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by

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Foreword

The objective of this paper is to relate entrepreneurship to a theory of the human mind, setting both within an evolutionary perspective. The first requirement, therefore, is to indicate what this perspective implies. As a generic concept, I take evolution to be the self-transformation of a system through the internal production and diffusion of novelty (Witt 2003, p. 280). The production of novelty may be initiated as a response to external events, but this response, and indeed the perception of the external events, is internally generated. This distinction is made explicit in Schumpeter's account of 'development from within' (Schumpeter 1934, p. 63). Changes in technology and consumer preferences are treated as changes in the data to which the economy adapts (Schumpeter 1934, p. 65); such adaptations are to be explained by co-ordination theory, and are contrasted with entrepreneurial action to induce changes in preferences and (especially when entrepreneurship is located in large firms) changes in technology.

This evolutionary self-transformation requires a combination of three processes: the emergence of variety, selection among this variety according to some reasonably systematic criteria, and retention of the selected variants, at least over a time-scale that is significant for the particular phenomena being studied. NeoDarwinian biology relies on a particular subset of these criteria, which prescribes, for example, absolute separation between the selection environment and the kinds of variation that are produced; it therefore excludes anything corresponding to Schumpeterian enterpreneurship, or indeed any kind of intentionality. Penrose (1952) rejected attempts to justify reliance on economic models that assumed perfectly-informed rationality by invoking biological analogies which excluded human purpose along with any traces of rationality; however there can, conceptually, be many evolutionary processes, operating at different levels and in a variety of ways. Some of these may be connected; and in the fourth section of this paper I shall suggest that the biologically-evolved characteristics of the human brain **(**the neoDarwinian explanation of which is not here at issue) have created the conditions for the significantly different processes of economic evolution. There may also be interdependence, or co-evolution, between similar processes, for example between the evolution of capabilities and of the firms which combine them; this particular relationship will not be explored here, but should be an important topic in evolutionary economics.

Though evolution provides the perspective and not the theme, it is important to recognise that this notion of evolution necessarily excludes the possibility that all the phenomena being studied – such as economic outcomes – are to be explained as rational choice equilibria**,** because these equilibria result from correct ex-ante deduction, whereas evolution operates through ex-post selection among alternatives that are based on conjectures. There is a methodological sub-theme to this paper, and it is explicitly Schumpeterian. Schumpeter was interested in ideas – for many reasons, but above all because ideas influence events. In particular, ideas about the economic system could change the way that the system worked, through their effects on individual actions and economic policy. This was the message of *Capitalism, Socialism and Democracy.* The criteria by which economic theories (and especially the models which purport to represent them) are appraised may have major impacts on the admissibility of ideas: the appraisal criteria of standard economics, such as

internal coherence, tractability, and consistency with particular conceptions of rationality and equilibrium**,** make many topics undiscussable, and may force practitioners into perverse interpretations and lead to policy conclusions that are inappropriate or even disastrous. In *Capitalism, Socialism and Democracy* Schumpeter (1943) denounced the errors of both Marx and neoclassical economists. Much earlier he had set out the basis of his own ideas.

The psychology of wealth: intelligence and will

Joseph Schumpeter took care to distinguish his theory of economic development from the theory of a fully co-ordinated economy. Development 'from within' was the result of human initiative; by contrast, and despite his admiration for Walras's analysis, Schumpeter's picture of the fully co-ordinated economy gives little credit to human agency. Although an economy which can be represented by a general equilibrium system is observationally equivalent to a system in which everyone is a completely rational optimiser, Schumpeter declares this to be an illusion. 'In so far … as it is a question of adapting himself to the conditions and of simply complying with the objective necessities of the economic system without wishing to change them, one and only one particular way of acting commends itself to the individual' (Schumpeter 1934, p. 40), and this particular way of acting, although undeniably efficient – within this context – in both outcome and method, cannot be achieved by rational choice but only 'if things have time to hammer logic into men' (Schumpeter 1934, p. 80). The failure of economists to provide any account of equilibration that is consistent with the fundamental principles of general equilibrium models reinforces Schumpeter's position. His reliance on an implicit selection process within a stable environment to achieve co-ordination permits us to consider Schumpeter as an evolutionary economist in terms of our definition, while allowing him to preserve his distance from concepts of biological evolution, as he was clearly anxious to do.

However, as soon as people encounter conditions in which optimal behaviour requires a change of routine, the fiction of rationality is exposed; 'the choice of new methods is not simply an element in the concept of rational economic action, nor a matter of course, but a distinct process which stands in need of special explanation' (Schumpeter 1934, p. 80, fn. 2). The special explanation that Schumpeter offers requires the creation of 'new combinations', which cannot be derived by logical manipulation or by the application of experience-based routine. (Why routines are likely to have limited applicability will be explained in the fourth section.) It also requires motivations of the kind that do not fit easily into conventional preference functions or modern analyses of incentives; indeed they imply a distinctive psychological basis, which supports the capability**,** the confidence and the determination to achieve major change. This combination of imagination, skill and motivation defines the Schumpeterian entrepreneur.

