Hayek's *Sensory Order*

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ABSTRACT. Friedrich Hayek's theory of mind is shown to have anticipated modern conceptualizations in neurology, psychology and artificial intelligence research. That theory is also a basis for the fullest understanding of Hayek's intellectual contributions in economics, epistemology, ethics, jurisprudence and politics. Hayek was the leading proponent of 20th-century Austrian microeconomics and the principal scourge of Keynesian macroeconomic demand management. He is also recognized for his antipathy to socialism, and for his association with 'Thatcherism' in the UK and 'Reagonomics' in the USA. Hayek's advocacy of a competitive market economy is founded upon a liberal ethos that allows individuals to discover most effectively how they might best serve their own ends. Since his death in 1992, Hayek's scholarship has become the subject of an extensive reappraisal. In this, a previously neglected work—*The Sensory Order*—has crucial importance.

KEY WORDS connectionism, economics, mind–body, liberalism, praxeology

> *I recommend this book [Hayek's* Sensory Order*] . . . as an exercise in profound thinking by a man who simply considers knowledge for its own sake*. (Edelman, 1982, p. 24)

Friedrich Hayek is held in the highest academic esteem for his contributions toward a genuine praxeology (a unified theory of human action) that incorporates economics, epistemology, ethics, jurisprudence, politics and psychology. In economics, he was the leading proponent of 20th-century Austrian microeconomics and the principal scourge of macroeconomic demand management as propagated by John Maynard Keynes. He is also recognized for his antipathy to socialism, for having propounded 'an extreme *laissez-faire* economic liberalism . . . [that] . . . was a notable influence on the economic and political right' (Blackburn, 1994, p. 167), and for his association with 'Thatcherism' in the UK and 'Reagonomics' in the USA.

Hayek's advocacy of a competitive market economy is founded upon a liberal ethos that allows individuals to discover most effectively how they

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might best serve their own ends. Individuals are free to apply their limited (but unique) knowledge as each sees fit. By the expression that Hayek gives to Adam Smith's 'invisible hand', he shows that an extended socio-economic order is created through the spontaneous emergence and adaptation of institutional forms, which include common law and cultural mores generally; and he shows how that extended order supports an enhanced economic productivity that derives from the division of labour, specialization in skills and mutual gains from trade: 'It is the essence of a free society that we should be materially rewarded not for doing what others want us to do, but for giving some others what they want' (Hayek, 1967, p. 234). However, where Adam Smith emphasizes the mutual benefits from the division of labour, Friedrich Hayek directs attention to the mutual benefits from making best use of divided knowledge. To those ends, the onus is placed upon individuals to act entrepreneurially (in respect of unique skills and knowledge) and to accept responsibility for their actions.

Since his death in 1992, Hayek's scholarship has become the subject of an extensive reappraisal. In this, a previously neglected work has crucial importance. Hayek contemporaneously described *The Sensory Order* as 'the most important thing I have yet done' (letter to John Nef, dated 6 November 1948, cited from Caldwell, 1997, p. 1856), and he retrospectively regarded it as 'one of his more important contributions to knowledge' (Hayek, 1994, p. 138). In terms of intellectual fulfilment, he commented that 'the insights I gained . . . both from the first stage in 1920 or later in the 1940s, were probably the most exciting events that ever occurred to me, and which shaped my thinking' (Hayek, 1994, p. 153). In which case, there must have been considerable disappointment—even perplexity—when, towards the end of his life, he believed that nobody understood it (Harris, 1992, p. 20).

With its long gestation, it is unsurprising that the exposition and conclusions of *The Sensory Order* are implicit in much of Hayek's other work-.[1] The book is important for having established the limitations of intellectual endeavour and explicit knowledge, and (thereby) the rationale for a dependency upon the tacit knowledge that is embodied in cultural and institutional forms. These were the themes that, in their development, brought an original 'integrative approach to the study of complex social phenomena' (Caldwell, 1997, p. 1857). Even so, Hayek made modest claims for *The Sensory Order*. He expressed surprise that 'so little attempt' had been made by others to deduce the 'consequences of existing knowledge'; he was unsure of having 'been able fully to keep up with current developments'; he was unconcerned that the details of his own particular theory should be 'entirely correct'; he claimed to present 'no new facts', nor to employ 'any hypotheses which were not the common property of current psychological discussion'; he noted that a more satisfactory exposition of his thesis would have been achieved through the collaboration of specialists in psychology, physiology, logic, mathematics, physics and philosophy; and he acknowledged Donald

Hebb's *The Organization of Behavior* (1949)—published as the final version of *The Sensory Order* 'was practically finished' (Hayek, 1952b, p. viii)—as having expounded with 'much greater technical competence' a thesis so like his own that he pondered whether publication was justified. A loss of clarity of general principles within the fullness of Hebb's exposition allowed Hayek to find that justification: he categorized the two books as 'complementary rather than covering the same ground' (Hayek, 1952b, p. viii).

