to be incurred along different pathways of attempted improvement. Knowledge is created by selecting connections which will constitute domain-specific modules; and we may identify two general principles on which to base this selection, which apply both to everyday cognitive operations and to those special cases in which we are consciously attempting to construct interpretative frameworks, some of which we may choose to call theories. As all four authors indicate, these cases are not so very special; Smith and Kelly explicitly focus, from different angles, on 'man as scientist'. One principle directs us towards fine discrimination in our definition of categories, at the expense of reducing the breadth of our view and ignoring interactions with the rest of the universe, thus restricting our pattern-making to a narrow domain which we may be able to explore in some depth. The second principle points towards the strategy of aggregating the elements of our universe into broad invented categories on the basis of similarities that we suppose are significant for our particular purpose, while ignoring the differences which we assume to be of little relevance for that purpose (or which we simply fail to

notice), thus creating a domain which is broad but almost empty. Normally, there is some accommodation between these two principles; and all our representations are sub-systems which include both a few external connections and a few subdivisions within their components. Though each has a physical counterpart in the human brain, all categories are conceptually located in the space of representations, and may be manipulated without further reference to what they are deemed to represent. Such manipulations may be enlightening, or misleading; much depends on how they are used (Loasby 2003).

As Hayek (1952, p. 176) pointed out, nothing can be recognised unless it can be assigned to some existing category; and all such categories are based on conjectural principles of selection. Perhaps the clearest, and prior, statement of this necessary principle of contextual similarity, and the implicit dangers of ignoring apparently irrelevant differences in favour of salient resemblances, was provided by Frank Knight (1921, p. 206). Hayek (1952, pp. 145-6) likewise emphasises that all classification must be based on selected elements, so that the resulting 'system of acquired connexions … will give only a very distorted reproduction of the relationships' which it purports to represent, and 'will often prove to be false', generating misleading expectations. Simon (1982, 2, pp. 306-7) similarly observes that because of the active filtering involved in both direct perception and the handling of information 'the perceived world is fantastically different from the "real" world'. Such representations, and the procedures that are associated with them, necessarily have limited ranges of convenience (Kelly 1963), and are therefore always vulnerable to changes in the environment to which they are applied. Hence the importance of a procedure for revising, or even replacing, classifications which no longer seem to work, and of a strong intrinsic (and therefore genetic) motivation for doing so; such revisions are of course the means by which the physical order began to emerge from the sensory order, and new sciences emerged.

The possibility of revision implies the ability to conceive of alternative principles of classification on which to construct representations – and the ability to accept them. As a clinical psychologist, Kelly was particularly concerned with the difficulties encountered by some people in preserving the coherence of their interpretative systems while making the adjustments necessary to maintain sufficient coherence with their changing external environment; and Smith and Marshall both recognized the tendency for the domain-limited systems of each individual to become more resistant to change, however desirable. Human communities may nevertheless escape, at least to some degree, the limitations of the individual. What is distinctive about our species is that the multifarious forms of the division of labour among its members have produced such an unprecedented variety of domain-limited representations and so have enormously increased the collective power of human intelligence and the total of human knowledge. Hayek's account of the functioning of the human brain and neurocognitive theory both lead to the conclusion that human knowledge is necessarily dispersed and incomplete; furthermore, the particular potential and limitations of the human brain imply that knowledge can be less incomplete only if it is more dispersed. The implications for specifying the central problems of economics are not difficult to envisage.

The division of labour exploits the ability of individuals to create domain-specific networks – if they are given the freedom to so. In currently-fashionable terminology that implies delegation and empowerment, or in economic language imperfectly-specified contracts; but the obverse of such discretion is loss of control, which to those concerned with the overall efficiency of allocation, either as analysts or policy-makers, appears to be a serious deficiency. The fundamental reason for this negative perception is the illusion that the system can be safely treated as if it were fully connected (Potts 2000); this is comparable to the illusion that the connective structure of the

greatly-enlarged human brain can be genetically specified. Both illusions exclude uncertainty; but in doing so they also exclude endogenous innovation.

The incentive problems of dispersed knowledge, under the title of asymmetric information, have become a major focus of attention in economics, and that in itself is no bad thing; but because full specification (at least of all contingencies and their implications) is necessary for the calculation of system optima it is inevitable, though unfortunate, that such problems are treated as some kind of 'organisational failure', rather than being part of the pathology of success. Kirzner, by contrast, has rightly insisted on differential alertness to opportunities, which may be explained by differential pattern formation, as an essential contributor to economic progress. One important consequence of this prevalent attitude is an implicit assumption that the co-ordination of dispersed knowledge is simple if incentives are entirely compatible, whereas there is abundant evidence of the major contribution of well-intentioned misunderstandings to many failures: for those of a generous disposition, economists' recommendations to the transition economies of eastern Europe may be so classified. The apparently-analysable problems of information have diverted attention from the more fundamental issue of interpretation; asymmetric interpretation is at once a threat to co-ordination, a basis for opportunism and a route to innovation. The recent growth of interest in 'knowledge management' may provide an opportunity for a balanced analysis of the costs and benefits of the growth of knowledge, related to an understanding of the processes of this growth – but not if the management of knowledge is treated as primarily a problem of information technology.

Economic growth and the growth of knowledge both entail the division of labour in order to achieve an effective allocation of resources to the development of appropriate domain-specific cognitive modules within the economy and within society – indeed within many kinds of 'space'. As Darwin learnt from Smith, perhaps indirectly through Milne-Edwards, these are the advantages of the division of labour that have led biological evolution towards the variety of species; they have led human societies towards the variety of knowledge. The genetic specification of life forms has created many short-lived inefficient allocations of resources along the way, for only a very small proportion of all possible genetically-induced specialisations produce any advantages; but as Smith saw, the most important advantage of the division of labour is not its effective application of the differentiated knowledge and capabilities that are already available but the effects of specialisation on the generation of new knowledge and new capabilities, which also create many short-lived inefficient allocations of resources to unsuccessful novelties along the way to significant improvements. Our introductory survey of the psychology of wealth is sufficient to show that 'optimal allocations' cannot be defined. The economy is an evolving system which is continually creating and modifying domain-specific modules of knowledge, and of productive organisations that are based on particular combinations of knowledge.

The realisation of this potential would be very severely restricted if domain-specific modules could be created only by genetic mutations and natural selection among the variants that they produce. Much more can be achieved once genetic mutations (which cannot, of course, be contrived) begin to supplement the programming of behaviour with the potential to develop domain-specific programmes of behaviour within the individual brain; for this allows the division of labour to be extended and knowledge to be improved within a human lifetime – especially when an increase in brain size expands the range of possible connections. As in the economy, the realisation of this potential requires a relaxation of control; and it was therefore fortunate that the genome did not grow enough to permit an increase in genetic instructions to match the increase in brain size. The imperfectly-specified brain structure has similar merits to the imperfectly-specified contract of the Coasean firm and the imperfectly-specified activities of a Hayekian economy. The implications for the organisation of economic activity of the characteristics of the human mind provide tomorrow's theme.

References

Audretsch, D. B., Baumol, W. J., and Burke, A. E. (1999) Competition policy in dynamic markets. *International Journal of Industrial Organization* 19: 613--64.

Bates, E., Elman, J., Johnson, M., Karmiloff-Smith, A., Parisi, D., and Plunkett, K. (1998) Innateness and emergentism, in: Bechtel, W. and Graham, G. (eds.), *A Companion to Cognitive Science*. Basil Blackwell, Oxford, pp. 590--601.

Bain, A. (1864) *The Senses and the Intellect*, 2nd edn. Longmans Green and Co, London.

Bain, A. (1865) *The Emotions and the Will*, 2nd edn. Longmans Green and Co, London.

Butler, R. (1991) The historical context of the early Marshallian work. *Quaderni di Storia dell'Economia Politica* 9 (2-3): 269-88.

Cattaneo, C. (2001 [1861]) *Del Pensiero come Principio d'Economia Publica*. Libri Scheiwiller, Milano.

Cosmides, L. and Tooby, J. (1994) Origins of domain specificity: the evolution of functional organization, in: Hirschfeld, L. and Gelman, S. (eds.), *Mapping the Mind*. Cambridge University Press, Cambridge.

De Vecchi, N. (2003) The place of gestalt psychology in the making of Hayek's thought. *History of Political Economy* 35 (1): 135--62.

Giocoli, N. (2003) *Modeling Rational Agents: From Interwar Economics to Early Modern Game Theory*. Edward Elgar, Cheltenham UK and Northampton MA, USA.

Groenewegen, P. D. (1995) *A Soaring Eagle: Alfred Marshall 1842-1924*. Edward Elgar, Aldershot.

Hayek, F. A. (1952) *The Sensory Order: An Enquiry into the Foundations of Theoretical Psychology*. Routledge, London.

Hume, D. (1875) *Essays Moral Political and Literary*, vol. 2. ed. Green, T. H. and Grose, T. H. Longmans Green and Co., London.

Karmiloff-Smith, A. (1998) Development itself is the key to understanding developmental disorders. *Trends in Cognitive Sciences* 2: 389--98.

Karmiloff-Smith, A. (2002) Elementary, my dear Watson, the clue is in the genes … or is it? *Proceedings of the British Academy* 117: 525--43. Oxford University Press for the British Academy, Oxford.

Kelly, G.A. (1963) *A Theory of Personality*. W. W. Norton, New York.

Knight, F. H. (1921) *Risk, Uncertainty and Profit*. Houghton Mifflin, Boston. Reprinted University of Chicago Press, Chicago 1971.

Lashley, K. S. (1929) *Brain Mechanisms and Intelligence*. University of Chicago Press, Chicago.

Loasby, B. J. (2001) Selection processes in economics, in: Dopfer, K. (Ed.), *Evolutionary Economics: Program and Scope*. Kluwer Academic Publishers, Boston, Dordrecht and London, pp. 253--76.

Loasby, B. J. (2002) The evolution of knowledge: beyond the biological model. *Research Policy* 37: 1227--39.

Loasby, B. J. (2003) Closed models and open systems. *Journal of Economic Methodology* 10 (3): 285-306.

Marshall, A. (1920) *Principles of Economics*, 8th edn. Macmillan, London.

Marshall, A. (1994) Ye machine. *Research in the History of Economic Thought and Methodology, Archival Supplement 4*: 116--32. JAI Press, Greenwich, CT.

Milne-Edwards, H. (1827) Nerf, in: Bory de Saint-Vincent, M. (Ed.) *Dictionnaire Classique de l'Histoire Naturelle*, 17 vols. Rey et Gravier, Paris.

Penrose, E. T. (1952) Biological analogies in the theory of the firm. *American Economic Review* 14: 804-19.