As a guide to exploring the psychological basis of entrepreneurship, we may turn to Carlo Cattaneo's essay 'Del pensiero come principio d'economia publica', written in 1861 and now republished with an English translation under the title of 'Intelligence as principle of public economy' (Cattaneo 2001). Cattaneo traces the development of economics as the study of the relationships between land, labour and capital and the flow of outputs, which he calls 'the physics of wealth'; and he notes – as has been repeatedly noted since – that differences in these inputs often seem

inadequate to explain observed differences in outputs, both between nations and over time. To explain these differences he urges economists to turn to what he calls 'the psychology of wealth', and specifically to the effects of intelligence and will. As we have just observed, in Schumpeter's theory of growth intelligence and will are both essential entrepreneurial qualities; we may therefore claim that his theory rests on a conception of the human mind which has much greater potential, both for economic analysis and the human agents whose actions are to be studied, than that of economic agents as rational optimisers. That concept is clearly restricted, in Cattaneo's classification, to the physics of wealth; its exclusion of psychology has indeed been regarded by many economists as a prime virtue. However in excluding psychology it excludes adequate explanation of some important phenomena.

The significance of intelligence, clearly differentiated from a concept of rationality as pure reason, emerges from Frank Knight's analysis of uncertainty. In his systematic attempt to clarify the suppositions and scope of the economic theory of perfect competition that was currently being refined into a precise model, Knight (1921) investigated the underlying knowledge requirements of this theory. He argued that precise information about future events was not necessary; risk could be readily incorporated, provided that there were procedures available for distributing probabilities over closed sets of possible outcomes. These procedures might be based on a priori calculation or appropriate evidence; what was essential was that they should be known to be correct. Any situation in which correct probabilities could not be supplied – including those in which probabilities were invented in order to make calculation possible, a practice that Knight (1933, p. xiv) criticised in the preface to the LSE reprint of *Risk, Uncertainty and Profit*, but which is now standard practice – he defined as one of uncertainty.

In Knight's view, uncertainty was not unusual, and its consequences were not of minor significance for economists. It substantially restricted the applicability of perfect competition theory; but in so doing it substantially expanded the scope of economics. Knight, like Schumpeter, believed that there were major economic phenomena that could not be explained by what we now call rational choice models. First, if publicly available procedures, which were known to be correct, could be applied to any decision, then no decision-maker could gain any advantage over rivals, except through the possession of some distinctive and non-imitable resource. However, such a resource would yield rent, not profit, and since all risk could be insured profit would be an empty category. Second, in such circumstances all activities could be co-ordinated by contracts for the exchange of goods and services; there would thus be no justification for contracts of employment, in which one person agrees to accept direction, however limited, from another. Third, because all opportunities could be fully specified, and would be open to all, there would be no entrepreneurship. Profit, firms, and entrepreneurship, Knight argued, all depended on uncertainty, defined as the absence of correct procedures for dealing with a range of possibilities. We may add to this the absence of correct procedures for defining the range of possibilities, so eloquently emphasised by George Shackle. Though less emphatically than Shackle, Knight clearly recognised that, despite its unfortunate implications for the applicability of models of rational choice equilibria, uncertainty created opportunities for economic development. Indeed Knight (1921, p. 348) regarded it as of fundamental importance for the human species, noting that 'a life with uncertainty eliminated or perhaps even very greatly reduced would not appeal to

us'. For Shackle (1966, p. 133) it implied 'the reverse of hope, the opposite of freedom'. It certainly would not appeal to a Schumpeterian entrepreneur.

Knight (1921, p. 268) went on to observe that in the absence of uncertainty all organic adjustments would be mechanical and all organisms would be automata. This corresponds closely to Schumpeter's claim that the circular flow of economic activity in a Walrasian equilibrium is maintained by a precisely-defined structure of mutually compatible routines. However, Knight draws a conclusion that Schumpeter does not make explicit: 'it is doubtful whether intelligence itself would exist in such a situation' (Knight 1921, p. 268). Intelligence and entrepreneurship are both responses to uncertainty, to situations in which there is no correct procedure for deciding what to do. In fact they may be considered as aspects of a single response, because crucial to both is the consequence that in such situations people must create their own structures for interpretation and decision, or find some ready-made structure that they are prepared to adapt; and these activities, rather than the rational choices that can be produced by automata, are the distinguishing characteristics of human intelligence. Rational choice theory excludes both entrepreneurship and intelligence: the appraisal criteria that we apply to theory choice are important, because, as Schumpeter insisted, ideas influence events.

Those who accept rationality as the ideal might reflect on David Hume's (1978, p. 164) observation that 'no kind of reasoning can give rise to a new idea'; they might further reflect that whereas, judged from the perspective of rational choice equilibrium, new ideas, which invalidate the data from which individual optima and system equilibria are derived, are a threat to efficiency, the possibility of new ideas exposes the inadequacy of this concept of efficiency. Though Knight does not explore in any detail the processes by which we create interpretative structures, he offers some very helpful suggestions, notably the proposition that we form categories on the basis of similarities that we deem significant, while ignoring differences that we believe to be irrelevant, where significance and relevance are conditional on 'the purpose or problem in view' (Knight 1921, p. 206). If we link this proposition to his observation that 'the existence of a problem of knowledge depends on the future being different from the past, while the possibility of the solution of the problem depends on the future being like the past (Knight 1921, p. 313), we can conclude that all decisions involve a selective mapping from past to future, where the principles of selection are themselves conjectural.