Hayek was altogether too modest. The general principles for psychology, outlined at such an early stage, are the foundation for the application of probability theory (as opposed to symbolic logic) to show how an 'imperfect' neural network can achieve reliable performance (see Rosenblatt, 1958). Indeed, *The Sensory Order* is acknowledged as the first proposal

> . . . of cortical memory networks on a major scale. . . . It is truly amazing that, with much less neuroscientific knowledge available, Hayek's model comes closer, in some respects, to being neurophysiologically verifiable than these models developed 50 to 60 years after his. (Fuster, 1995, pp. 87–89)

The Sensory Order also anticipates developments in the application of evolution to neurology and to psychology; it foreshadows Gerald Edelman's neural Darwinism[2] and Henry Plotkin's evolutionary epistemology. Indeed, Plotkin's *The Nature of Knowledge* might be viewed as an elaboration of the central concept of *The Sensory Order*: that

> . . . mental events are a particular order of physical events within a subsystem of the physical world that relates the larger subsystem of the physical world that we call an organism (and of which they are part) with the whole system so as to enable the organism to survive. (Hayek, 1982, p. 288)

In the light of dissatisfaction with classical theories of memory and brain function among clinical neurologists, child development theorists, cognitive and experimental psychologists, linguists and psychoanalysts, and of the direction taken by theoretical and experimental developments in these areas in the 1990s, *The Sensory Order* appears remarkably modern:

> *The Sensory Order* ought to be regarded as one of the most creative and innovative attempts to develop a biologically founded epistemology by means of establishing a direct link between a global brain theory and philosophy. More particularly Hayek provided the starting points for a fully-fledged evolutionary epistemology that simultaneously analyses phylogenetic and ontogenetic aspects of human cognition present in the development of neuronal structures. (Herrmann-Pillath, 1992, p. 147)

In particular, its conceptualization of the mapping between physiological and mental phenomena anticipates the central thesis of artificial intelligence research: that mind can in principle be 'realised in a wide range of different sets of material, both organic and inorganic' (Smith, 1997, p. 9). Most

important, however, is the rationale that *The Sensory Order* provides for self-knowledge, social adaptation and social science generally. It is this rationale that renders it essential to a full understanding of Hayek's intellectual contributions to cognitive science, to economics and to that encompassing science of human behaviour: praxeology.

Origins

In the winter of 1919–1920 a fuel shortage and forced closure of the University of Vienna presented Hayek with an opportunity to travel to Zurich, where—as well as attending lectures in law and philosophy—he 'worked for a few weeks in the laboratory of the brain anatomist von Monakow, tracing fibre bundles through the different parts of the human brain' (Hayek, 1994, p. 64). Although the first crucial insight—'[w]hat I had from the beginning been unable to swallow was the conception that a sensory fibre could carry, or a nerve cell store, those distinctive attributes that we know mental phenomena to possess' (Hayek, 1952b, p. 289)—indicated that an alternative conceptual approach was required, only limited progress was made: '[T]hough I felt that I had found an answer to an important problem, I could not explain precisely what the problem was' (Hayek, 1952b, p. v).

It was not until 1948 (and for the ensuing three years) that Hayek returned to work inspired by those few weeks of laboratory experience. (An original 41-page manuscript, 'Beiträge zur Theorie der Entwicklung des Bewußtseins'—'Contribution to the Theory of The Development of Consciousness'[3]—is dated September 1920.) Hayek cites the following motivations: academic interest *per se*; a 'concern with the logical character of social theory' (Hayek, 1952b, p. v); an interest in scientific method and his criticism of 'scientism', a name given to the 'harmful effects that the physics model had had on the methodology of the social sciences' (Hayek, 1982, p. 289); and the need to counter professional discredit that followed publication of *The Road to Serfdom* (1944) (not least for its serialization in *The Readers' Digest*). Hayek's desire 'to be accepted in the scientific community' would, he thought, be served by 'something purely scientific and independent of my economic view' (Hayek, 1994, p. 25). In this respect, the project failed: the trend towards specialization, his attack upon the dominant behavioural psychology and an inability to cite the literature[4] saw Hayek branded as an interloper.

The question that the young Hayek had failed to articulate and that became identified as 'the central problem of the nature of mental phenomena' is: 'What is mind?' (Hayek, 1952b, p. v). More expressly, it is 'the problem, "What determines the difference between the different sensory qualities?"' (Hayek, 1994, p. 138). Hayek's aim—'to work out certain

implications of generally accepted facts or assumptions in order to use them as an explanation of the central problem of the nature of mental phenomena' (Hayek, 1952b, p. vii)—was focused upon general principles (a theoretical psychology) the purpose of which was to identify the necessary constituents of a satisfactory 'explanation of mental phenomena' (Hayek, 1952b, p. viii). Further elucidation of the 'philosophical consequences' (the title of the final chapter) of *The Sensory Order* came in subsequent essays, notably 'Rules, Perception and Intelligibility' (1963) and 'The Theory of Complex Phenomena' (1964). These are summarized by a single postulate that underlies 'all our efforts to arrive at a scientific explanation of the world' (Hayek, 1952b, p. 173): that knowledge of the phenomenal world (the picture constructed from senses) raises problems, for which solutions are to be found only by reclassifying the constituent elements of that picture. (This is discussed further in 'Scientific Knowledge', pp. [30-2disk] below.)

Limits to Understanding

Mind is the black hole of human science: no empirical evidence emanates from within. Although mind can be inferred by its direction of human behaviour or through speculative introspection, those findings must be interpreted with caution. Behaviourism *per se* has no access to cognitive functions: it cannot reveal motivation. Introspection gains access to mental images not mental processes: empathy may disclose motivation but gains no insight into relevant neurological structures. At best, the electro-physical materials that comprise the latter can be monitored and correlated with observed behaviour. Whether in their natural presentation, or in consequence of brain damage, or medical or surgical intrusion, the measurement of brain activity provides some of the foundation upon which mind mechanisms are hypothesized.