Penrose, E. T. (1959, 1995). *The Theory of the Growth of the Firm*. Basil Blackwell, Oxford (1959); Oxford University Press, Oxford (1995).
Pinker, S. (1997) *How the Mind Works*. W. W. Norton, New York.
Pinker, S. (1999) *Words and Rules: The Ingredients of Language*. Basic Books, New York.
Potts, J. (2000) *The New Evolutionary Microeconomics: Complexity, Competence and Adaptive Behaviour*. Edward Elgar, Cheltenham UK and Northampton MA, USA.
Raffaelli, T. (2003) *Marshall's Evolutionary Economics*. Routledge, London and New York.
Ryle, G. (1949) *The Concept of Mind*. Hutchinson, London.
Simon, H. A. (1982) *Models of Bounded Rationality*. 2 vols. MIT Press, Cambridge MA.
Smith, A. (1976a [1759]) *The Theory of Moral Sentiments*, ed. Raphael, D. D. and Macfie, A. L. Oxford University Press, Oxford.
Smith, A. (1976b [1776]). *An Inquiry into the Nature and Causes of the Wealth of Nations*, ed. Campbell, R. H., Skinner, A. S. and Todd, W. B. 2 volumes: Oxford University Press, Oxford.
Smith, A. (1980 [1795]). The principles which lead and direct philosophical enquiries; illustrated by the history of astronomy, in: *Essays on Philosophical Subjects*, ed. Wightman, W. P. D. Oxford University Press, Oxford, pp. 33--105.
Smith, V. L. (2003) Constructivist and ecological rationality. *American Economic Review* 93 (3): 465-508.
Whitaker, J. K. (ed.) (1996). *The Correspondence of Alfred Marshall Economist*. 3 vols. Cambridge University Press, Cambridge.
Ziman, J. M. (1978) *Reliable Knowledge*. Cambridge University Press, Cambridge.
Ziman, J. M. (2000) *Real Science: What It Is, and What It Means*. Cambridge University Press, Cambridge.

ORGANIZATION AND THE HUMAN MIND

Brian J. Loasby

What bounds on rationality?

The twin foundational principles of this paper are that the structure and working of organisations reflect the characteristics of the human mind and that the analysis of organisations should respect this relationship. This presentation will accordingly draw primarily on the theories of the mind discussed in the preceding paper. However no analysis of organisation should ignore the work of Herbert Simon, and that is where I shall begin (using some passages from Loasby 2004). As we shall see, there is a substantive correspondence between Simon's ideas and these earlier theories, beginning with a common focus on the interactions between structure and process.

Simon is the most explicit about the methodological issue.

> Nothing is more fundamental in setting our research agenda and informing our research methods than our view of the nature of the human beings whose behavior we are studying.
>
> Herbert Simon (1985, p. 303)

This principle is, of course, applicable to the whole of economics, as to all attempts to study human behaviour; but it may be thought especially relevant to analyses of the organisation of economic activities, both designed and emergent, and to attempts to prescribe improvements in this organisation. It is important to add, as Simon did, that we need to consider human nature in its environment, both because of the evolutionary processes by which that environment has influenced human nature and because what kinds of behaviour and what kinds of organisation, among the repertoire of human possibilities, are likely to be effective naturally varies with circumstances. As shown in the preceding paper, the interaction between internal and external environment is the driver of Smith's (1980 [1795]), Marshall's (1994) and Hayek's (1952) theories.

Simon's 'view of the nature of human beings' is typically summarised as 'bounded rationality'. For many economists this is interpreted as a peripheral irrationality which provides an error term in models of rational choice; its effects are therefore of secondary importance and may accordingly be left to psychologists and sociologists. A few economists, however, have found 'bounded rationality', suitably domesticated, to be a convenient instrument for coping with particular anomalies within the theoretical system of modern economics. The most notable example, which is directly relevant to the present theme, is its invocation to explain the existence of firms in an analytical scheme which proceeds directly from data to an equilibrium allocation and therefore has no room for them. By combining opportunism with narrowly-specified restrictions on the ability of individuals to meet all the requirements of the standard model (such as debarring them from writing contracts that include all contingencies or from correctly observing all states of the world) it can be shown that the overall efficiency of outcomes may depend on who makes which

decisions. The restrictions are themselves so limited that their consequences are known to all relevant agents, and so one can deduce a rational choice equilibrium of property rights in which what is allocated is the right to take particular classes of decisions.

This theory of property rights is offered as the rationale of the firm; the intellectual standing of its principal exponents has made it generally acceptable, although some leading theorists are still uneasy about the apparent compromise with methodological purity. Oliver Williamson's theory also turns on the allocation of property rights, and has also gained considerable acceptance because it conforms to this format of an equilibrium of almost-perfectly rational agents; but his insistence on the importance of a hierarchy, within which post-contractual decisions can be enforced according to the terms of the contract, takes us beyond property rights towards the concept of firms as organisations, and is correspondingly less acceptable by modern standards of rigour. Nevertheless Williamson (e.g. 1997, p. 130) is himself insistent that firms are no more than a defence against opportunism and can exist only in circumstances when markets fail to offer protection – and moreover fail so badly as to outweigh the consequences of forgoing the 'high-powered incentives' that only markets can provide. In Williamson's as in standard property-rights models, firms are not necessary for production, because production knowledge is available to all (Demsetz 1988, p. 150); they are incentive structures which ensure that the analysis of production remains within the established models of equilibrium, and is thereby insulated from bounded rationality. This separation helps to explain why even Williamson offers no theory of management; post-contract control is simply a set of instructions to subordinates that validate the rational expectations on which the governance system was based. There is no process.

This is some way from Simon's ideas, as Williamson himself has recognised. Though he agrees with Simon that 'the importance of intentional governance has been undervalued' he immediately and explicitly dissociates himself from Simon's (1991, p. 27) vision of an economy that is dominated by conscious organisation: 'that we appear to be subject to intentional governance structures everywhere we turn is misleading: the real action is largely invisible' (Williamson 1996, p. 145). Williamson has used the opening quotation of this paper to justify his own analysis; but the only aspect of human nature on which he relies is opportunism, and his repeated assertion that in the absence of opportunism there is no theoretical reason for the existence of firms reveals that his view of the nature of human cognition is identical to that which underlies rational choice theory; and that view has no distinctively human reference (Giocoli 2003).

Economic theorists seem more concerned to save the theory than to understand the phenomena of business organisation; as we shall see this desire to preserve existing cognitive structures is a major influence on both individual and organisational behaviour – and in many other contexts. Even the exclusive focus on the internal consistency of models without regard for consistency between models and phenomena to which they might be applied, so incisively documented by Giocoli (2003), is by no means peculiar to economics. Nicolai Foss (2001) has pointed out that Williamson's account of intentional governance, although allowing for superior-subordinate relationships that are not encompassed by principal-agent models, provides a very 'thin' theory of organisation, because it is based on a very 'thin' notion of bounded rationality. Foss is seeking something better; and he suggests that psychologists have supplied enough evidence of systematic patterns of behaviour that violate the standard rationality assumptions in orthodox economics to permit much 'thicker' theorising about organisational problems and organisational remedies. In addition to respecting Simon's (1991, p. 43) call for 'empirically sound theories' which make some direct reference to evidence about human nature, this proposal has the substantial merit of suggesting a continuing role for managers within a firm: the establishment of a firm is not the end but the beginning of analysis, as Simon wished.

In one important respect, however, Foss's proposal is still inadequate; it continues the established tradition of regarding firms as devices to protect against human inadequacies. If we wish to honour the memory of Herbert Simon (and also to improve our understanding of the working of economic systems and develop a better basis for policy recommendations) we should do better than that; and we should start, as Simon proposed, by taking a more careful look at the nature of human beings than most economists have been prepared to do in the past half-century. Our analysis should be based on an understanding of the distinctive capabilities, as well as the limitations, of the human mind. We may then observe that capabilities and inadequacies are often related. Indeed the systematic patterns of apparently 'non-rational' behaviour presented by Foss provide an immediate example, for they are pathologies of the particular evolved characteristics of human cognition which have valuable consequences. Many features of economic and social organisation may be explained as responses (often unintentional) to the potential as well as the pathology of this cognition. (That valuable characteristics are typically accompanied by their own particular pathologies is an example of the ubiquity of opportunity costs, which should be a key concept in evolutionary theories.) Organisation is much more than a response to either human or market failure – and much more than a means of optimisation.

Integral and non-integral systems

In the same year in which Debreu published his definitive analysis of general equilibrium, Simon observed of the choice-theoretic tradition in economics that

> when perception and cognition intervene between the decision-maker and his objective environment, this model no longer proves adequate. We need a description of the choice process that recognizes that alternatives are not given but must be sought; and a description that takes into account the arduous task of determining what consequences will follow on each alternative.
>
> (Simon 1959, p. 272)

Jason Potts (2000) has recently emphasized the fundamental difference between these two conceptions of analysis. General equilibrium exists in integral space, which ensures that every element in the system is directly connected to every other element; thus every preference, resource, commodity, location, date and contingency enters directly into the determination of the solution for the system being modeled. In integral space there is no room for dense clusters of connections, such as those that constitute firms or markets. 'Organization' as a topic is undiscussable.

Equilibrium allocations are derived from the data, and do not depend on rational choice by anyone within the system; from the perspective of economic theory, therefore, it is of no account that rational choice theory has so little relevance to the process of decision-making, with which Simon was concerned. Indeed, the role of economic agents, however rational, is incompatible with the concept of a fully-connected system; it is necessarily true that, as Frank Hahn (1984, p. 64) observed, 'traditional economic theory does best when the individual has no importance – he is of measure zero'. Any interaction within a subset of agents implies non-integral space and highly selective connections, and therefore requires a different category of analysis. Whether a multitude of such local interactions replicates the deduced allocation is a question which cannot be properly formulated within the conventions of general equilibrium models, as Richardson (1960) demonstrated – not least because the concept of 'time' as a period during which these interactions

take place is categorically distinct from the concept of 'time' as a dimension of all goods which is embodied in the specification of the general equilibrium model.

Perception and cognition have no usable meaning in integral space, since their significance is defined by the selectivity of the connections by which they are constituted. In sharp contrast to the standard assumption that the information available to agents is always a partition of the full information set which corresponds precisely to the configuration of the economy, the selectivity of perception and cognition results from conjectures (rarely completely conscious) that are imposed on phenomena. It is not then surprising that 'the decision-maker's information about his environment is much less than an approximation to the real environment' (Simon 1959, p. 272), especially when we recognize that the relevant 'real environment' is nothing less than the total system, including its structure of connections. 'The decision-maker's information' itself rests on perceptions which are themselves structures of connections, and so the knowledge within an economy is always dispersed and incomplete, as Hayek insisted. That of, course, is why the performance of economic systems depends on the way that they are organized. What is crucial to our understanding of economic organization and economic development is that this dispersion and incompleteness is not simply a 'failure', but a condition of success – because of the nature of human beings who, as explained in the previous presentation, are obliged to economise on cognition but are then able to use it to create new representations and new capabilities within particular domains.