Intelligent behaviour depends on making sense by making selective connections, thus creating new combinations; this, of course, is Schumpeter's own summary of the entrepreneurial vision. Knight (1921, p. 241) also notes that people differ in their capacity to create appropriate structures, and that for each individual this capacity varies substantially between domains; both are natural consequences of the conditionality of relevance to which Knight had already drawn attention. The effectiveness of individual entrepreneurs will therefore be limited, though these limits may not correspond with conventional industrial categories, and may be misjudged, not least by the entrepreneur. We should not therefore be surprised that intelligence, combined with will, produces outcomes that cannot be predicted by any analysis which is restricted to what Cattaneo called the physics of wealth. Intelligence and entrepreneurship produce new ideas, most of which do not survive. Entrepreneurship, like any kind of evolution – even that driven by the search for success, entails

widespread failure. The psychology of wealth is the psychology of behaviour in an uncertain environment, though not, as we shall see, in an environment of unbounded uncertainty. In the remainder of this paper we shall attempt to explore entrepreneurship as a particular application of human intelligence, and therefore of the human mind.

Economists and the human mind

A notable feature of twentieth-century theoretical development in economics, recently analysed by Nicola Giocoli (2003), was the multi-faceted endeavour to 'escape from psychology', notably by successive respecification of preferences, increasing resort to game theory to circumvent difficulties in closing models, and generally by reducing all choice to pure logic – and therefore reducing human beings to Knight's automata. This development was prompted by the fear that the human mind is an alien topic for economists; it is therefore salutary (and for some of us encouraging) to recall that the operation of the human mind attracted the attention, early in their careers**,** of three people who are generally regarded as among the greatest of economists. The first was Adam Smith (1980 [1795]), who was probably responding to David Hume's demonstration that there could be no way of demonstrating the ultimate truth of any empirical proposition, either by deduction or experiment, and to Hume's proposal that we should therefore seek to understand how people come to accept certain empirical propositions as true. Schumpeter's proposal to move from the formal deduction of equilibria from data sets to the internal generation and diffusion of novelty is a cognate idea.

Smith developed a psychological theory of the emotional and aesthetic motivations and imaginative processes by which phenomena are gathered into categories, and causally linked to other categories, by the invention of 'connecting principles'. He argued that the gradual concentration of attention on developing connecting principles that could be applied to major categories of phenomena, such as astronomy, led to the emergence of science as an identifiable activity; and thereafter increasing specialisation between fields of science accelerated the growth of knowledge. The effects of a knowledge-generating division of labour within the economy subsequently became his fundamental explanation of the wealth of nations (Smith 1976b [1776]). Thus Smith substantially anticipated Cattaneo's call for a focus on the psychology of wealth, although Cattaneo was correct to observe that much of Smith's economic analysis is not thus oriented. The reasons for this change of orientation are beyond the scope of this paper; but we cannot fail to note that it had substantial implications for the subsequent history of economics**.**

Imagination, we should remember, is almost as central to Smith's thought as to George Shackle's. It is also essential to Schumpeter's conception of the entrepreneur, though Schumpeter uses the term 'vision', with the explicit implication, contrary to Smith's, that what is envisaged is likely to prove true. (Acknowledging the possibility of false visions might have diverted attention from his theory of successful development, and this was easy to avoid in an account that eschewed any notion of evolution.) It may seem remarkable that Schumpeter failed to recognise the similarities between Smith's explanation of the growth of knowledge and his own theory, especially as he drew attention to Smith's 'History of Astronomy' as the prime exemplar of the quality of Smith's thinking (Schumpeter 1954, p. 182), and because

the role of Smith's (1976b [1776], p. 21) 'philosophers and men of speculation' is precisely to envisage 'new combinations'. This apparent failure is a notable (but far from unique) illustration of the difficulty of selecting appropriate contexts of similarity as the basis for intelligent action, a difficulty that, as we shall see, is inherent in the characteristics of the human mind, and which supports the preference for evolution rather than rational choice as an analytical perspective.

A few years after Cattaneo's essay, Alfred Marshall was confronted with the problem of human knowledge as a young Fellow of St John's College, Cambridge (Butler 1991); and he too responded with a process theory, in which he combined Darwin's evolutionary principle with physiologically-based psychology, which had been developed by Alexander Bain (1864, 1865), and mechanical systems, as envisaged by Babbage. Marshall (1994) postulated a 'machine' that was equipped with an operating system (a 'body'), which could receive impressions and perform various actions, and a control system (a 'brain'), which communicated only with the 'body' and worked with 'ideas' of impressions and actions. This distinction between body and brain immediately excluded any direct perception of external data; 'ideas' are representations, even when they are ideas about facts, and (like Smith's 'connecting principles') they may be inaccurate.

Marshall went on to consider how these representations are formed, and how and why they may be modified. The machine's brain consisted of nodes and an array of potential connections between them, and in the course of the machine's operations a combination of positive and negative feedback would gradually build up strong linkages between 'ideas' of repeated impressions that the 'body' received from its environment and 'ideas' of those repeated actions in response which led to acceptable consequences. It thus gradually developed a cluster of self-reinforcing routines that, together with the routines developed by similar firms according to their varied circumstances, could support what Schumpeter was to call a circular flow. The resemblance to Marshall's subsequent account of the emergence of partial equilibria, which is set in a context of continuing development, may now seem as obvious as it was previously obscure – there are clues in the *Principles* which can be recognised only by those already equipped with appropriate connecting principles (Raffaelli 2003). Marshall suggested that, once a satisfactory repertoire of routines had been established, and therefore required no further explicit attention – but not before – then the development of a superior level of control within the 'brain' of a modified species of machine allowed that 'brain' to respond to novel situations by mental experiments in which ideas of novel actions might be generated and their possible consequences envisaged. Successful novelties would then be incorporated into the repertoire of routines.