Although 'in some ultimate sense mental phenomena are "nothing but" physical processes' (Hayek, 1952b, p. 190), an explanation of how mind reaches any particular disposition is logically impossible. This is because, in order to provide that explanation, it would be necessary to have knowledge of the physiological processes that might have led to different dispositions. In principle, that counterfactual would be knowable only to a more sophisticated instrument than the brain itself: '[A]ny apparatus of classification must possess a structure of a higher degree of complexity than is possessed by the objects which it classifies' (Hayek, 1952b, p. 185). Hayek subsequently recognized this as a corollary of Cantor's theorem, that 'in any system of classification, there are always more classes than the things to be classified' (Hayek, 1967, p. 61 fn.). (Further elaboration and the relevance of Gödel's theorem is given in 'What Mind *Is*', pp. [18-26disk] below.)

Even though knowledge of the mind by the mind's own activity is fundamentally unknowable, self-knowledge of mental events can still be used to 'understand', and even to predict, the results to which mental processes might lead under certain conditions. The insights to be drawn from this kind of introspection rest upon a 'uniformity (of human minds) thesis', for which precedents are to be found in Kant, Hobbes, Hume and Smith (see Fitzgibbons, 1995, pp. 62ff.). Without some degree of uniformity, there can be no meaningful social interaction: a human is more sensitive to (the perceptions of) another human than to a rat or (less still) to a bat or (less still) to a gnat. Introspection reveals (hypothetically, and given genetic and cultural similarities) what is thought by other minds; and that same kind of conscious self-examination provides a basis for ameliorating purely instinctive (or emotional) responses. It thereby admits a social dimension that invites both conditioned and considered reactions. Hayek's detailed elaboration of the juxtaposition of instinct, reason and culture (see Hayek, 1989, pp. 11–28) bears close similarities to Plotkin's later categorization of the primary, secondary and tertiary heuristics. (These are discussed further in the following section.)

Connectionism

Additional insights into cognitive processes may be drawn from the devices of artificial intelligence, where there are competing methodologies. With the orthodox 'symbol-processing' paradigm, symbols 'have semantic and syntactic properties' (Smith, 1997, p. 9): a series of binary decisions is made within the context of set rules. As in a computer, the biological memory-store is portrayed at definite locations in the brain. Early evidence to the contrary—rat behaviour after the surgical destruction of parts of their brains—was an inability 'to demonstrate the isolated localisation of a memory trace anywhere within the nervous system' (Lashley, 1950, p. 478). The alternative paradigm—of which Hayek's *The Sensory Order* is an early statement—is that of 'connectionism', according to which memory and thought engage (potentially) the whole brain by the variable strength of inter-neural impulses. Memory and thought are indistinguishable neurological processes—particular configurations of an intricate neural network—that are an adaptation to (and an understanding of) the external world.

In rejecting the orthodox notion that sensory fibres transmit mental phenomena to be stored in nerve cells, connectionism challenges the distinction between sensory perception and the operations that are performed on those data to generate understanding and memory. 'Sense data' is a redundant concept. The mind is not a store of data that reflect (or are correlated with) characteristics of elements in the physical world. Rather, we live in a sensory order that is created by the central nervous system:

> . . . we do not first have sensations which are then preserved by memory, but it is a result of physiological memory that the physiological impulses are converted into sensations. The connections between the physiological elements are thus the primary phenomenon which creates the mental phenomena. (Hayek, 1952b, p. 53)

Sensory qualities are determined by the 'differentiating' neurological responses of the system as a whole. The significance of each stimulus derives from its relationship to, and combination with, other stimuli. It is by the coordination of those sensory impulses that an effect is created. More recent neural network (connectionist) theories hypothesize that general information about the world is coded in a background configuration of the network's synaptic weights. Real-time information is coded in activation vectors that are processed by the weight-configurations through which sensory impulses pass. Learning is hypothesized as the adjustment of the global weight-configuration (see Churchland & Churchland, 1995, p. 73). Such views sit comfortably within Hayek's earlier and more general contention that

> Perception is . . . always an interpretation, the placing of something into one of several classes of objects. An event of an entirely new kind which has never occurred before, and which sets up impulses which arrive in the brain for the first time, could not be perceived at all. (Hayek, 1952b, p. 142)

Furthermore, Hayek's interpretation encompasses Edelman's more focused considerations. Thus, for illustration, cognitive psychologists and linguists

> . . . have become intensely interested in Edelman's ideas, in particular by the implication of the extended theory of neuronal group selection which suggests that the exploring child, the exploring organism, seeks (or imposes) meaning at all times, that its mappings are mappings of meaning, that its world and . . . symbolic systems are constructed of 'meanings'. (Sacks, 1995, p. 116)

The broadest feature of connectionism is that mental properties are 'determined by the place of the impulse in a system of relations between all the neurons through which impulses were passed' (Hayek, 1952b, p. 289). This is the 'clear perception' that led Hayek (1952b) 'to interpret the central nervous system as . . . a process of continuous and simultaneous classification and constant reclassification' (p. 289); a conclusion that is endorsed both contemporaneously and subsequently:

> The complexity of the functions involved in reproductive memory implies that every instance of recall requires the activity of literally millions of neurons. The same neurons that retain the memory traces of one experience must also participate in countless other activities. (Lashley, 1950, p. 479)
>
> . . . synaptic changes do not represent information that is stored in individual connections between single neurones. . . . Instead, signals act to

> select variant populations of synapses that connect cells within and between neuronal groups. (Edelman & Tononi, 1995, p. 82)
>
> . . . there are no innate mechanisms for complex 'personal' recognition, such as the 'grandmother cell' postulated by researchers in the 1970s to correspond to one's perception of one's grandmother. . . . Rather, the perception of a grandmother or, say, a chair depends on the synchronisation of a number of scattered mappings throughout the visual cortex: mappings relating to many different perceptual aspects of the chair (its size shape, its colour, its 'leggedness', its relation to other sorts of chairs—armchairs, kneeling chairs, baby chairs, etc.); and perhaps in other parts of the cortex as well (relating to the feel of sitting in a chair, the actions needed to do it, etc.). In this way, the brain, the creature, achieves a rich and flexible precept of 'chairhood' that allows the recognition of innumerable sorts of chairs as chairs (computers by contrast, with their need for unambiguous definitions and criteria, are quite unable to achieve this). (Sacks, 1995, p. 107)