Rational choice theorists have preserved their conceptual system by endowing economic agents with 'rational expectations' which are the equivalent of the analyst's integral model and even allow the set of agents to be collapsed into a single representative agent. The essential incompleteness of connections, which is the precondition of organisation – including the organisation of markets, which are a pure fiction in standard equilibrium models – and the essential incompleteness of knowledge both require an analytical foundation in non-integral space. Simon (1991, p. 27) argues for 'the ubiquity of organizations': I suggest that we delete the final letter, and emphasize the ubiquity of organisation, because perception, cognition, and decision processes, for individuals as well as firms, are organizational phenomena. Methodological individualism should begin, not with preference sets and possibility sets, but with evolving cognitive structures. Connections matter (Loasby 2001).

It is within non-integral space that we can begin to explore the implications of Marshall's (1920, p. 138) linked principles: 'Knowledge is our most powerful engine of production. … Organization aids knowledge'. (This passage dates from the fourth edition of 1898.) Simon's (1991, p. 28) suggestion that 'organizational economy' is a more appropriate term than 'market economy' is powerfully reinforced by the recognition of the intimate connection between organisation and the knowledge on which an economy – especially a modern economy – depends. This connection also suggests that the familiar contrast between 'firm' and 'market' may be misleading; in addition to the variety of intermediate relationships to which Richardson (1972) drew attention, there are 'market' elements within many firms, and 'markets', like firms, are important features of organisation. The multiplicity of markets reflects the advantages of specialization in the organisation of particular kinds of transactions, where the classification of transactions is the product of human minds and continues to evolve as a product of experience and imagination. Markets rest on institutions (Ménard 1995), which emerge from human behavior, both conscious and unconscious; as Schumpeter (1934) and Casson (1982) noted, they may be the focus of entrepreneurial actions. Both firms and markets are structures that facilitate human interaction by reducing transaction costs through various kinds of investment, and the flexibility of both depends on imperfect specification.

Why should organisation aid knowledge? The essential point is that knowledge itself is organisation: 'Whatever we call reality, it is revealed to us only through the active construction in which we participate' (Prigogine and Stengers 1984, p. 293). As Simon (1959, p. 273) observes, if perception is a filter, then 'the filtering is not merely a passive selection … but an active process involving attention to a very small part of the whole and exclusion, from the outset, of almost all that is not within the scope of attention'. The possibility of establishing 'true knowledge' on an undisputable basis, either axiomatic or empirical, was conclusively refuted by David Hume (if not earlier); and in the preceding paper we saw how Hume's friend Adam Smith (1980 [1795]) produced a remarkable psychological theory of the development of human, and eventually scientific, knowledge as a work of human imagination by which order was imposed on otherwise unaccountable phenomena through the invention of 'connecting principles'. Because, to use Karl Popper's term, all knowledge consists of conjectures, it is always liable to be confronted with anomalies; and a persistent failure to accommodate anomalies provides powerful psychological incentives to invent a new set of principles that will restore the comfort of understanding. The increasing focus on incentives within economics has not yet encompassed these particular motivations, which seem to be no less powerful than opportunism, and no less significant in their effects.

From rationality to cognition

I am afraid we must conclude that, in relation to conventional economics, 'bounded rationality' is not a good label for the view of human nature on which Simon wished to base his analysis, because it has been interpreted as an occasional and strictly limited exception to the norm of unbounded rationality, which might be useful in resolving some awkward anomalies such as the existence of firms. Even Foss's proposal to make use of the evidence of psychologists seems to suggest that firms exist in order to cope with a well-defined class of systematic departures from a norm of strictly rational behaviour. But if the adjective is unfortunate, so is the noun; for once we accept that rationality is bounded, the economic concept of 'rationality' is insufficient, and 'optimality' is simply not good enough. Quite different cognitive skills are now required. (For a discussion of such skills, see Gigerenzer and Selten (2001), who emphasise the efficacy of 'boundedly rational' heuristics.) Therefore instead of thinking only about remedies for particular deficiencies of rationality we should turn our attention to the means of exploiting the remarkable human cognitive skills of classifying and connecting phenomena and ideas, which Adam Smith identified as the prime instruments of both scientific and economic progress.

As is well known, Simon gained early inspiration from Chester Barnard; and Barnard had very clear views on the relationship between human nature and the environment. In a lecture on 'Mind in human affairs', printed as an appendix to *The Functions of the Executive*, he emphasised the importance of such skills in the many situations in which there was no adequate basis for logical operations. 'Much of the error of historians, economists and all of us in daily affairs arises from imputing logical reasoning to men who could not or cannot base their actions on reason' (Barnard 1938, p. 305) – because, even if the logic is impeccable the premises are typically ambiguous, erroneous or incomplete (Barnard 1938, p. 304). 'The correctness of such decisions must, therefore, depend upon the effectiveness of the mental processes of the type that can handle contingencies, uncertainties and unknowables' (Barnard 1938, p. 312). Logical reasoning has a role in these processes, by identifying implications and inconsistencies, but they require a human mind which cannot be represented adequately as a general purpose information processor, but one which operates within particular localised frameworks and uses particular criteria, all developed within particular environments (as discussed in the preceding presentation). As Barnard (1938, pp. 301-2) observes, this creates difficulties in adjusting to new kinds of work, however complete the advance

provision of knowledge, and in achieving understanding between persons or groups. Barnard cites his own experience in moving between jobs, but such difficulties arise whenever there are attempts to reorient well-established businesses. These cognitive and organisational problems provide a rationale for Schumpeter's initial association of entrepreneurship with outsiders.

The switch from rationality to cognition entails, I believe, a shift of emphasis from symbol processing, on which Simon focused his attention by way of computer models of artificial intelligence, to pattern-making and pattern-using. Symbol-processing has the dual virtues of directing our thoughts to how problems are handled and reminding us that our mental processes necessarily take place in the space of representations, and not in the space of real-world phenomena. The correspondence between the two spaces (which Popper called World 3 and World 1) is problematic, and may be extraordinarily flimsy. Simon was well aware of the importance and the fallibility of representations, more aware than politicians, business strategists and economists often seem to be. However, I suggest that the most promising approach to understanding representations is not by modelling humans as analytic engines but through the human facility for pattern-making, by which representations are created. (The substantial precedents created by economists for this approach provided the basis for yesterday's presentation.) This leads us to recognise the importance of locally-connected systems rather than a general processing capability. A recognition that all decisions are necessarily 'framed' will allow us to understand Foss's examples as part of the pathology of a capability that can also be remarkably effective, and to incorporate Foss's proposal into a balanced appraisal of organisations as structures which may help to realise cognitive potential while combating cognitive error and opportunism – and, of course, which often fail to do so.

George Kelly's (1963) *Theory of Personality* is remarkably similar to Adam Smith's theory of science and to Shackle's (1967) reinvention of the latter. A 'sense of order and consistency' (Shackle 1967, p. 286) is a psychological necessity, and this order must be created by the human imagination. Experience is not a sequence of events, but is constituted by the order that is imposed on them (Kelly 1963, pp. 72-4): thus a sequence of events may constitute different experiences for different observers. Kelly (1963, p. 8), like Simon, insists that perceptions are themselves 'entirely real', and have real and analysable consequences. (Giocoli (2003) argues that the perceptions of economists – paradoxically including the perception that all human mental processes must be internally consistent, implying that Kelly's (1963) concerns are illegitimate – have had major consequences for the development of economics.)

For Kelly as for Smith, time is fundamental, because time brings change. We make patterns of what we think might be viable subsystems, and use them as heuristics, both for action and for absorbing (or adapting) new knowledge. All heuristics are limited in their applicability, and these limitations carry the potential for systematic error, especially when faced with novelty – which may not be recognised as novelty. A substantial degree of decomposability, as Simon insisted, is essential, but decomposability tends to degrade with time, as Kelly and Marshall both recognised; and 'time provides the ultimate bond in all relationships' (Kelly 1963, p. 6) – but not as domesticated within an Arrow-Debreu equilibrium. Local patterns provide local structures within which to think and act; but compatability between patterns that may be juxtaposed is also a psychological need. The search for compatability may be a major stimulus to the creation of new knowledge and new skills; but individual failure to achieve or maintain internal coherence may be disastrous, paralysing action and even leading to mental breakdown, which was Kelly's professional concern. As we shall see, these human characteristics are significant in explaining the organisation of economic activities**,** and also in explaining organisational pathologies, from systematic weaknesses to ultimate collapse, as we have seen in individual businesses, industrial districts, and economic systems.

Making patterns, in the form of grouping phenomena according to some principle of similarity while ignoring differences in other respects, was identified by Knight (1921, p. 206) as a condition of intelligent behaviour in an uncertain world. (On one occasion when I was explaining Knight's principle, one member of the audience commented that this behaviour was better described as 'sane', rather than 'intelligent'; this perceptive comment links Knight's analysis precisely to Kelly's.) Unlike Knight, Simon never sought to base his approach on fundamental uncertainty; he was content to rely on the interaction between complexity and human limitations to generate endogenous uncertainty. That allowed him to demonstrate that even in situations – notably when playing chess – for which it can be demonstrated that there is in principle a correct procedure, and therefore no intrinsic uncertainty in Knight's sense, there is nevertheless no possibility of formulating this correct procedure, and players must find their own guidelines. This demonstration may be thought of as the equivalent of a victory when playing away; however, such 'certainty in principle' invites representation as unqualified certainty, or well-defined risk (which immediately rules Simon's match-winning goal offside), within a model that serves what Shackle (1967, p. 288) called 'the chief service' of a theory in offering protection from 'the uneasy consciousness of mystery and a threatening unknown'. Knightian uncertainty cannot be so represented, though it may be, and has been, denied or ignored; it also has the particular advantage, emphasised by Knight, of providing theoretical space for entrepreneurship.

If there are no demonstrably correct procedures for making decisions, then the decisions themselves cannot be predicted without some knowledge of the procedures which are being followed by the decision makers, and nor can the actions which they initiate. Individuals matter, because the individual organisation of knowledge influences both actions and the development of knowledge. An inescapable consequence is that it is impossible to be certain about the decisions of others that may affect the outcome of a choice that one is about to make. Thus decision-making systems, such as firms, require to be organised, and we are therefore directed towards Simon's theme of the decision premises and procedures by which this is done, and the influences on the quality of the decisions that emerge from them, broadened to incorporate linkages between decision-making systems (for example within networks of firms) and more generally to the role of institutions and informal organisation (which was emphasised by Barnard) in channelling behaviour. Organisations (of many kinds) and institutions matter, because they provide a (fallible) basis for securing compatability between their members.