Unlike most subsequent economists, Marshall, though as yet unschooled in economics, recognised that cognition was a scarce resource. Low-cost operation was therefore a precondition for mental experiments, and the occasions for such experiments must be carefully chosen. (Compare the philosopher Whitehead (1948 [1911], p. 42) on the need for operations of thought to be reserved for 'decisive moments'.) In this mechanical system innovation is triggered by a failure of routine, but only if this failure is limited to a small part of the repertoire; and any success is preserved by routinisation. This interdependence between routine and innovation is a feature to which we shall return – as Raffaelli (2003) has demonstrated, it is the core

of Marshall's theory of growth through organisation; for the present we will note that in examining the potential of such psychological machinery Marshall postulated results that have some obvious resemblance to Smith's theory of the growth of knowledge (of which Marshall seems not to have been aware). We may also recognise the conceptual similarities with Nelson and Winter's (1982) theory, in which growth results from the stimulus to develop and install new routines. It should be noted that the development and publication of that theory preceded any recognition of the significance (and barely of the existence) of Marshall's model; the primary inspiration was a combination of Schumpeterian innovation and 'Carnegie' analyses of organisational behaviour, and the explicit analogy was between routines and genes. Subsequent claims for the role of neoDarwinian evolutionary genetics has raised associations which both Nelson and Winter believe are inappropriate to economic development; what once appeared a convenient context of similarity for persuading economists is now a context in which differences between evolutionary processes have become prominent. They now argue that the evolution of connections within purposeful organisations, but still through a process of problem-stimulated trial and error (which is the operating principle of the 1982 theory), does not need a specifically genetic analogy.

It was the third of our trio of people who went on to become economists, Friedrich Hayek, who produced much the most elaborate theory of the human mind. Like his two predecessors, the stimulus was an early encounter with problems of knowledge; in this instance what puzzled him were the substantial discrepancies between our sensory perceptions and the scientific formulations that were subsequently developed to represent the same phenomena. These formulations have progressively discarded sensory qualities in favour of the relations between objects (Hayek 1952, pp. 2-3), and in the process have created physical categories that do not match our sensory categories. Hayek's solution to this problem entails the concept of the mind as a structure of connections, each cluster resulting from interaction with particular environments. These interactions might occur during the development of the species or of the individual; Hayek carefully avoided any attempt to delimit the domain of each kind of development, in order to emphasise his fundamental argument that the sensory and physical orders are built up by similar but separate evolutionary processes which result in differentiated systems of connections.

Sensory and physical orders – and by extension, all kinds of human knowledge, including 'knowledge that', 'knowledge why', 'knowledge who' and 'knowledge how' – are represented by physical connections within the brain and exist as sets of relations that are imposed on events. Therefore '*all* we know about the world is of the nature of theories and all 'experience' can do is to change these theories' (Hayek 1952, p. 143). Note that this conclusion may also be derived from Smith's psychological theory of knowledge – and indeed from Hume's argument against demonstrable truth. It applies both to knowledge which results from the development of the species and knowledge that is developed within the individual, despite the differences between these processes. The supersession through 'experience' of those theories which are genetically embedded in the structure of the brain occurs by the natural selection of genetic instructions at the level of the species, whereas the supersession of those theories which have been constructed in the course of the individual development of a genetically-endowed potential occurs by a reordering of connections at the level of the individual. The time-periods required by

these two sequences differ by many orders of magnitude; hence, we shall argue shortly, the advantage of distinctive evolutionary processes.

Hayek's theory may be interpreted as combining a development of Marshall's ideas about mechanism with Smith's account of mental processes; the key concept shared by all three is the formation of selected connections, which are corroborated or refuted by the perceived consequences of their application to understanding or to action. Because individuals differ in their orientations, and because they are nevertheless motivated to observe the behaviour and study the ideas of others, and capable, within limits, of adapting some of their practices and ideas – characteristics to be considered in the following section, human communities exhibit the three basic evolutionary elements of variation, selection, and retention. This is the cognitive basis of 'development from within', and the foundation of the psychology of wealth that Cattaneo advocated.

As Herbert Simon insisted, human rationality is bounded. Three kinds of bounds may be identified. First, human beings are not good natural logicians, and consequently not good natural statisticians either; second, the premises for logical operations are often doubtful, and even more likely to be incomplete; and third, cognition is a scarce resource, and so rationality has to be applied very selectively. Within conventional economics bounded rationality is usually treated (if it is treated at all) as a kind of cognitive failure; but this perspective diverts attention from the remarkable human capability to create and use patterns – which is the common theme of Smith, Marshall and Hayek. Given the second and third bounds on rationality (which correspond to Knight's definition of uncertainty), this pattern-making capability seems to be much more useful than a high level of logical skills. (Chester Barnard (1938) presented a similar argument for the importance of non-logical processes, against a background of business experience.) With Marshall's and Hayek's accounts as examples, it is also easier to see how this capability might develop; and Smith shows how it might lead to the growth of both scientific and economic knowledge. We can therefore acknowledge Knight's insight that uncertainty is the precondition of intelligence – and intelligence of the kind that is particularly relevant to entrepreneurship.

The human mind and human capabilities

Hume's demonstration that there can be no way of proving any general empirical proposition may be augmented by Hayek's (1952, p. 185) argument that 'the capacity of any explaining agent must be limited to objects with a structure possessing a degree of complexity lower than its own'. An immediate consequence is that 'the human brain can never fully explain its own operations'; any psychological theory of the individual must always be incomplete. The theories by which the human brain attempts to explain any system that includes many other human brains (and usually many non-human elements) are inevitably much less complete. Even theories that are intended to match real structures are themselves confined to the space of representations, and their relationship to the real-world phenomena that they are intended to interpret is inescapably subject to Knightian uncertainty – a theme explored by Shackle (1972). Neither biological evolution nor human reason, backed by scrupulous experimentation, can avoid this.