At the highest levels of consciousness, responses to stimuli are modified by the influence of the widest range of impulses from other sources. For simple reflex action, higher centres receive simultaneous reports of both stimulus and response. Between these extremes of conscious and reflex response, a continuous range of 'engaged' connections is hypothesized within which no qualitative distinction is afforded to the most abstract processes of thought. All experience is shaped by memory and understanding; and whenever a new experience is inconsistent with 'the classification based upon past linkages', the classification must be revised:

> While there can thus be nothing in our mind which is not the result of past linkages (even though, perhaps, acquired not by the individual but by the species), the experience that the classification based on past linkages does not always work, i.e., does not always lead to valid predictions, forces us to revise the classification. (Hayek, 1952b, p. 168)

The differentiating responses of the neurophysiological system are determined by linkages previously created within the organizational structure of the central nervous system: a system of connections 'acquired in the course of development of the species and the individual by a kind of "experience" or "learning'' ' (Hayek, 1952b, p. 53). Pre-sensory linkages determine 'the order of the apparatus of classification', that is, the framework that determines all our 'conscious experience of qualitative attributes of external events'. Pre-sensory linkages—'relations of which we are not consciously aware' (Hayek, 1952b, p. 142)—are that part of *a priori* knowledge that 'is not learnt by sensory experience, but is rather implicit in the means through which we can obtain such experience' (Hayek, 1952b, p. 167).

By this interpretation, there are both phylogenic and ontogenic dimensions to the development of the sensory order. Others have reached similar conclusions. 'Commenting on the claim that Plato thought our "necessary

ideas" arise from the pre-existence of the soul, Darwin had written: "read monkeys for pre-existence" ' (Dennett, 1995, p. 130). In Henry Plotkin's exposition, pre-sensory linkages are produced by events typically encountered by a species over successive generations. This instinctive knowledge (the primary heuristic) is embodied within the genetic structure and evolves by natural selection to accommodate events that recur within the generational cycle (the period between the conception and reproductive adulthood of an organism). Non-recurrent changes require a special class of adaptation—intelligence (the secondary heuristic)—to allow an organism to cope with a future that is unlike the past. Intelligence tracks events that have not been accommodated by the primary heuristic. However, investigation of the consequences of each new sensation would squential intelligent learning to be impossibly slow. Instead, intelligence is primed by the primary heuristic, which ' "tells" the secondary heuristic what to learn' (Plotkin, 1994, p. 162). The neurophysiological explanation is that a deep-seated cerebral structure (the 'value system') projects over the entire cortex:

> Values reflect events involving the nervous system that have been selected during evolution because they contribute to adaptive behaviour and to phenotype fitness. Examples of low-level values are: 'eating is better than not-eating' or 'seeing is better than not seeing'. (Edelman & Tononi, 1995, p. 85)

What Mind *Is*

The answer to Hayek's question is that mind is a subjective mental order of events that prevails in that part of the physical universe that is self. Three structures are therefore relevant to an individual's (subjective) knowledge (see Hayek, 1952b, p. 39): the material world (the physical order); the human nervous system (the neural order), which is a part of the material world; and a personal interpretation of reality (the mental or sensory order of mind), which is created by the neural order.[5] The relationships between (i) the composer's vision, (ii) an orchestra with a particular symphonic score and (iii) the symphonic performance are roughly analogous to those between (i) reality, (ii) a brain with a particular neural order and (iii) the sensory order. The 'physical aspect' of the mind is mind itself (symphonic performance): it is not the individual neural processes (instrumental notes) but emanates from the complete order (the neural order) of those processes. Here resides consciousness.

Modern attempts to conceptualize consciousness *per se* are structured upon connectionism. In seeking to gain an understanding of how 'I' know that it is 'I' who knows, 'the investigation of consciousness (and all other cognitive phenomena) is condemned to some indirectness' (Damasio, 1999, p. 81). So, it is from general observations—that '[e]motions and core

consciousness tend to go together in the literal sense, by being present or absent together'; and that 'the absence of emotion is a reliable correlate of defective core consciousness' (Damasio, 1999, p. 100)—that Antonio Damasio (1999) argues the thesis that emotions *per se* are the bedrock of self: '[T]he plotting of a relationship between any object and the organism becomes the feeling of a feeling. The mysterious first-person perspective of consciousness consists of newly-minted knowledge, information if you will, expressed as a feeling' (p. 313). Upon that basis, the widest range of human emotions upon which self-consciousness (individuality) is based becomes relevant to any meaningful praxeology.