We are also directed towards a second theme, which is much more closely associated with George Shackle, though it is clearly foreshadowed by Knight's insight that uncertainty is the precondition of entrepreneurship. Opportunities as well as contingencies and interdependencies may be unknown; where there are no demonstrably correct procedures there is scope for novelty, and thus for the generation of variety that is essential to any continuing process of evolution. Coping with uncertainty merges into 'the general problem of management' (Knight 1921, p. 259), which in the end cannot be separated from enterprise – as Marshall insisted, in accordance with his own theory of the human mind (Marshall 1994). Knight's focus on the indispensability of procedures that rely on problematic categories even supplies a theoretical basis for Schumpeterian entrepreneurship as a vision of new combinations – each of which is essentially an organisational problem, first within the brain and subsequently within the economy. Shackle's contribution is the importance of imagination as the counterpart of uncertainty, though we should not forget the central role of imagination in Adam Smith's (1980 [1795]) account of the growth of knowledge. Simon's own insistence that the range of alternatives between which people choose is a product of the decision process leaves ample scope for imagination; and people differ in their capacity for imagination and in the particular connections that they make.

For a link between Shackle and Simon we cannot do better than to cite Shackle's (1969, p. 224) proposition: 'The boundedness of uncertainty is essential to the possibility of decision'. My own view is that 'bounded uncertainty' rather than 'bounded rationality' is the right end from which to start. Our systems of thought set fallible bounds to uncertainty: they are not simplifications of known complexities**,** but have to be created by our own imagination. Organisations likewise set bounds to uncertainty both for the organisation as a whole and for its subdivisions – or, to be more precise, for the individuals who have responsibilities for the system and its subsystems, and they do so according to Knight's principle of supposedly-relevant similarities. It is because we all need such bounds that we commonly observe, as Simon noted, members of an organisation internalising decision premises that are supplied by that organisation (and which may even have been formulated by people who have long departed); this need crowds out a good deal of opportunism. Witt (1999) has suggested that the creation and maintenance of compatible interpretations within a firm is a major entrepreneurial role. Since there is no demonstrably correct procedure for determining the bounds of uncertainty it is not surprising that there will typically be some variation, even between organisations that are apparently engaged in similar activities; such intra-industry variation was Marshall's distinctive complement, inspired by Darwin, to Smith's (1976b [1776]) principle of the division of labour, and it was presented, not as a sign of remediable inefficiency, but as a source of progress.

From individual to organisation

The total knowledge and skill, and the particular content of knowledge and skill, that is available to a society, depends on the way in which the potential for development at the level of the individual is organised within the economy. The psychology of wealth leads to a particular perspective on this problem of organisation. We can see at once that it requires a balance between apparently conflicting principles: the coherence, and therefore the effectiveness, of this differentiated system requires some degree of compatability between its elements, but the creation of differentiated knowledge and skills depends on the freedom to make idiosyncratic patterns by thinking and acting in ways which may be radically different from those of many other people. The relative importance of compatability and independence, of course, varies enormously across an economic system, and so any tolerably successful system requires a combination of many different kinds of balance. The drastically simplified categories of 'firms' and 'markets' do at least recognise the need for the co-existence of arrangements that emphasise independence and arrangements that emphasise co-ordination; but each category contains many different degrees and kinds of balance between the two, and there are also many arrangements that do not fit easily into either, as Richardson (1972) pointed out. Richardson also showed how to make sense of this multiplicity of arrangements by analysing the interplay of degrees and kinds of similarity and complementarity between the capabilities (which we may think of as patterns of selected connections) that are required in any modern system of production.

In considering how one might effectively organise activities which are to be controlled by many brains, it is helpful to identify some principles which are common to the structure and working of the brain and of organisations: and we can do this by drawing on the preceding presentation. The natural starting-point for an economist is the importance of economising on what we may call 'the costs of running the system'; the phrase is adopted from Kenneth Arrow, who unfortunately has not given much thought to the costs of running mental systems. These costs impose a requirement to be highly selective in forming connections and thereafter in relying on them, within individual brains, formal organisations, and economic systems (a requirement which was ignored in turn by advocates of central planning and of supposedly pure market systems); they

also imply an essential complementarity (as well as conflict) between routine and innovation, to which we will return very shortly. This commonality of problems can in the end be traced back to the simple fact that the formation and the functioning of social organisations (unlike chemical compounds) is strictly (though not exclusively) dependent on the behaviour of the human beings that contribute to their formation and their operation, behaviour which in turn is strictly (though not exclusively) dependent on the functioning of the human brain.

We will now briefly consider some of the issues that arise from this cognitive perspective on organisation.

Baselines

A fundamental characteristic of the cognitive theory underlying this presentation is the intimate dependence of all change on the absence of change. Systematic development is impossible unless there is a stable baseline from which to begin and a stable environment against which options may be assessed, and which may give direction to deliberate attempts to generate conjectures. Smith's (1980 [1795]) psychological theory was illustrated by the history of astronomy, for which the heavens provided a stable environment, subject to improving techniques of observation; and the sequence of robust interpretative systems examined by Smith resulted from the rearrangement of 'connecting principles'. When, two centuries later, Kuhn (1962, 1970) produced a theory of scientific development, it was in most respects remarkably close to Smith's, and also illustrated by the history of astronomy; but Smith, unlike Kuhn, took care to explain the continuity that underlay the apparent discontinuities of theory.

Routines stabilise evolved patterns, thus releasing mental energy and providing a basis for experiment; this interplay between routine and innovation, within an individual, a firm, an industry, and an economy, is a pervasive theme in Marshall's economics (Raffaelli 2003). Thus a sensible use of the concept of equilibrium is to enquire which elements of a system stand in an equilibrium relationship to each other; for these equilibrium relationships provide the foundations of change. Marshall's period analysis relies on period-specific equilibrium relationships to explain period-specific adjustments. A natural consequence of this dependence of innovation on stability (which is also essential to neo-Darwinian theory) is a substantial degree of path-dependency within each cognitive domain – including that of a whole economy, as is indicated by Marshall's (1919) surveys of national systems; but this tendency is partially offset by the variety and the quasi-independence of domains – another consequence of the combined effects of cognitive limitations and the division of labour. The maintenance of stable baselines within particular domains is a prime function of formal organisations, and the appropriateness of the baseline is a major determinant of organisational success or failure.

Limited domains

The universal importance of limited domains (in contrast to general equilibrium) is a key concept in the analysis of individual cognition, and therefore in economic organisation. Domain-specificity, the usual label, is misleading, because the term suggests too narrow a range and far too much precision. Although some domains are both narrow and well-defined, usually there is some breadth of application and the limits are not well understood (as Knight and Hayek, for example, make clear in writing of the fallible bases of categorisation). We may recall from our previous excursion into biological evolution that the genome appears to have evolved as a method of constructing a system of domain-specific elements, embodying Smith's principle of the division of labour; but the remarkable enlargement of the human brain led to a partial but significant movement

away from genetically-determined domain-specificity within the brain towards a genetically-enabled potential for developing domain-limited processes at the level of the individual, as suggested by Karmiloff-Smith and her associates. Though such individual development may simply modify genetically-endowed patterns, it may also lead, as Hayek argued, to the creation of novel – and additional – patterns of connections within the brain, such as those that constitute the physical order; and these patterns are produced, as Smith and Shackle notably emphasised, by the human imagination, which operates at the second level of Marshall's 'machine'. Though the results of genetic evolution are still pervasive, there are now significant possibilities for development at the level of the individual to modify, and even sometimes to override, development at the level of the human species.

The evidence on facial recognition (Karmiloff-Smith 2002) presented in the preceding paper is particularly relevant at this point. The motivation to recognize faces is, we may presume, a shared genetic endowment – its advantages in the formation of human society (including its importance in controlling opportunism) are obvious; but it is not linked to a unique facial module. Recalling that recognition by feature is always employed by those affected by the Williams Syndrome, but also by those not so affected when they are presented with inverted faces, we may identify recognition by feature as the default mode; configural recognition is employed by those who have the requisite capability and have also been presented with the material that is necessary to build patterns. Pattern-making is an inherited capacity, which may therefore be impaired by a genetic disorder; how that capacity is used depends on the environment and individual attempts to make sense of it. The use of different procedures for upright and inverted faces is also a demonstration that domains of application may become very specific through development; few people encounter inverted faces frequently enough to build appropriate patterns by which to identify them, but experiments with inverting spectacles have shown that it can be done. There is a familiar economic principle at work here; investment in developing the skill of configural recognition within a specific domain, such as inverted faces, is not justified if this skill is very rarely used.

Developed capabilities are configurations that economise on cognition by the creation of cognitive capital that is appropriate to particular fields; Marshall (1920, p. 251) explains how someone who has learnt to skate can employ that routinised knowledge as a unit in constructing more elaborate figures, and the release of mental energy by the development of automatic connections becomes the operating principle that generates the benefits of an appropriately-organized division of labour. Smith showed how human motivation could guide this investment of rather general pattern-making skills in domain-limited configural capabilities, drawing his examples from the physical order; and Ziman (2000, p. 120) points out that 'pattern recognition is deeply embedded in scientific practice', noting that the construction, use and modification of such patterns within each scientific field is a particular (we may say domain-limited) application of a universal and inter-subjective human capability. Even skills of integration across domains are themselves domain-limited; for each individual, as the careers of 'Schumpeterian' entrepreneurs have shown, they are normally restricted to particular categories of 'distant and dissimilar objects'.

The mental orders that are created by our imagination and tested in particular domains (ranging from very carefully controlled experimental settings to casual application – which may itself be very local or a broad commitment) are themselves forms of organisation, for all knowledge is a structure of selected connections. Now although much of our 'life-world knowledge … is coded organically into our behaviour, genetic make-up and bodily form' (Ziman 2000, p. 299), the mental orders generated by the imagination vary greatly across individuals; and this variation may be decisively influenced by created as well as natural environments. Education in any scientific discipline is intended to produce such influence; so is any commercial organisation. Consequently

the knowledge available in any human society depends on organisation – which means on particular patterns of connections – of the kinds listed by Marshall; these exploit the advantages of similarity (which depend not on total homogeneity but on local variation within imperfectly-specified patterns, as in genetic modifications) and of differentiation, which can produce new species of knowledge incomparably faster than genetic evolution. The distribution and selective connection of domain-limited modules within the economy is a central issue for explaining economic development and for effective policy at the level of firms and governments.

It is important that the resulting knowledge-domains should also be imperfectly specified. In Nelson and Winter's (1982) evolutionary theory, the primary units of evolution are skills, including skills of organisation, which are treated as cognitive programmes of limited scope; but Nelson and Winter take care to emphasise and to illustrate how ambiguous this scope may be, and use this ambiguity within their theory. Imperfect specification is also a condition of those experiments at the margin, inspired by differences of temperament and interpreted experience, on which Marshall relied for the variations that were 'a chief cause of progress' (Marshall 1920, p. 355), and it is essential for Penrose's (1959, 1995) central notion of the imagination of new services to be obtained from resources and of new productive opportunities to which these services may be directed.