In practice, both natural selection and the mind's selection among human ideas, artefacts, organisations and institutions are based on characteristics that are successful within particular environments (in accordance with Knight's principle of relevant similarity); and because all representations are incomplete, the opportunity cost of success is likely – indeed, one may say virtually certain – to include the absence of characteristics that would be essential for success in some other possible environments. Every successful system has its characteristic way of failing; and even systems that survive may exhibit persistent pathologies, which may be fatal to some members of the relevant population. The population of entrepreneurs is a notable example; although, as noted earlier, Schumpeter does not discuss entrepreneurial failure, it is a natural conclusion from this conception of the mind that the great majority of new combinations that can be imagined will turn out to be poor representations. If, as Popper argued, this is true in science, why should it not be true in the economy?

This coexistence of systematic advantage and systematic deficiency is a common finding of experimental economics and psychology; if such results seem surprising, that is because they are interpreted by inappropriate theories and because economists have forgotten that opportunity costs (revealed by systematic deficiencies) are inherent in their own professional activities. It is a notable merit of Gigerenzer and Selten's (2001) investigation of 'the adaptive toolbox' that they explicitly link the systematic advantages of 'fast and frugal heuristics' within a particular domain with systematic errors outside that domain, even though the boundaries of the domain are often difficult to recognise by those using a particular heuristic (as Hayek's comment on the brain's inherent limitations implies). Schumpeter's claim that the response to major innovations is not smooth adjustment but co-ordination failure – a claim that is the foundation of his business cycle theory – is soundly based in human psychology.

In this paper I shall follow Hayek's example in avoiding any discussion of the relative importance of species and individual development, which (as many readers will know) is a major topic of contemporary discussion among biologists and psychologists; a more extensive, but still limited, discussion will be found in another paper (Loasby 2004). For our present purposes it seems reasonable to assume that development at the level of the individual must draw on that individual's genetic endowment, which is the outcome of species development and may impose many programmes of behaviour, or elements of such programmes, but that the form of development for each person may be substantially influenced by interaction with particular environments, and may be difficult to predict in detail.

In the course of biological evolution, the relatively very small proportion of mutations that happened to confer some relative advantage led to the differentiation of genetically-programmed physical form and behaviour across species; that the diversity of species could be explained by Smith's principle of the division of labour as a source of differentiated knowledge and skills was noted by the Belgian biologist Milne-Edwards (1827), and this attracted the attention of Charles Darwin. Because the content of biological mutations does not respond to the environment, and because the effectiveness of natural selection in matching development to environment depends on the stability of that environment, biological evolution must be very slow (and relatively rapid environmental change tends to be followed by multiple extinction).

In principle, therefore, if some means of accelerating adaptation should appear it might well be favoured by natural selection; and this is what seems to have happened with the emergence of *homo sapiens*. A substantial enlargement of the human brain, unaccompanied by changes in the human genome which were sufficient to programme it, created a relatively extensive scope for programmes to be constructed within each brain in the process of individual development, in addition to those programmes that remain genetically controlled; and as much of this development now necessarily occurred after birth (because of the constriction of the birth canal as a consequence of upright posture) it could be influenced by interaction with the local environment of each individual. Thus a particular example of environmental selection among random biological mutations made possible a new evolutionary process that incorporated directed variation: intelligence was guided by will towards the search for solutions of perceived problems (as in Smith's, Marshall's and Hayek's theories). However this process could not escape the context of uncertainty and so it was still governed, although in a different form, by the evolutionary principles of variation, selection and retention. The advantages for the human species of this genetically-endowed capacity for far more rapid adaptation than genetic evolution can permit has so far outweighed the substantial costs of this capacity. The personal costs, however great, of individual failure to adapt (which may be readily observed) are, of course, irrelevant at the genetic level.

This development at the level of the species greatly enhances the possibilities of distinctive development at the level of the individual, leading to the differential emergence of domain-relevant knowledge and skills, which are much less demanding of cognitive capacity and brain energy than general-purpose logical processing, against a continuing low-cost background of programmed bodily functions and brain operations. The conversion of novelty to routine releases capacity for creating further novelty. Hayek's analysis is an appropriate illustration of this sequence: though the physical order originated from sensory perception, it has led to innovations that could not have been produced without evading the constraints of the sensory order; but the sensory order is still essential to normal human activity. The evolutionary process has itself evolved; but it is nevertheless an evolution and not a revolution. This, we shall argue, is true of all innovation; discontinuities are never absolute.

The conception of the human mind as an extensive cluster of quasi-decomposable and selective connections corresponds with Jason Potts' (2000) general proposition that the crucial fact about systems is the incompleteness of their connections. If connections are incomplete, then the performance of a system depends not only on what elements are included but also on the links between these elements and the specific pattern of connections (and absence of connections) to other systems. Performance may then be changed either by modifying the set of elements or by a rearrangement of connections, internal or external; and it is important to note that the breaking of established connections, both in ways of thinking and in organisational relationships, may be no less important, for good or ill, that the formation of novel cognitive and organisational relationships. Such changes are characteristic of intelligence and entrepreneurship. They cannot be achieved by purely logical processes, though logical processes may subsequently be invoked to check for consistency or to trace some of the implications.