The 'efficacious role of consciousness is to construct an information scene ("the remembered present") that connects present reality to the past value-ridden history of each individual, conscious animal' and that confers such evolutionary advantages as 'the rapid integration of information and planning' and ' he translation of such planning into unconscious learned routines' (Edelman & Tononi, 2000, pp. 217–218). In utilizing the instrument of the brain, the mind classifies the regularities of the experience of living in a material world. Knowledge is created by mind, by its categorization of perceptions as memory:

> . . . *memory is more like the melting and refreezing of a glacier than it is like the inscription on a rock* . . . memory is not a representation; it is a reflection of how the brain has changed its dynamics in a way that allows the repetition of a performance . . . memory results from the selective matching that occurs between ongoing, distributed neural activity and various signals coming from the world, the body, and the brain itself . . . [memory is] a form of constructive *recategorization* during ongoing experience, rather than a precise replication of a precise sequence of events. (Edelman & Tononi, 2000, pp. 93–95)

This analogy is redolent of Henri Bergson's emphasis upon the continuous nature of experience. For example, the repeated reading of a poem is a series of unique events in that the 'experience on each occasion is modified by the previous readings' (Russell, 1929/1953, p. 403). Rigorous analysis shows such causal chains to be irreciprocal: 'There is no theory we may hold and no observation we can make that will retain so much as its old defective reference to the facts if the net be altered' (McCulloch & Pitts, 1943, p. 131). More generally, in bringing the past into the present, the process of memory creates phenomena: uniquely evolved mind-categories that constitute the coordination of sensory inputs invoked by external stimuli.

A vast network of neurophysiological connections re-creates and revises past and present associations (in respect both of the individual and—by genetic traits—of the species) between stimuli that have provoked impulses in the central nervous system. This neural order is determined by forces that belong entirely to (and is, itself, entirely of) the physical world. It is shaped upon the physical materials of the brain by the categorization of stimuli from

sense receptors. Hayek cites a number of reasons why different brains hold neural structures that are similar without being identical: (i) receptor organs are imperfectly selective and are of limited sensitivity, so that different (the same) physical stimuli may generate the same (different) impulses; (ii) physical stimuli are determined by conditions within a local environment (including the internal environment of the organism that houses the central nervous system); and (iii) different anatomical structures facilitate the formation of certain linkages and make the formation of others more difficult.

Species survival rests upon the abilities to anticipate external events and to respond appropriately. Although that anticipation requires an organism to have a mind-model of relationships between events and itself, the extent to which that mind-model can be understood is limited, because

> . . . any coherent structure of this kind [mind] which within itself contains a model guiding its actions, must be of a degree of greater complexity than that of any model that it can contain, and therefore than that of any object it can reproduce. (Hayek, 1952b, p. 131)

So, although the regularities of the physical world can form the basis of an hypothetical order (scientific theory) that constitutes an understanding of mind, the location of mind within the physical order cannot be explained:

> . . . it is impossible that our brain should ever be able to produce a complete explanation . . . of the particular ways in which it itself classifies external stimuli. . . . [T]o 'explain' our own knowledge would require that we should know more than we actually do, which is, of course, a contradictory statement. (Hayek, 1952a, p. 86)

The irresolvable conundrum is that the neural order is a subsystem of the physical order, but any understanding of the relationship between the sensory order (mind) and the physical order must derive from the neural order.

The enormity of the task of producing some theory of the interrelation between mind and brain function[6] is more readily appreciated than the necessity of its incompleteness.[7] Yet Hayek's speculation was that a machine designed by the human mind might yet be capable of 'explaining' what the mind is incapable of explaining without its help.[8]

> . . . such a machine would not differ in principle from . . . a calculating machine which enables us to solve problems which have not been solved before, and the result of whose operations we cannot, strictly speaking, predict beyond saying that they will be in accord with the principles built into the machine. (Hayek, 1952b, p. 189)

Such speculation can be viewed as a generalization of Gödel's theorem: that in no consistent axiomatized mathematical system can the proposition expressing its own consistency be proved:

> Gödel's theorem is but a special case of a more general principle applying to all conscious and particularly all rational processes, namely the principle that among their determinants there must always be some rules which cannot be stated or even be conscious. (Hayek, 1967, p. 62)

In less urbane terminology, Gödel's theorem shows that 'there are truths that "we can see" to be true that can never be formally proved to be true' (Dennett, 1995, p. 429). The association with Hayek's speculation is that

> . . . it remains possible that there may exist (and even be empirically discoverable) a theorem-proving machine which in fact *is* equivalent to mathematical intuition, but cannot be *proved* to be so, nor even proved to yield only *correct* theorems of finitary number theory. (Gödel, 1951; cited from Wang, 1995, p. 180)

The argument is that, deep within the mind, there may lie some 'unconscious unknowable algorithm' that affords it an ability to judge logical consistency:

> . . . the Gödel argument demonstrates that whatever understanding is, it is not a computational thing. This allows that natural selection could operate for this general non-computational quality—a quality which could be applied to a whole range of problems and not simply to mathematics. . . . If mentality is a function of brain action, and we accept that brain action is subject to the same laws of physics as everything else, those physical laws must allow for non-computational action. (Penrose, 1995, p. 26)

One obvious implication is that some amendment is necessary in respect of Hayek's belief that something like a calculating machine might be used to explain the human mind. There *is* a difference between computational and non-computational activity, but Gödel's theorem says nothing in respect of machines (or, rather, algorithms of artificial intelligence) that might exercise (non-computational) mathematical intuition as competently as the finest mathematicians; and so the human mind might be explained by means of some more elaborate artefact (though unlike a calculating machine).

A recent speculation focuses upon non-computational physical activity and how the special powers of the brain might derive from quantum effects. A potential solution has been predicated upon advances in 'the region between the quantum and classical levels of physics' (Penrose, 1995, p. 26). Whether these would be categorized as non-computable is as much an issue of semantics as of principle. Where physics is revolutionized, so too are the semantics. Yet, whatever the categorization, it 'would still be a physical science of the mind' (Dennett, 1995, p. 446), in opposition to the dualist notion of an immaterial mind.