Since increasing attention is being paid to the knowledge content of capital (of which Marshall was very well aware), it may be helpful to apply to structures of knowledge Lachmann's (1978) analysis of capital goods: they are substitutable between uses but within each use they are complementary to a particular set of other capital goods when combined in a specific way; in other words they are multi-specific. Lachmann's warning also applies: just as the value of capital cannot be maintained simply by maintaining the current set of combinations, so the value of knowledge cannot be maintained simply by perpetuating its current uses. It is indeed a most important characteristic of knowledge that it can be reused, *but in a way that is not simply deducible from current uses* – a consideration which is not prominent in endogenous growth theory, because it is not easily accommodated within the system of thought to which that theory belongs. Imagination (which Lachmann rated almost as highly as Shackle) is the genetically-derived device by which genetic evolution allows the human species to exceed the limits of genetic evolution.

The necessity of operating within limited domains is clear; and so are the advantages that result. However, economists should never forget opportunity costs. There are important disadvantages of domain-limited patterns at all levels. Though it is perhaps somewhat easier to escape from internally-generated patterns of thought and action than from those that are genetically determined, it is nevertheless true, as the studies reported by Karmiloff-Smith (2002) confirm, that patterns resulting from development become increasingly rigid. The reconstruction of a personality to match a drastically-reorganised environment is a formidable challenge. (As a problem for clinical psychologists, it stimulated Kelly's (1963) *Theory of Personality*). Changing the patterns of all the members of a group in a way that preserves intra-group compatability while adjusting to a different environment is even more difficult; reconstructing an organisation, formal or formal, of any size seems to be impossible without making some, often substantial, changes in its membership. Penrosian firms, like individual entrepreneurs, may find that nothing fails like success, because success may entrench belief in the patterns that appear to have produced it. The coherence of larger societies may depend on moderating the demands for compatability; for although, as Ziman (2000, p. 121) observes, the world-wide appeal of some soap operas indicates the similarity of evolved mental and emotional mechanisms, the power of genetics is being continually attenuated by individual and social developments which, though genetically enabled, are not genetically controlled.

Co-ordination and purpose

The counterpart of quasi-independence is the problem of co-ordination, which arises in two forms: the compatability of separately-produced knowledge, and its comprehensibility to those who have not participated in its production. The division of labour offers to the innovator the protection of cognitive distance; the integration of what has been divided requires cognitive proximity. We still feel the effects of our shared genetic inheritance, which extends beyond the substantial component of programmed behaviour to the shared procedures by which our interpretative frameworks are formed (Ziman 2000, p. 121); and Smith's (1976a [1759]) hopes for a civil society rested substantially on his argument that our common heritage allowed us to understand and appraise the behaviour of others in situations that were different from our own. Since then, however, social and economic evolution, based on an inherited capacity to create differentiated patterns, has increased the variety of situations and increased the possibilities of juxtaposing interpretative frameworks that have few elements or connections in common. Development within the individual dilutes the shared genetic inheritance of domain-specific behaviours; cultural evolution, in particular, may serve either to reinforce or to override the similarities of attitudes and behaviour embedded in humans on which both Smith and Hayek relied.

Kelly (1963) construes human personality in terms of the interpretative frameworks that guide each person's understanding and behaviour; and the failure to achieve an acceptable coherence between interpretative frameworks in a changing environment thus becomes Kelly's construction of a personal breakdown. In an organisational context, this analysis can easily be extended to include problems of incompatability between the frameworks which seem to apply in the work environment and those with which each worker is comfortable in other parts of life, and also to problems of incompatability between the changes of framework that seem to be required in different parts of the organisation to cope with major changes in the organisation's environment. 'A breakdown of corporate personality' may be an appropriate way to describe what has happened to many organisations (including the Soviet Union).

We should remember, however, that compatability may be necessary in only a few dimensions, and systems may sometimes be sufficiently connected along the dimensions where it is most readily achieved (Ziman 2000, pp. 302-6). Success may depend both on bringing some people together and keeping others apart; and this may sometimes require the redefinition of organisational boundaries, both internal and external, as Allyn Young (1928) argued. Richardson's (1972) analysis of capabilities along the dimensions of similarity and complementarity provides a basis for such redefinition. Adaptability – the capacity to modify connections – is preserved, and sometimes enhanced, by rearranging the connections between units or between levels. Such rearrangements may increase independence or exploit complementarities, thus redefining the cognitive unit, though not without creating new problems.

Coase (1937) explained the firm as a set of incompletely-specified contracts which provided resources to be deployed at some date yet to be chosen and within a domain that could be broadly envisaged, thus avoiding the cost and time of making the necessary arrangements at that date; it is an investment in creating capabilities that provide options. Flexibility is preserved by the incomplete specification of both contracts and capabilities. Firms therefore require a combination of discretion and purpose – the scope for choice, and the capability and will to take good decisions and make them effective. This, of course, is Cattaneo's psychology of wealth; it is not what is now presented as rational choice. It requires appropriate knowledge and capabilities, both direct and indirect (the latter incorporating how to access and interpret other people's knowledge and how to get things done by other people). It also requires the appropriate premises and procedures for

making decisions, which normally include the appropriate decomposition of objectives and their distribution across individuals. Purpose is related to strategy in the old military sense of a vision of what is to be achieved, a set of assumptions on which action is to be based, and a set of principles to guide a sequence of decisions. This is very different from the degenerate sense of the term in game theory, in which strategy is degraded to a completely-specified plan. Plans are contingent schemes to implement strategy (and game theory might be used in the process of planning), but as Clausewitz observed no plan survives contact with the battle. A sound strategy, however, may survive to guide a succession of plans.

A Coasean firm is a combination of purpose and capabilities which retains sufficient degrees of freedom to allow people to take decisions that may make a difference. Like knowledge, decision spaces are representations which have to be created, by defining boundaries and selecting connections across those boundaries and between the elements within the space. This is Simon's view of organisations as decision-making systems. There is no procedure which can ensure that decision spaces are correctly defined, and there must be some possibility of modifying them; however, although the distinction is fuzzy, it is generally convenient to take separate account of management within decision spaces, together with the maintenance of these spaces, and their redefinition, whether through internal initiative or in response to the pressure of events. This distinction resembles that between detailed and architectural change in contemporary writing on strategy and management, and it may be applied not only to a single firm but also to networks or clusters of firms. A similar distinction may be applied to the organisation of knowledge, and changes in the architecture of knowledge may lead to changes in the architecture of both firms and industries. Pharmaceuticals and telecommunications are prominent current examples, and both demonstrate (as have many previous examples) that matching new structures of knowledge with new organisation is not a simple business. The limited domain-relevance of cognitive structures, compatability between domain-limited structures, and the appropriate kinds and degrees of discretion are all likely to be problematic.

Economic organisation, however it is arrived at, creates multiple frameworks for the division of labour in decision-making and in productive activities (which themselves, as Schumpeter (1934, p. 20) pointed out, entail the making of decisions). The fundamental allocation problem is who does what, and within what constraints.
The 'who', the 'what' and the constraints all contribute to the shaping of patterns of behaviour, which in turn lead to changes in economic organisation. If we focus on formal organisation, then the boundaries between firms and their internal structure have major implications for what get to be defined as issues for attention, who deals with them, by what processes and using what premises for reasoning and what criteria for choice, how these choices are implemented (and how they are modified during the implementation), what checks are made on the outcomes, and what notice is taken of the results. External boundaries should be drawn so as to leave outsiders free to develop their own distinctive patterns when these are needed to provide a firm with appropriate knowledge or appropriate capabilities. All these elements contribute to influencing whether there will be innovations in product or process and, if so, what forms these innovations take.

A firm is a sense-making system (Nooteboom 2001, p. 43); what sense it makes depends on how it separates and connects its ways of organising, creating, and using knowledge, for different structures have different implications, not only for protecting against opportunism but more importantly for creating useful knowledge. Formal organisation is an imposed order, which creates an environment for further order, both as predictable behaviour and as new structures of knowledge. This is a path-dependent process, but it is not path-determined; movement is easiest to adjacent states, but typically there are many states that are adjacent to each current position (Potts 2000), so

that even individuals or organisations with identical current positions may develop in different ways. In practice, individuals and firms will not have identical positions, even those with similar experiences and engaged in similar businesses, and this increases the potential for variation, as Marshall noted.

Organisational design exists in the space of representations; it rests on conjectures (often implicit) about the similarity and complementarity of activities to be undertaken. No organisational structure can be best for all that it does or for all the problems and opportunities that it faces; organisation provides structure for trial and error processes, but is itself subject to trial and error, with a mixture of conscious design and unintended consequences, which may be beneficial, harmful, or simply unexpected. The future manifestations of this never-ending sequence, which was most forcefully described by Allyn Young (1928), cannot be predicted because they depend on knowledge that has not yet been created; and so the efficiency of an organisation, defined as the ability to adapt to or exploit future events, can at best be defined as a region (Potts 2000, p. 95) within which order may be maintained while permitting changes which are necessary or desirable.

Institutions

So far our discussion of the relationship between organisations and the human brain has excluded (apart from passing references) what many people may think is the missing link between the two: institutions. Now I certainly agree that any comprehensive treatment of economic organisation must give a great deal of space to institutions; but, in accordance with a theme of these presentations, I am being highly selective in making connections, and inviting discussants and members of the audience to fill in some of the gaps. However, I now wish to suggest how institutions may be brought into the analysis by relating them directly to the individual. If we think of institutions as 'the rules of the game', or slightly more precisely as indicating the premises and procedures for deciding what to do, then we can see that this definition can be applied directly to the way in which the developed brain functions according to the ideas of Smith, Marshall, Hayek and Kelly. We may also agree that these premises and procedures are partly genetically determined but in substantial degree installed during the development process of each individual. The origin of the cognitive role of institutions, as premises and procedures, is therefore to be found in the development of the individual brain.

Now, as we have seen, the characteristics of the human brain limit the internal creation of premises and procedures, but these characteristics also allow them to be imported from others, either by observation or direct instruction. Moreover, we seem to be quite strongly motivated to seek guidance from others. This motivation may be genetically determined, and could have been selected at the level of the species because it accelerates development at the level of the individual. Socialisation could not be as effective as it often is if it were solely dependent on pressure (though in some circumstances there may be formidable pressure); it is often readily acceptable, and sometimes actively sought. For example, some people are very keen to learn how to behave like an economist.

Although there seems to be no reason to reject a substantial genetic influence, the widespread sharing of particular domain-relevant premises and procedures may therefore be substantially explained by individual cognitive needs. (The argument was developed by Choi 1993.) This propensity to share for individual purposes provides a natural basis for managing interactions; indeed some interactions, as we have just noted, are prompted by the desire to acquire better cognitive skills. Furthermore the experience of managing interactions by the application of

previously-developed principles could suggest how other kinds of interactions might be managed by developing new institutions, which could often be modifications of established individual practices, and also foster the belief that agreement on how to think about matters of common – or even potentially conflicting – interest might well be beneficial. This sequence also suggests how people might contrive to choose between alternative equilibria, because it tends to generate shared notions of saliency.