It is not possible to get outside our own minds in order to reconfigure them, and the possibilities of reconfiguration open to any one of us are quite severely limited. These limits result partly from the programming installed by our biological inheritance and partly from the need to economise on cognition by relying at any moment on the great majority of connections which exist at that moment. Therefore it seems reasonable to conclude, with Potts, that most changes will consist of movement to some 'adjacent state'. We may, however, include within this category not only limited rearrangements within an existing system or modest adjustments to its boundaries, but also the transfer of an existing pattern of thought or action across domains which are thought to exhibit relevant similarities. Of course, what states are adjacent, in this range of senses, will vary greatly between individuals, according to the development of their cognitive systems in relation to the particular environments that they have encountered. There will also be some variation across individuals within similar environments because of the particular patterns that they have developed for interpreting and responding to them**,** as Marshall (1920, pp. 355-6) noted. When many people are following different paths, these differences promote both differentiated knowledge and skills across domains and 'the tendency to variation' (Marshall 1920, p. 355) within each domain which together fuel economic evolution. In these conditions path dependency (which is not to be identified with path determination) is a source of novelty.

We may therefore conclude that what Cohen and Levinthal (1989) called 'absorptive capacity' will differ substantially across individuals, not only in degree, but also in dimension; what kinds of ideas or skills each of us can absorb is heavily influenced by the ideas and skills we already possess. (An important corollary of this principle is that people who have recently absorbed a substantial change – of the kind that is sometimes called a 'paradigm shift' **–** are likely to be particularly resistant to further substantial changes.) Absorptive capacity helps to shape entrepreneurship. However, the distinctive entrepreneurial contribution identified by Schumpeter is the complement of this: the imagination of new connections from existing patterns to elements that lie outside these patterns. This we may call creative capacity; it generates the variety on which selection can work. Recognising the potential relevance of other people's knowledge, skills and motivation may also require an awareness of other people as intentional agents, which appears to be at best primitive even among other primates (Tomasello 1999); and this awareness, as Smith recognised, is the basis of imitation and trade, which together allow new knowledge to diffuse incomparably faster than genetic evolution could permit. In turn it is this diffusion that makes entrepreneurship so powerful an instrument of economic development.

Problems and decisions

Hayek (1945, p. 523) declared that 'economic problems arise always and only in consequence of change', defining this as a departure from anticipated patterns. Such patterns might include considerable but familiar variations, which could be handled by standard procedures. Knight (1921, p. 313) had already identified unanticipated change as a prerequisite of uncertainty, and therefore as 'a condition of the existence of any problem whatever in connection with life or conduct'. But as Shackle above all emphasised, if external change creates uncertainty, uncertainty makes internally-generated change possible: problems – perceived inadequacies of existing patterns of

interpretation and action – are also opportunities for imagining new patterns of interpretation and action which may be better fitted to the new circumstances. Innovation which is prompted by the perception of problems is essential to Smith's, Marshall's and Hayek's theories of the mind, to Smith's and Marshall's theories of economic development, and to Schumpeter's theory of entrepreneurship. Cattaneo argues that the psychology of wealth is necessary to explain how will that is directed towards wealth fosters the development of intelligence which generates what we now call entrepreneurship.

We may consider Kirzner's version of entrepreneurship in this perspective. In Kirzner's (1973) initial analysis, the entrepreneur is presented as the agent of equilibration, who responds to a change that has already happened. This allows Kirzner to deal solely with the polar cases in the spectrum of uncertainty: 'sheer ignorance' and certain knowledge. An arbitrage opportunity is inherent in any economic change: until it is perceived we have sheer ignorance and no action, but once it is perceived, the action required is obvious and unimpeded – in Kirzner's own phrase, the ten-dollar bill is discovered to be already in the entrepreneur's hand. This instantaneous transition between cognitive states is achieved by alertness, which we may interpret as the absorption of a new fact into a familiar framework. It does not require the creation of new patterns; indeed it relies on a fundamental assumption of well-defined markets for clearly-differentiated products.

The first-mover profit on which Kirzner's theory depends requires alertness to be domain-limited for each entrepreneur, because, as Richardson (1960, p. 57) had already pointed out, a 'profit opportunity, which is both known to everyone, and equally capable of being exploited by everyone, is, in an important sense, a profit opportunity for no one in particular'. It is therefore essential that each pair of locations within a specific market is observed by a limited number of people; and Kirzner's justification for this is that people will tend to notice what they are interested in. This differentiated interest appears to be a compound of motivation and specific knowledge; each entrepreneur is receptive to an opportunity of moving to profitable adjacent states, but what states are adjacent varies widely between entrepreneurs. Kirzner takes this as an obvious fact of life; we have suggested a cognitive explanation. The variation of interpretative frameworks naturally limits the number of people who are capable of recognising any particular opportunity, while allowing the entrepreneur's actions to attract sufficient competition to bring this particular market into profitless equilibrium.

Kirzner's initial model, which is illustrated by price differences between locations, is therefore compatible with our cognitive theory. However that theory suggests that later versions of Kirzner's analysis, in which the relevant arbitrage is between resources and the outputs that they might produce, or requires intertemporal transfers, should be modified by recognising that potential competitors may have difficulty in interpreting what is happening. Indeed as the complexity of the profit opportunity increases, the consequences of Kirznerian entrepreneurship may increasingly resemble those of Schumpeterian entrepreneurship, in disrupting established routines without indicating adjacent cognitive states to which those deprived of their routines might move. Its cognitive basis also becomes increasingly similar.