In regard to perennial mind–body issues, Hayek describes dualism and the notion of 'mind "stuff" ' as an 'old habit' that derives from humankind's 'early study of nature'; and he delivers a conclusion that anticipates subsequent categorizations:

> To think of mind as a substance is to ascribe to mental events some attributes for whose existence we have no evidence and which we postulate solely on the analogy of what we know of material phenomena.
>
> In the strict sense of the terms employed an account of mental phenomena which avoids the conception of a distinct mental substance is . . . the opposite of materialistic, because it does not attribute to mind any property which we derive from our acquaintance with matter. In being content to regard mind as a peculiar order of events, different from the order of events which we encounter in the physical world, but determined by the same kind of forces as those that rule in that world, it is indeed the only theory which is not materialistic. (Hayek, 1952b, pp. 177–178)

From that description, *The Sensory Order* finds its place within the categorizations of dual-attribute or central-state theories that identify brain processes as wholly physical but with non-material properties that cannot be reduced to material ones.

The Adaptation of Mind

The brain is a biologically evolving instrument of an adaptive system: the sensory order of mind. The potential fallibility (of both) is a necessary characteristic to allow the Darwinian selection process to operate. The three key principles of Darwinian selection (see Lewotin, 1970) are *diversity* (of component elements), *interaction* (with the environment to test adaptive fitness) and *differential amplification* (successful variants are reproduced in relatively greater number).

On a phylogenic time-scale, 'the development of distinct receptors for different physical stimuli probably goes hand in hand with the development of different responses to those stimuli' (Hayek, 1952b, p. 158) and this leads to the plausible suggestion that the objective order (science) and the sensory order would evolve 'harmoniously' if

> as a result of the advance of our explanation of the world we also come to 'see' this world differently, i.e. that we not merely recognize new laws which connect the given phenomena, but that these events are themselves likely to change their appearance to us. (Hayek, 1952b, p. 175).

The evolutionary significance of this mutual feedback is that behavioural traits could lead (as well as follow) changes in organic structures; and others have argued that subjective aims might be similarly relevant, so that, for example, 'in choosing . . . to take interest in speech, man has chosen to evolve his brain and his mind; that language, once created, exerted the selection pressure under which emerged the human brain and the consciousness of self' (Popper & Eccles, 1977, p. 13).

The idea that organisms might guide the further evolution of their species (the Baldwin Effect) occurred to at least three early Darwinians. Where an

evolutionary mutation has brought some advantage, organisms that are not favourably endowed but which are 'capable of "reinforcement learning" not only do better individually . . . [but] . . . their species will evolve faster because of its greater capacity to discover design improvements' (Dennett, 1995, p. 79). While this is different from Lamarckism, in that it is a self-conscious development, the general point is that, although biological adaptations derive from random genetic mutations, natural selection ensures that modifications to physiological and behavioural characteristics endure when they enhance an organism's chances of survival.

The sensory order is similarly developed: as previous experiences are represented in the neural patterns of memory and consciousness, the mind 'simultaneously plays with a great many patterns of which some are confirmed as conducive to the preservation of the species' (Hayek, 1978, p. 43). The closer the proximity of knowledge to 'truth', the greater the survival probability; and 'the biotic system as a whole endures, being rather adept at solving the problem. Life is rather good at the knowledge game' (Plotkin, 1994, p. 244). In the widest possible sense, all knowledge is adaptation, and all adaptation is knowledge:

> The fleshy water-conserving cactus stem constitutes a form of knowledge of the scarcity of water in the world of the cactus. . . . Lacking a brain of any kind, the cactus has its knowledge built upon a less complex structure of genes and development. (Plotkin, 1994, p. 229)

Where brains are involved, knowledge is 'a special kind of adaptation': that is, the mind state (the sensory order) exists as a neurological adaptation to phylogenic and ontogenic experience, upon which an hypothetical future is constructed. Here, knowledge is a disposition towards the external world that manifests itself in action—'the organism must live as much in a world of expectation as in a world of 'fact'' ' (Hayek, 1952b, p. 121)—so that 'even the most abstract and "rational" thought is, in the end, a patterned behavioural response to environmental stimuli' (Butos & Koppl, 1997, p. 336).

Knowledge is not a unitary entity that exists to a greater or less extent in different species. Knowledge is domain-specific: different genes direct the selectional process of intelligence to produce different adaptations (knowledge) in different species: 'In so far as rat genes are different from human genes, then so too is rat intelligence different from human intelligence' (Plotkin, 1994, p. 165). So, it would be meaningless to ask how close perceptions are to the noumenal world: 'Which external events are recorded at all, and how they will be recorded, will . . . depend on the given structure of the organism as it has been shaped by the process of evolution' (Hayek, 1952b, p. 108).

Information is intelligible only where it can be compared with the already familiar; and since we can 'understand only what is similar to our own mind

it necessarily follows that we must be able to find all that we can understand in our own mind' (Hayek, 1949, p. 68). As a corollary, it follows that a uniquely original concept would be inherently incomprehensible: '[O]bservations themselves would not even exist if there was no previous knowledge which they could modify', and while this implies an 'infinite regress', this is the same kind of problem as 'the riddle of life itself' (Popper & Eccles, 1977, p. 425). Such difficulty is common to all evolutionary systems. As with life itself, mind is a dynamic product of evolutionary processes in which each new sensory quality (adaptation) is reliant upon earlier linkages, but retains a potential to modify them in consequence of further experience.