The creation of organisations would be extremely difficult without the pre-existence of institutions to supply some initial premises and procedures which need not be discussed in the process of organisation-building; and indeed there is clear evidence of the severe, and sometimes insuperable, problems that are readily generated by attempts to create organisations that bring together people who rely on very different institutional supports, because they come from very diverse professional, cultural or national backgrounds. Despite many years of organisation building within the European Union, such institutional differences continue to hinder agreement, most recently by prompting conflicting interpretations of how the recently-proposed new constitution may be expected to work. There is no possibility of resolving these difficulties by creating an organisation that will supersede the institutions; on the contrary, formal organisations define a privileged space for the evolution of institutions that will, it is hoped, be particularly appropriate within that space; and since evolution always start from what already exists, pre-organisational institutions are likely to have major influences on post-organisational developments. This is precisely the issue in interpreting the European constitution.

In a business organisation such difficulties are mitigated because membership is voluntary – at least in reasonably open economies that are not dominated by monopolies; and the effectiveness of a business is powerfully assisted by the development of locally-appropriate institutions within that business. That was the basic message of Peters and Waterman's (1982) best-selling recipe for business success, and it is not invalidated by the subsequent discovery that the particular institutions on which some of their successful companies relied had ceased to be appropriate, because that is a danger with all institutions. As financial advisers warn us, in the small print, past performance is no guarantee of future success. Simon (1982 [1963], p. 399) observed that, because internal coherence may sometimes be more important than accuracy, 'the procedures for fact finding and for legitimating facts may themselves be institutionalized'. Ziman (2000) observes that similar legitimisation is to be found in science. It may be helpful to recall that the proceedings of learned societies were often published under the title of 'Transactions'; the development, exchange, and application of knowledge within any working group is facilitated by a shared understanding of the procedural rationality of that group. Within a firm, this procedural rationality, which is inter-subjective, may be partly shaped by the senior executives – Witt (1999) identifies it as a crucial entrepreneurial function; but it also, and sometimes primarily, reflects the informal organisation that develops within any formal organisation; the contributions of both formal and informal organisation to the effectiveness – and sometimes the ineffectiveness – of every business receive due attention in Barnard's (1938) analysis of management. This is an essential part of firm-specific capital.

It is a major function of institutions to maintain coherence within groups by legitimating particular facts, interpretations, procedures, and criteria, and individuals are generally disposed to accept such legitimation as a scarcely dispensable aid to preserving the coherence of their own ideas and thought processes. Opportunism is a serious issue (and there is spectacular evidence that it is sometimes easier in organisations); but what also needs to be acknowledged and explained is the widespread willingness of people to internalise 'a social prescription of some, but not all, of the premises that enter into an individual's choice of behaviours' (Simon 1982 [1958], p. 345). People

seek out such prescriptions in many contexts; it is not surprising that they do so within the organisations in which they work. The fundamental explanation, I suggest, lies in the human brain.

Tacit knowledge and codification

From institutions as premises and procedures that are rarely questioned there is a simple connection to the theme of tacit and codified knowledge, which may be illuminated by Smith's, Marshall's, and Hayek's theories. All the knowledge that is developed within Marshall's first level is necessarily tacit, since there is no way in which it can be formally represented; though it is codified in the neural system, this code is not accessible to the brain by which it is governed. Anything in the environment which cannot be matched to the neural code cannot be recognised; within the human sensory order, infra-red light and ultrasound are simple examples. It is a crucial feature of Marshall's model that the operations of the second level do not displace the operations of the first; they build upon and complement it, by highly-selective intervention; and the additional knowledge generated at the second level is installed and maintained at the first level, where it necessarily becomes tacit, although recodification is possible if the codebook is not lost. These features are not simply the product of Marshall's fancy, even though his account is the product of his own brain, constructed from ideas supplied by Bain, Darwin, and Babbage, among others, as indicated in the previous presentation. Tacit knowledge must be the foundational knowledge within biological evolution, and both evolutionary principles and the importance of cognitive economy imply that it remains so in modern humans. Although codification offers a means of selective improvement in the quality of tacit knowledge, the economising imperative ensures that knowledge moves in both directions, as the philosopher A. N. Whitehead (1948 [1911], pp. 41-2) pointed out in denouncing 'the profoundly erroneous truism … that we should cultivate the habit of thinking about what we are doing. The precise opposite is the case. Civilisation advances by extending the number of significant operations which we can perform without thinking about them'. The conversion of explicit innovations into routines which are no longer verbalised is an essential feature of Marshall's theory of development, and it reappears in Nelson and Winter's (1982) theory.

Whitehead explicitly included within the scope of his proposition the operations of science which are intended to produce highly-codified knowledge. Scientific practice is largely tacit, and parts of the codebook on which each system of practice is based may have been lost, especially when the codebook was compiled by an earlier generation. No one can learn to be a scientist solely by learning scientific propositions, or even by adding to this knowledge the rules of scientific procedure; much of the time required to become a scientist is taken up by learning how to act correctly without thinking about performance – even to the point of having no accessible way of thinking about it. Moreover, the very process of codifying cannot dispense with tacit elements. We can go further. The actual generation of new ideas (whether good or bad, true or false) is necessarily tacit; although we may construct, as an academic exercise, a codified representation of a system in which all possible connections between its elements are clearly defined, nevertheless for anyone within an existing system, whether it be, for example, a firm, an economy, or a system of thought, the process of making a novel connection is necessarily tacit. We can, as it were, give our brains directions to help us with a particular problem, but there is no procedure by which we can control precisely what they should think. What has not yet been thought cannot yet be codified.

Turning tacit into codified knowledge may not be at all straightforward. Codification implies classification, which is always problematic. Hayek's (1952, pp. 145-6) principle of necessarily selective and distorted representations allows scope for some dissonance between the sensory order which had been created as tacit knowledge in the course of evolution, extending

presumably far back before the emergence of any humanoid species, and the expressed physical order that claims to represent the same phenomena. That is a constructive existence proof which is sufficient to explain the possibility of significant differences between the orders. Adam Smith gives a powerful reason why this possibility should be realised; scientific principles appeal to the imagination, not to the practicalities which provide the selection criteria for the sensory order. However, even sciences may appeal to the imagination in different ways, and develop coding systems that encourage communication and reduce ambiguity within each group, but at the cost of discouraging communication and increasing ambiguity between groups. Incommensurability, in the literal sense of the absence of any common measure (which does not imply undiscussability), may be the means to advance common knowledge, and the search for a universal codebook is likely to be misguided, since it is likely to be highly restrictive.

Underlying the whole argument is the simple idea that brains which develop selective connections are likely to create representations that are, in some degree, specifically appropriate to their contexts, and that these representations, once developed, may resist transformation. Moreover, all representations are selective; codified knowledge, no less than tacit knowledge, is an imposed order, and it necessarily simplifies, aggregates, and excludes in some respects. Even within each group, the possibility of developing some relevant kinds of new knowledge may be constrained by attempts at closure. Codification may usefully provide decision premises, and positive and negative heuristics, but there must be some flexibility, which means ambiguity, in interpretation. The search for codification may have unfortunate consequences. Official standards are almost inevitably defined in terms of present knowledge, and may therefore become an obstacle to innovation. The progressive codification of economics has not been free of opportunity costs. The first notable casualty was the concept of competition as a process; more recently we have seen the disappearance of innovative activity from the theory of growth.

The desire for coherence, particularly within Popper's World 3, which is the domain of codification as that is commonly understood, may close minds to the possibility of alternative ways of organising knowledge. That is not to decry codification; it has its own virtues, and even its own potential remedies for its defects. The particular constraints of coherence within a firm may prompt those unhappy within these constraints to create another firm; and the particular constraints of coherence within standard economics may prompt some defections inspired by the hope of something better. The example of innovative activity was not a random choice, but a connection especially relevant to this occasion.

A Marshallian view of organisation

'Our logical methods and our endless analysis of things has often blinded us to an appreciation of structure and organization. Yet our physical and social worlds are full of structures, organizations and organisms' (Barnard 1938, p. 317). Moreover, organisation is 'something else than the sum of its parts, wherever human beings are involved'. Its effects depend on the pattern of connections between the parts of the organisation, precisely because what has to be organised is the interaction between human brains in particular contexts. It is no accident that changes in organisation were incorporated by Marshall (1920, p. 318) in his definition of increasing return. As Quéré (2003, p. 198) writes, 'Increasing returns do not pre-exist. They are the result of an economic process; that is, a result of the way co-ordination problems are managed over time'. Our clearer understanding of the relationship between Marshall's theory of the mind and his theory of economic progress may suggest that he was thinking not only of the reordering of relationships between people but also of the subsequent reordering of relationships within minds; at both levels the increasing returns are not produced by the elements but by the connections between them. (Failure

to recognise this basic point wreaked much havoc on economic theory in the 1920s – and continues to cause trouble.) As argued in the preceding presentation, the theory of the mind is an organisational theory; and in the brain as in the economy, organisation matters because it makes a difference. The difference is not always for the better, as Barnard notes: that is why he wrote about it and why it is still studied. However, although 'economic organisation' is of interest to economists, within the assumptions of rationality it is hard to identify any source of difference other than its effects on incentive compatability, and so we cannot get beyond the distinction between 'firms' and 'markets', with no explanation of the structures which are essential to the operation of each.

Smith's, Marshall's and Hayek's psychological theories reveal both the operational constraints and the productive potential of human mental processes, and so provide a basis for examining the effects of organisational and social structures on the performance of human societies. Common to all is the importance of the dispersion of knowledge as the result of developmental processes within the brain: contrary to the usual (and natural) presumption in theories that idealise fully-connected systems, this is not a problem (though it gives rise to problems) but an efficient allocation of human cognitive capabilities through the development and effective use of heterogeneity. Science itself, the activity most crucially dependent on cognitive skills, is undertaken by a dispersed community that relies on a wide-ranging *ceteris paribus* clause in order to focus on closely-defined problems, which it attempts to reduce to repetitive patterns (Ziman 2000); and the enterprising business man must likewise be selective in his focus and rely on many established regularities in order to devise and implement new patterns. General equilibrium is not the appropriate concept; the growth of knowledge is always at the margin.

Marshall's recognition of this is exemplified by his 'principle of substitution', which is a guide to selective experimentation against a baseline of established practices (Loasby 1990), as in scientific procedures. From an orthodox perspective he appears to confuse changes of resource combinations within well-defined production sets to reflect changes in relative prices (the general equilibrium perspective) with modifications of these sets by economic agents (which in general equilibrium theorising is a privilege reserved to economic analysts); but if human knowledge is formed by the processes discussed in the previous presentation then the production possibilities available to any firm are partly the product of its own activities and are never well defined. This double insight was to become the basis of Penrose's (1959, 1995) theory of the firm; her distinction between resources and productive services may be regarded as an elucidation of Marshall's analysis, and the conjunction of resources and the administrative framework in her definition of the firm introduces a major development of it. In Penrose's theory, firms grow because of the creation, selective retention and application of resources, including managerial resources; and each resource, instead of constituting a well-defined input into one or more production functions, is a multi-specific asset the potential uses of which have to be discovered, invented, or imagined.