Schumpeter's explicit exclusion of invention from his theory of entrepreneurship suggests that his entrepreneurs, like Kirzner's, benefit from changes that have already happened and which imply opportunities that are ready for exploitation. However, these are not presented as arbitrage opportunities which are immediately obvious to anyone who knows about the change and is equipped with the appropriate domain-specific cognitive apparatus; instead the opportunity can be revealed only by the construction of a new cognitive apparatus. This feature has prompted some comparisons between Schumpeter's theory of economic development and Kuhn's (1962, 1970) theory of scientific revolution; both kinds of progress depend on the creation of new ways of thinking. Neither author, it may be said, gives adequate consideration to the elements of continuity which are necessary to carry even radical transformation; Smith (1980 [1795]) is a better guide.

The creation of a new combination of economic significance is an act of intelligence, which as Cattaneo (2001, p. 101) tells us, can be stimulated by a will that is directed towards wealth. This relationship is surely a natural reading of Schumpeter's theory, especially in his discussion of the psychology of the entrepreneur (Schumpeter 1934, pp. 90-94). From the perspective of this paper, what is particularly interesting about this theory (apart from its relationship with Cattaneo) is that external change is not sufficient, and not even necessary. The crucial element is a change within the individual that creates a new vision; what is required is not domain-specific alertness but domain-linking imagination. This is perhaps the most fundamental of Schumpeter's challenges to standard economics, because it is a challenge to the standard conception of human agency.

Problems, and indeed all occasions for initiating any decision process, are defined by differences (Pounds 1969). Responding only to differences (and not to all of them) is an efficient way of allocating the scarce resource of attention, without the need to allocate resources to the process of allocating attention; and this is a pattern of behaviour that seems to have evolved long before the primates. Indeed the self-regulating systems of the body seem to be governed by the identification of differences that are large enough to trigger a response. We should not therefore be surprised by the abundant experimental evidence (Kahneman 2003) that people rarely follow the prescriptions of decision theorists to concentrate on the levels of outcomes but persist in looking for differences. Anyone designing a control system, whether mechanical or for members of any organisation, will focus on differences, and decide what differences should generate signals for action; and major disasters have often resulted from a failure to notice differences that have not been specified. The perception of an external change defines a difference between our established interpretation of past events and some new phenomenon; and this perception itself depends on an established interpretation**.** Without a background of relevant stability change cannot be recognised as change (a principle that I learnt in conversation with Andy Van de Ven).

More generally, the perception of an occasion for decision requires a reference standard by which a difference can be defined. Our interpretation of a particular supposedly relevant segment of history, limited in time and scope, is an obvious and important example, and already indicates the importance of interpretative systems (such as those suggested by Smith, Marshall and Hayek) in influencing human thought and action. However, there are other bases of comparison, and in a

development of Pounds' classification (Loasby 1976, pp. 96-103; Loasby 2000, p. 723) which was intended for application to economic development I suggested that we should consider additional reference standards, including the performance of relevant comparators, our own intentions or specific plans, and imaginative standards – what Shackle (1979, p. 26) called 'the imagined, deemed possible'.

Even more clearly than interpretations of the past, all three of these reference standards are partly subjective, and they may themselves be the outcome of decision processes that are initiated in response to other differences: people may be motivated to search for comparators, to review plans, and to devise or import procedures that might generate novelty. It is therefore natural to find great diversity in the definition of problems, and consequently great diversity in ideas and actions. Moreover, since there are no guaranteed procedures for discovering the best responses to differences that are defined in any of these ways, it is not unusual for the consequences of decisions to generate new differences, leading to new decisions and so on in sequences that may extend over many years. Indeed, this is the characteristic pattern of major innovations. The 'new combinations' envisaged by Schumpeterian entrepreneurs are very rarely visions that simply turn out to be true; and the research departments of the large businesses which take over much of the entrepreneurial role in Schumpeter's later exposition do not find it easy 'to turn out what is required and make it work in predictable ways' (Schumpeter 1943, p. 132), however extensive and knowledgeable their members may be. This is what we should expect from our understanding of the human mind and its relationship to the universe.

The great majority of substantial innovation processes fail, and those that succeed often require a great deal of cognitive reconstruction of the initial understanding of the project, and may deliver outcomes which do not correspond at all closely with initial intentions. These processes, like so many managerial activities, cannot be controlled by logical procedures (Barnard 1938), and rational choice models of innovation are correspondingly misleading. Instead we may observe evolutionary processes, conspicuously in research and development but more generally in dealing with complex problems, in which selection leads directly and repeatedly to the generation of new variants over a time-scale that is extremely brief in relation to biological evolution; and each new variant is a conjecture that is offered for selection. (Decision cycles are discussed in Loasxby 1976 and 2000.) Within these processes, differences continue to define the next issue to be tackled, and – not surprisingly – also the criteria for choice.