In summarising the qualities required of 'the manufacturer who makes goods not to meet special orders but for the general market', Marshall links ' a thorough knowledge of *things* in his own trade' with 'the power of forecasting the broad movements of production and consumption, of seeing where there is an opportunity for supplying a new commodity that will meet a real want or improving the plan of producing an old commodity' and also with the encouragement of 'whatever enterprise and power of origination' his employees may possess (Marshall 1920, pp. 297-8). It is worth noting that even Schumpeterian entrepreneurs, who make 'new combinations', do not, at the same time, seek any radical redesign of the subsystems of knowledge that they seek to recombine; that is also true of Smith's 'philosophers and men of speculation'. Innovation requires both

imagination and existing procedures, which are represented by distinct levels in the 'brain' of Marshall's 'machine'.

This sequence of creativity against a background of routines, leading to new routines which provide a more advanced basis for further creativity, is a dialectical process. When many people or many organisations pursue this sequence, their somewhat differently-organized mental structures, which are the product of different histories, generate a variety of products and processes to be winnowed by competition. Unlike biological variety, however, this economic variety is the product of freedom as well as chance; and the selection among this variety depends on its compatibility with existing patterns, and to some extent on conscious choices. The dialectics of evolution are presented by Marshall in his discussion of custom.

> If custom had been absolutely rigid, it would have been an unmixed evil. … However it did not crush out of everyone the desire to humour his own fancy, or his love of novelty, or his inclination to save trouble by a rather better adjustment of implements to the work done: and … the solidity of custom has rendered the supreme service of perpetuating any such change as found general approval
> Marshall 1919, p. 197

This 'limited but effective control over natural development by forecasting the future and preparing the way for the next step' (Marshall 1920, p. 248) may be reasonably compared with Darwin's recognition of the significant success of artificial breeding; in both, purposeful though fallible activities, the results of human selection, are subject to the selection processes of the wider environment, and the favoured activities become embodied in routines. Marshall believed that this process tended to result in ever greater differentiation of function, matched by closer co-ordination, as suggested by Herbert Spencer (Marshall 1920, p. 241). This closer co-ordination was exhibited in the various forms of organisation that aid the utilization and expansion of knowledge, which for Marshall were joint products of the human mind and the systems which it supported. That may well be why he suggested that organisation might be recognised, alongside land, labour, and capital, as a fourth factor of production (Marshall 1920, p. 139).

Marshall's treatment of organisation matches his early model of mental activity (Raffaelli 2003). Indeed, Marshall's discussion of organisation begins in Chapter 9 of the *Principles* with an account (corresponding to his early model) of the multi-level structure of the brain, in which conscious attention is reserved for problem-solving or the introduction of novelty; the application of solutions or the repetition of new actions 'develops new connections between different parts of the brain' (Marshall 1920, p. 252), which gradually take over the maintenance of these activities, leaving the conscious brain free for new initiatives, including those which utilise these now-automatic connections. The process is illustrated by learning to skate; acquired skills no longer require thought, which may then be devoted to devising and controlling particular sequences of skating (Marshall 1920, p. 251). Order makes room for creativity, which is stabilised in a new order which combines newly-established expectations and beliefs into a patterned performance. Knowledge which may have been constructed through codification is preserved as tacit knowledge, and the 'codebook' may be lost.

All this applies to organised groups of humans. Directed action within a group relies on pre-existing routines within which no choices, in the normal sense, are exercised; if directed action fails to achieve its objective, the recognition of failure leads either to a modification of existing routines or to experimentation resulting in new routines. Thus knowledge that is already organized into routines facilitates the creation of new knowledge – especially that which builds on the old; and

new knowledge which is corroborated by apparently successful application is consolidated into new routines. It is not then surprising that experimentation should be at one or other of the margins of knowledge; and these margins will differ according to the past history of the growth of knowledge within each organisation, because this history influences the development of capabilities within that organisation and also of beliefs about these capabilities and about the ways in which they might be most effectively applied. The generation of variety across organisations is a natural consequence; and this may be considered an effective response to the underlying and pervasive uncertainty about the likely directions of progress.

Among the difficulties that naturally arise from this conception of progress is that of finding an appropriate balance between order and creativity. Marshall saw this as a particular problem with large firms, in which routines are prime supporters of organisational coherence, and especially dangerous because of the valid claims that large firms could achieve greater efficiency through more carefully-planned and larger-scale routines: the means of achieving this efficiency may repress 'elasticity and initiative' (Marshall 1919, p. 324), and therefore the changes in mental and formal organisation that aid knowledge. Moreover, larger firms necessarily imply fewer firms, and therefore a reduction in variety. In standard economics fewer firms may reduce welfare because they reduce allocative efficiency; that they may reduce welfare because they reduce the range of experiments is not compatible with the assumptions that are necessary to sustain the standard analyses of rational choice equilibria. This, however, is a direct implication of Marshall's theoretical system, in which economies of scale should not be confused with increasing returns, as is still too often done.

It is perhaps because of this double threat to initiative and variety that Marshall was so impressed with the virtues of an industrial district, which seemed to ensure the 'automatic organization' (Marshall 1919, p. 600) of highly specialised activities while facilitating both the generation and the active discussion of novel ideas, including ideas for constructing new patterns of relationships between firms. In view of the more recent history of many British industrial districts, it is worth recording Marshall's (1919, pp. 135-7) warning that a network of well-proven routines could impede a major reordering of productive systems, which would then be undertaken by newcomers. Confidently-held expectations provide the assurance to act; but this confidence may prevent the timely revision of those expectations.

The industrial district organises most of the external knowledge on which each firm within it relies. But Marshall insisted that every firm required some form of external organisation: a set of linkages to customers, suppliers and (perhaps indirectly through trade associations and trade journals) to other firms in the same trade. The development of an appropriate and reliable set of linkages is necessarily a lengthy business (Marshall 1920, p. 500), and requires much conscious attention before it can be taken sufficiently for granted to provide the expectations on which both regular business and experimentation can be based. (Remember that the two are closely linked.) Atomistic competition will not suffice. As Richardson (1960) demonstrated, it will not suffice for equilibration, whereas Marshall's own analysis of industrial organisation allowed him to distinguish between classes of equilibria and explain each as the outcome of a process.

Conclusion

It is no accident that the principles and compromises that are inherent in the use of human mental capabilities are to be found in the organisation of social, economic and political systems, for the operation of these systems entails equivalent cognitive problems, which cause us to rely on abstract systems of rules for the selection and classification of relevant phenomena. As De Vecchi

(2003) points out, Hayek used this equivalence in his later work, and advocated the dispersion of both political power and economic decision-making; Kirzner has pursued the theme of domain-specific entrepreneurial alertness; and Marshall (1919, pp. 647-8), though describing the state as 'the most precious of human possessions', insisted on the importance of confining it to 'its special work', and applied his cognitive model of conjectured linkages to industrial organisation (Raffaelli 2003). Marshall recognized the connection between the management of co-ordination problems in the economy and the management of co-ordination problems within the brain: both require combinations of routines and novelty, and these combinations are themselves modified by evolutionary processes of trial and error.

Productive organisations are knowledge communities, and all knowledge communities require shared assumptions (which remain problematic). The perpetual questioning of assumptions paralyses action while the avoidance of all questioning may lead to disaster, and among the key questions for any economy are how much and what kind of variation should be encouraged and where should it be encouraged. Underlying all this is Potts' (2000, p. 80) question, which has also been Simon's question: 'how do we, both as individuals and collectives, make good choices of the connections that build systems?'

In the end, there is no escape from Knightian uncertainty; no procedures for expanding either theoretical knowledge or practical skills can be proved to be correct in relation to the total system to which they are to be applied, because our best representations of this system are necessarily incomplete, and likely to be erroneous in some unrecognised respects. However, Knightian uncertainty is also a precondition for novelty, as Shackle kept reminding us; and human cognitive systems have a distinct, if limited, capacity for creating novelty as an integral part of their cognitive operations. They may well also have a genetically-based need to search for novelty, and so a degree of uncertainty (balanced with some perceived stability) may be a necessity for the survival of the human species, as well as a potential threat to that survival.

References

Barnard, C. I. (1938) *The Functions of the Executive*. Harvard University Press, Cambridge MA.

Casson, M. (1982) *The Entrepreneur: An Economic Theory*. Martin Robertson, Oxford.

Choi, Y. B. (1993) *Paradigms and Conventions: Uncertainty, Decision Making and Entrepreneurship*. University of Michigan Press, Ann Arbor.

Coase, R. H. (1937) The nature of the firm. *Economica, N. S.* 4: 386-405.

Demsetz, H. (1988) *Ownership, Control and the Firm*. Basil Blackwell, Oxford.

De Vecchi, N. (2003) The place of gestalt psychology in the making of Hayek's thought. *History of Political Economy* 35 (1): 135-62.

Foss, N. J. (2001) The problem with bounded rationality: on behavioural assumptions in the theory of the firm. DRUID Discussion Paper 01-15.

Gigerenzer, G. and Selten, R. (eds) (2001) *Bounded Rationality: The Adaptive Toolbox*. MIT Press, Cambridge MA and London.

Giocoli, N. (2003) *Modeling Rational Agents: From Interwar Economics to Early Modern Game Theory*. Edward Elgar, Cheltenham UK and Northampton MA, USA.

Hahn, F. H. (1984) *Equilibrium and Macroeconomics*. Basil Blackwell, Oxford.

Hayek, F. A. (1952) *The Sensory Order*. University of Chicago Press, Chicago.

Karmiloff-Smith, A. (2002) Elementary, my dear Watson, the clue is in the genes … or is it? *Proceedings of the British Academy* 117: 525-43. Oxford University Press for the British Academy, Oxford.

Kelly, G. A. (1963) *A Theory of Personality: The Psychology of Personal Constructs*. W. W. Norton, New York.

Knight, F. H. (1921) *Risk, Uncertainty and Profit*. Houghton Mifflin, Boston. Reprinted University of Chicago Press, Chicago 1971.

Kuhn, T. S. (1962, 1970) *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago.

Lachmann, L. M. (1978) *Capital and its Structure*. Sheed, Andrews and McMeel, Kansas City.

Loasby, B. J. (1990) Firms, markets and the principle of continuity, in: Whitaker, J. K. (ed.) *Centenary Essays on Alfred Marshall*. Cambridge University Press, Cambridge, pp. 108-26.

Loasby, B. J. (2001) Time, knowledge and evolutionary dynamics: why connections matter. *Journal of Evolutionary Economics* 11: 393-412.

Loasby, B. J. (2004) Economics after Simon, in: Augier, M. and March, J. G. (eds) *Models of a Man: Essays in Memory of Herbert A. Simon*. MIT Press, Cambridge, MA and London, pp. 259-78.

Marshall, A. (1919) *Industry and Trade*. Macmillan, London.

Marshall, A. (1920) *Principles of Economics*. Macmillan, London.

Marshall, A. (1994) Ye machine. *Research in the History of Economic Thought and Methodology, Archival Supplement 4*. JAI Press, Greenwich CT: 116-32.

Ménard, C. (1995) Markets as institutions versus organizations as markets? Disentangling some fundamental concepts. *Journal of Economic Behavior and Organization* 28: 161-82.

Nelson, R. R. and Winter, S. G. (1982) *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge MA.

Nooteboom, B. (2001) From evolution to language and learning, in: Foster, J. and Metcalfe, S. J. (eds) *Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy*. Edward Elgar, Cheltenham UK and Northampton MA, USA.

Penrose, E. T. (1959, 1995) *The Theory of the Growth of the Firm*. Basil Blackwell, Oxford (1959); Oxford University Press, Oxford (1995).

Peters, T. J. and Waterman, R. H., Jr. (1982) *In Search of Excellence: Lessons from America's Best-run Companies*. Harper and Row, New York.

Potts, J. (2000) *The New Evolutionary Microeconomics: Complexity, Competence and Adaptive Behaviour*. Edward Elgar, Cheltenham UK and Northampton MA.

Prigogine, I and Stengers, I. (1984) *Order out of Chaos: Man's New Dialogue with Nature*. Random House, Boulder.

Quéré, M. (2003) Increasing returns and competition: learning from a Marshallian perspective, in: Arena, R. and Quéré, M. (eds) *The Economics of Alfred Marshall: Revisiting Marshall's Legacy*. Palgrave Macmillan, Basingstoke and New York, pp. 182-201.

Raffaelli, T. (2003) *Marshall's Evolutionary Economics*. Routledge, London and New York.

Richardson, G. B. (1960) *Information and Investment*. Oxford University Press, Oxford.

Richardson, G. B. (1972) The Organisation of industry. *Economic Journal* 82: 883-96.

Schumpeter, J. A. (1934) *The Theory of Economic Development*. Harvard University Press, Cambridge MA.

Shackle, G. L. S. (1967) *The Years of High Theory: Invention and Tradition in Economic Thought 1926-1939*. Cambridge University Press, Cambridge.

Shackle, G. L. S. (1969) *Decision, Order and Time in Human Affairs*, 2nd edn. Cambridge University Press, Cambridge.

Simon, Herbert A. (1959) Theories of decision-making in economics and behavioral science. *American Economic Review* 49: 253-83.

Simon, Herbert A. (1982 [1958]) 'The role of expectations in an adaptive or behavioristic model', in: Bowman, S. J. (ed.) *Expectations, Uncertainty and Business Behavior*. Social Science Research Council, New York. Reprinted in Simon, H. A. *Models of Bounded Rationality, Volume 2*. MIT Press, Cambridge MA and London.

Simon, Herbert A. (1982 [1963]) Economics and psychology, in: Koch, S. (ed.) *Psychology: a Study of a Science*, vol 6: 685-723. McGraw-Hill, New York. Reprinted in Simon, H. A. *Models of Bounded Rationality, Volume 2*: 318-355. MIT Press, Cambridge MA and London.

Simon, H. A. (1985) Human nature in politics. *American Political Science Review* 79: 293-304.

Simon, H. A. (1991) Organizations and markets. *Journal of Economic Perspectives* 5 (Spring): 25-44.

Smith, A. (1976a [1759]) *The Theory of Moral Sentiments*, ed. Raphael, D. D. and Macfie, A. Oxford University Press, Oxford.

Smith, A. (1976b [1776]) *An Inquiry into the Nature and causes of the Wealth of Nations*, ed. Campbell, R. H., Skinner, A. S. and Todd, W. B. Oxford University Press, Oxford.

Smith, A. (1980 [1795]) The principles which lead and direct philosophical inquiries: illustrated by the history of astronomy, in *Essays on Philosophical Subjects*, ed. Wightman, W. P. D. Oxford University Press, Oxford, pp. 33-105.

Williamson, O. E. (1996) *The Mechanisms of Governance*. Oxford University Press, New York and Oxford.

Williamson, O. E. (1997) Review of Demsetz, H. *The Economics of the Business firm: Seven Critical Commentaries*. Oxford University Press, New York. *Journal of Economic Literature* 35: 129-30.

Witt, U. (1999) Do entrepreneurs need firms? A contribution to a missing chapter in Austrian economics. *Review of Austrian Economics* 11: 99-109

Young, A. A. (1928) Increasing returns and economic progress. *Economic Journal* 38: 527-42.

Ziman, J. (2000) *Real Science*. Cambridge University Press, Cambridge.

A COMMENT

Stefano Brusoni
Bocconi University

Prof. Loasby's papers aim to lay down meaningful – and much needed- micro foundations to recent research on the dynamics of innovating organisations. Such foundations are developed building upon two rather different streams of research. On the one side, Professor Loasby analyses key contributions of early classical economists such as Smith and Cattaneo, which are then linked to subsequent work by Marshall and Hayek. On the other side, recent work in neuropsychology is also relied on to develop the analysis. The first paper (The Psychology of Wealth) focuses on the individual as the level of analysis. The second paper (Organisation and the Human Mind) extends the analysis to the organisational level. In this brief note, I will not to summarise the argument developed in the papers, or present a thorough theoretical critique. I will merely try, consistently I hope with the epistemological stance on which these papers are developed, to highlight those aspects that in my view lend themselves to empirical exploration. In so doing, I will identify a few links between these papers and recent developments in the innovation management and organisational sociology literatures.

Together, these two path breaking papers provide a first, integrated account of how humans in organisations solve complex problems. This, I believe, is the key contribution of these two papers: approaching the study of organisations not as institutions that align individual incentives, but as devices that support and enhance the problem solving efforts of individual agents. Consistently, Professor Loasby's papers build upon the idea that economic agents are not (only) optimisers of their own utility, but problem solvers that look for –and establish- regularities in uncertain environments. Besides, problem solving activities are not conceptualised as symbol processing algorithms, but in terms of pattern-making and pattern-using skills. In many ways, the cognitive processes discussed in these papers are closer to Weick's 'sense making' activities than to Simon's 'problem solving' algorithms. In this context, the key 'economic' problem that agents need to solve is not that of scarcity of resources to be allocated among competitive uses. Rather, Professor Loasby's agents are engaged in a restless effort of making sense of a changing environment. Scarcity (of physical and cognitive resources) becomes a learning opportunity, more than an economic constraint.

The reference above to Weick's (1995) work on sense making is a reminder of the fact that, while economists may have forgotten some of the early contributions of Smith and Cattaneo, and tend to ignore recent developments in psychology, other branches of the social sciences have developed along lines which are quite consistent with the approach proposed here by Professor Loasby. Making a link between these contribution and the present papers may provide a head start toward the development of propositions and hypotheses amenable of empirical testing.

Indeed, the body of theory developed in these papers does provide useful guidance to empirically minded researchers in two related –although so far disconnected- areas. Both areas touch upon the link between human cognition and the organisation of economic activities. First of all, there is a nowadays enormous body of literature that looks at the evolution of networks in various environmental contexts. Originated within the sociological analysis of organisations (e.g. Powell,

1990), this methodology of analysis is nowadays increasingly common also within the so called 'innovation studies' community. Much of this literature tends to emphasise the competitive advantages that stem from being 'central' within 'dense' networks. The often accepted hidden assumption is that connectivity is 'good', as it provides opportunities to learn from a variety of sources. Prof. Loasby's work cautions against this assumption. Solving problems is a process of identification of the relationship that matters the most, not of maximising the connections between each node in the system. Up to a point, recent research on modularity does provide an empirical counterpart to Prof. Loasby's theoretical pieces, as this literature stresses the need to design products and organisations in a way that minimise the links between self contained modules (e.g. Baldwin and Clark, 2000). Prof. Loasby's work emphasise the need to shift from the analysis of given 'design rules' (ibid.), that embody a specific pattern of connections among modules, to the analysis of the dynamics of design rules. Key to such an activity is the ability to establish new patterns of connections between new and existing nodes. How this happens, and what are the drivers of this type of search activities remain largely unexplored in the modularity literature. Professor Loasby's papers provide useful insights, particularly in terms of the understanding of the human motivations that underpin the search for new combinations.

Second, once the most important links are identified through an effort of pattern making, issues arise about how coordination is achieved among agents, communities and organisations that are only weakly connected. Here, a useful bridge could be built toward the organisational literature that looks at the interaction of communities of specialised agents. Traditionally, economists look at the market place as 'the' place where interactions happen. As discussed in Organisation and the Human Mind, market-based processes of coordination occur in 'integral space', that is to say, all nodes have to be connected to every other node. The weaknesses of such systems are thoroughly discussed in the paper. Alternatives to markets as coordination devices exist. Professor Loasby discusses at length the role played by organisations. However, there is no reason to believe that organisations, within their boundaries, should be 'integral' (in the sense discussed in the papers). Quite the opposite, the very essence of organisational design is about drawing lines and borders at the functional level, at the process level, etc. In this respect, research on boundary objects (e.g. Star, 1980) emphasises the possibility to develop artefacts that allow heterogeneous communities to interact, while maintaining very independent, and even irreconcilable, identities. Virtual prototypes provide an example of boundary object that allow groups to interact while maintaining high cognitive and behavioural dissonance (D'Adderio, 2004). This line of research can be used to operationalised some of the concepts developed in Professor Loasby's papers.

In this respect, the discussion about the development of physical and sensory orders is of great interest, and of paramount empirical relevance. Classification systems are in fact the invisible architecture of any information system or, to use Bowker and Star's (1999) words, 'the scaffolding of information infrastructures'. Very little, and in economics nothing at all, is known about how individuals develop their own classification systems, and how different classificatory systems interact and compete to form higher level systems. Professor Loasby's papers highlight the fact that we need to understand more about how business firms, for example, develop their accountancy systems if we want to be able to make sense of these organisations and of the cognitive processes that underlie their inner workings. More precisely, the interplay of different classification systems within the same organisation can help shed light on the process through which inconsistencies and exceptions are identified and approached.

References

Baldwin C. and K. Clark (2000), *Design Rules*, *Vol 1: The Power of Modularity*. MIT Press.

Bowker, G. C. and S. L. Star (1999), *Sorting Things Out: Classification and Its Consequences*, The MIT Press.

D'Adderio, L. (2004), *Inside the Virtual Product*, Edward Elgar.

Powell, W. W. 1990 . Neither market nor hierarchy: Network forms of organizations. Barry M. Staw, L. L. Cummings, eds. *Research in Organizational Behavior*, vol. 12. JAI Press, Greenwich, CT: 295 –336.

Star S. L. (1989) *The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving*. In: Distributed Artificial Intelligence (eds. L. Gasser and M. N. Huhns), Vol. 2, pp. 37-54. Pitman, London.

Weick, K. E. (1995), *Sensemaking in Organizations*, Sage.