Organisation, intelligence and evolution

Everything in the universe appears to depend on selective connections (or, in Herbert Simon's language, quasi-decomposability). Because our ability to comprehend phenomena seems to be strictly dependent on the formation of selective connections, thus restricting the forms of representation that we are able to construct, this appearance may be deceptive; there may be other phenomena, of which we are not aware, which do not depend on selective connections. However, because selectivity appears to be inherent in both the structure and the functioning of all the phenomena that we encounter, it may be reasonable to assume that selectivity is not simply a property of our understanding but inherent in what we are trying to understand. Even if this assumption is not reasonable, it seems to be inevitable. It is nevertheless

important to remember that the particular set of elements and connections by which we represent a phenomenon is unlikely to correspond precisely to those that constitute the phenomenon itself, and may be adequate for only a limited range of applications, as Knight implies; moreover, these limits may be discoverable only by exceeding them. We should also remember that different people may develop, or adopt, different representations of what they consider to be the same phenomenon – consider, for example, the variety of representations to which economists have applied the labels 'competition' and 'innovation'. Such differences sometimes cause misunderstandings and co-ordination failures; but they may also help to solve problems, improve knowledge, and stimulate enterprise. This is a principal means by which the tendency to variation – a crucial feature of intelligence as understood by Cattaneo and Knight – aids progress. All these possibilities are natural consequences of uncertainty, combined with human skills in pattern-making. They are elements of an evolutionary process: all knowledge is constructed, by individuals and within communities – though the proportion of these constructions that survive application is very small.

Systems of selective connections may be called organisations; thus organisation is a central issue in thinking about the human mind and the economy. Knowledge itself is organisation, imposed on phenomena, and it is the result of organising activity. In the realm of ideas, this organising activity is intelligence; in the realm that we call economic, it is entrepreneurship. (The concept of entrepreneurship**,** and its connection with Knightian principles of intelligence, may be readily extended to other realms.) However, both kinds of organising activity are dependent on the prior existence of structures which set bounds to uncertainty; for, as Shackle (1969, p. 224) observed, 'the boundedness of uncertainty is essential to the possibility of decision'. A rather similar notion seems to underlie Alfred Marshall's (1920, pp. 138-9) principle that 'Organization aids knowledge', especially because of his insistence that it 'has many forms', which are needed, together with variety within each form, in order to provide the differentiated bounds to uncertainty which will permit the development of locally-appropriate knowledge, leading to locally-appropriate decisions, which is essential for both Kirzner's and Schumpeter's theories of entrepreneurship.

However, in the context of this paper – and only in this context – I would like to conclude by emphasising three kinds of non-formal organisation that aid knowledge. The first of these is the foundational principle of this paper: the internal organisation of the human mind as a partly-adjustable cluster of selectively-connected systems. Two features of this organisation, discussed earlier, deserve specific attention, and they may both be considered to be economising principles. The first is the complementarity between automaticity and new combinations in allocating cognitive resources; this emphasis on complementarity is necessary to balance Schumpeter's emphasis on the contrast between them, and it suggests that Schumpeter's assignment of co-ordination and growth to incompatible but independent theoretical systems needs reconsideration. Marshall's attempt to combine them led to trouble, but his instinct was surely sound; and a good deal of his analytical apparatus may still be serviceable, because of its consistency with our current understanding of human cognition. The second feature is the contrast between the potential of the human mind for developing knowledge and skills within many possible domains and the limited range within which this potential can actually be developed by any single individual. It is this particular contrast between individual

and population that underlies the significance of Adam Smith's great principle of the division of labour, which allows a community of differentiated specialists to develop a range of knowledge and skills far greater than even the greatest philosopher or scientist could accomplish.

It is also this feature that justifies economists' focus on co-ordination – for which, in modern societies, prices are indispensable but insufficient, even for many market transactions. The internal organisation of the individual human mind provides a balance – not always adequate – of differentiation and integration; but a different perspective on co-ordination results from thinking of the population of minds on which each particular individual can draw. In order to do this effectively people must develop a second form of organisation; for minds, like firms, flourish best when they have effective internal and external organisations. That is an important part of the message of Smith's (1976a) *Theory of Moral Sentiments*, and it allows us to bypass part of the problem of altruism; even if we have no direct concern for the welfare of others we have an interest in their success in generating knowledge because, in addition to the exchange opportunities that may result, we may be able to draw on their new knowledge to improve our own, taking advantage both of the speciation of knowledge and of variations within each species. For exactly this reason, firms have an interest in the success, not only of firms with complementary capabilities, but also of their rivals.

The third kind of non-formal organisation comprises the set of institutions that supply the procedures and premises which help us to economise on cognition. We rely on such premises and procedures even when no interaction with others is involved; indeed much of education, formal and informal, supplies us with rules to guide our thought and action. Because we share so many institutions for our private purposes, we are predisposed to look for institutions that will facilitate interactions and are likely to find many of them already part-formed in the similarity of patterns of thought and action within groups where interaction is most likely to occur (Choi 1993). Markets are the most obvious class of institutions within modern economies, though often not recognised as such (Ménard 1995); the creation of a new business is much easier if appropriate institutions are already in place, and the performance of any business is critically dependent on the institutions that develop within it, as Barnard (1938) well knew. The creation or modification of institutions is a necessary element in any entrepreneurial project, as Casson (1982, 2003) has shown.

Innovation processes are evolutionary. They also appear to be channelled by some of the consequences of biological evolution that are manifest in the human mind, where channelling involves a mixture of constraint and facilitation. The co-ordination of the growth of knowledge is supported by the ability to rely, most of the time, on the regularity of other people's behaviour, which is a product of automaticity, while having some expectation that they will occasionally produce ideas which are relevant to particular problem domains. The generative potential of an economic system depends on an adequate variety of organisational forms and interorganisational relationships (Richardson 1972), each with its domain-limited advantages embedded in combinations of cognitive proximity and cognitive distance, and also adequate variety within each form. The realisation of this potential depends on uncertainty, which provides scope for, though it does not ensure, the exercise of imagination and will, leading to intelligence and entrepreneurship.

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