In general terms, knowledge is presented as an evolutionary adaptation 'by which the microcosm of the brain progressively approximates to a reproduction of the macrocosm of the external world' (Hayek, 1952b, p. 108). However, this simple (and potentially misleading) analogy is necessarily compromised, since 'the question of whether there exist "objectively" two different worlds is really unanswerable or perhaps meaningless' (Hayek, 1982, p. 292); and so, ' he relationship between these two orders, one of which is part of the other, is still one of the most intriguing problems of philosophy' (Hayek, 1982, p. 291).

While it is implicit that no clear boundaries separate biological, psychological and social adaptation, there are obvious variations in the pace of evolutionary change. In a social context, it is by a process of relatively rapid adaptation that the 'knowledge and intentions of different members of society are supposed to come more and more into agreement' (Hayek, 1937, cited from Hayek, 1949, p. 45). In attempting to model those patterns, a feasible task for social science is to seek empirically testable theories of expectation formation and learning. It was this that became the focus of Hayek's scholarly contributions.

Scientific Knowledge

An individual's behaviour is based upon the assumption that his or her sensory order is both safe and similar to that of organisms with which he or she associates. To remain safe, knowledge must be continuously revised at two levels: (i) 'we not only establish new relations between the data given within a fixed framework of reference' but (ii) 'we are led to adjust that framework itself' (Hayek, 1952b, p. 169). In this manner, *a priori* knowledge of one kind (pre-sensory linkages, which precede all conscious experience) becomes augmented by *a priori* knowledge of a second kind (i.e. objective knowledge or 'science'), as classifications based upon 'immediately given sensory qualities' are replaced by those 'defined in terms of consciously experienced relations' (Hayek, 1952b, p. 170). In this regard,

Hayek is influenced by the scientific 'reality' of Moritz Schlick. For example, colours are re-categorized as wave-length relativities. It was during his visit to Zurich in the winter of 1919–1920 (see note 5 and Hayek, 1994, pp. 4–5) that Hayek became acquainted with Schlick's work:

> . . . reality is called 'physical' *in so far as it is designated by means of the spacio-temporal quantitative system of natural science.* . . . [T]he world picture of natural science is no more than a system of signs that we correlate with the qualities and complexes of qualities whose interconnected totality forms the universe. . . . [T]he space of physics . . . is a wholly abstract structure, a mere scheme of ordering. (Schlick, 1925/1985, p. 294)

Scientific knowledge seeks ever-greater consistency in the account of events; it determines which kinds of events are possible so that, on the basis of 'a fairly complete history of a particular sensory object' (Hayek, 1952b, p. 172), an event can be assigned (with some degree of probability) to a place within the mind model.

Science is a conscious search for new classes—defined in terms of interrelationships between events rather than in terms of their sensory properties—such that general propositions (about the behaviour of events) are universally true. Ultimately (and hypothetically), '[s]uch a complete system of explanation would necessarily be tautological, because all that could be predicted by it would necessarily follow from the definitions of the objects to which it referred' (Hayek, 1952b, p. 173). While this categorization of events, by characteristics that belong to the objective order, defines the (natural) scientific method, progress by this 'reductionist' approach must not be so rigidly applied as to inhibit understanding. Thus, for example, while every electron obeys the same laws of physics, the profusion of activity within two calculators is too great for theoretical electronics to be used to explain why one of them gives incorrect answers. Investigation of the broad pattern of errors (the differences between the two calculators) is more likely to reveal their source. Electrons are simple phenomena; calculators are complex phenomena[9] that must be approached through the application of a different set of principles.

Complex Phenomena

Hayek (1967) draws a distinction between 'the relatively simple phenomena with which the natural sciences deal' and 'the more complex phenomena of life, of mind, and of society' (p. 25), which are less accessible than those of physical systems. So, although classes of patterns identified by social science might allow for predictions, these must be predicated upon highly specific circumstances: that is, upon extensive empirical data. However, predictions are not the sole concern and, if the data are insufficient to

allow predictions, the theory—the knowledge of the pattern—is still useful. Where a theory has little empirical content, 'hypothetical predictions' may be possible: 'i.e., predictions dependent on yet unknown events' (Hayek, 1967, p. 29). For the most part, the primary achievement of social science has been to show that events determined by human interaction depend upon so many circumstances[10] that we can never hope to be able to ascertain them all:

> The very insight that theory provides . . . that almost any event in the course of a man's life may have some effect on almost any of his future actions, makes it impossible that we translate our theoretical knowledge into predictions of specific events. (Hayek, 1967, p. 34)

So, for example in economics, Hayek variously warns that predictions cannot be predicated upon 'pseudo-entities' of the kind that comprise the Keynesian approach. Furthermore,

> he number of separate variables which in any particular social phenomenon will determine the result of a given change will *as a rule* be far too large for any human mind to master and manipulate them effectively. In consequence our knowledge of the principle by which these phenomena will be produced *will rarely if ever* enable us to predict the precise result of any concrete situation. (Hayek, 1952a, pp. 73–74, italics added)

The insuperable limitation of the human mind and the knowledge that it can command is the theme of Hayek's last book (*The Fatal Conceit*), published three years before his death: 'The process of selection that shaped customs and morality could take account of more factual circumstances than individuals could perceive, and in consequence tradition is in some respects superior to, or "wiser" than, human reason' (Hayek, 1989, p. 75). Yet there are no means to determine in advance if cultural adaptations are likely to bring greater social cohesion. Evolution (biological and cultural) cannot proceed without variations, and it is impossible to anticipate more than their *immediate* impact upon organic function. Herein lies the argument for liberal social systems that have allowed experiment, adaptation and selection such that 'practices which had first been adopted for other reasons, or even purely accidentally, were preserved because they enabled the group in which they had arisen to prevail over others' (Hayek, 1973, p. 9). By their greater catallactic[11] and/or organizational harmony, some communities prosper as others decline; and that success is achieved only in consequence of the general characteristics of an evolutionary process:

> . . . a mechanism of reduplication with transmittable variations and competitive selection of those which prove to have a better chance of survival will in the course of time produce a great variety of structures adapted to continuous adjustment to the environment and to each other. (Hayek, 1967, p. 32)

Conclusion

In the years that followed publication of *The Sensory Order*, Hayek's own work on the 'far-reaching philosophical problems' that derive from 'the distinction between what we can say "within a system" and what we can say "about a system" ' (Hayek, 1994, p. 29) proved 'so excruciatingly difficult' that a long and unfinished paper was abandoned after he found that nobody he 'tried it upon could understand' (Hayek, 1982, p. 290). Even so, the immutable constraints upon the understanding of mental processes have important philosophical and social implications that set the tone in all of Hayek's other work:

> While our theory leads us to deny any ultimate dualism of the forces governing the realms of mind and that of the physical world respectively . . . we shall never be able to bridge the gap between physical and mental phenomena; and for practical purposes . . . we shall permanently have to be content with a dualistic view of the world. (Hayek, 1952b, p. 179)

Hayek saw a way forward in drawing a distinction where none exists: between forces that govern the mind and forces that govern the physical world. The social relevance of that conclusion is that it removes the basis for mitigating circumstances that might excuse some particular action. There is no 'metaphysical self which stands outside the chain of cause and effect' (Hayek, 1967, p. 232). In other words, an individual's action is *always* integrally linked to the circumstances of that action by our essential ignorance of the physical conditions that would have given rise to some different action. Such ignorance would be removed only by an understanding of the derivation of the sensory order from the physical order, but that is impossible. This explains the emphasis that Hayek places upon an individual's action and the responsibility of that individual for his or her action. If an individual were not held responsible for his or her action, nothing would be left for which that individual could be held responsible.

To hold an individual 'responsible for the consequences of an action' is an assertion neither of causation nor of fact, but 'is rather of the nature of a convention introduced to make people observe certain rules' (Hayek, 1960, pp. 74–75). Such conventions are the representation of commonly held attitudes and relationships that, by their evolutionary adaptation, endure as one generation succeeds another. This is a genuinely social structure that is separated from any particular set of individuals, who just happen to be 'the *foci* in the network of relationships' (Hayek, 1952a, p. 59). In accepting the discipline of those conventions, and despite personal ignorance, the individual is guided by a cultural inheritance that facilitates the achievement of the widest range of individual purposes: the groping, uncertain, evolving behaviour of agents—making decisions (with both success and failure) within a liberal social order—is the Hayekian prospectus that is founded upon the most encompassing of praxeological conceptions.

Notes

1. 'Hayek's approach to the explanation and comprehension of complex phenomena provides a conceptual focus that underlies virtually everything he has written' (Weimer, 1982, p. 241); '[T]he view of knowledge which it defends can be shown to presuppose many of the positions Hayek adopted in economic theory and social philosophy' (Gray, 1984, p. 3); '[W]hat I'd done in economics helped me to do this biological work as much as the opposite' (Hayek, 1994, p. 153).
2. Hayekmade the quite fruitful suggestion, made contemporaneously by the psychologist Donald Hebb, that whatever kind of encounter the sensory system has with the world, a corresponding event between a particular cell in the brain and some other cell carrying the information from the outside world must result in reinforcement of the connection between those cells. These days, this is known as the Hebbian synapse, but von Hayek quite independently came upon the idea. I think the essence of his analysis still remains with us. (Edelman, 1982, p. 24)

   Edelman's work is admirably summarized in Sacks (1995).
3. A typescript produced some time in the late 1940s is in the Hayek collection at the Hoover Archive, Hoover Institute, Stanford. I am indebted to Bruce Caldwell for pointing to a letter dated 21 July 1945 in which Hayek tells Otto Neurath that he is engrossed in an attempt to elaborate the psychological implications of his scientism articles and to restate ideas he had formed on the subject many years earlier.
4. '[Y]ou wish he would do a reasonable share of the work in connecting up his thought with that of his predecessors . . . one would like to be shown . . . his theory in the perspective of the history of scientific thought about these matters' (from a review of *The Sensory Order*, cited from Hayek, 1994, p. 27).
5. These structures are almost certainly derived from Schlick's *Allgemeine Erkenntnislehre* (translated and published as *General Theory of Knowledge*), which is acknowledged as one of those works that influenced 'the original formulations of the theory here developed' (Hayek, 1952b, p. 195). From Schlick (1925/1985), there is:

   > 1) reality itself . . . ; 2) the quantitative concepts of the natural sciences . . . ; and 3) the intuitive images by means of which the magnitudes cited in 2) are represented in our consciousness. Here 3) is of course a part of 1), that is, a subdivision of the part of reality we designate as consciousness. (p. 295)

   In Hayek, (2) and (3) are transposed and (with 2) emphasis is placed upon subjectivism; it is through the continuous process by which knowledge is revised that primary categorizations give way to scientific knowledge (see 'Scientific knowledge', pp. [30-2disk] below).
6. 'The needed theory . . . must account for (or at least be compatible with) all the facts of evolution and neural development and neurophysiology, on the one hand, and all the facts of neurology and psychology, on the other' (Sacks, 1995, p. 103).
7. For example: The brain is subtle and capable it seems of infinite understanding of its self, its origin, its cosmic origin, the origin of the cosmos, and of that

cosmos's immediate, intermediate, and long-term featureless future' (Atkins, 1995, p. 130).

8. In respect of Karl Popper's criticism—that *The Sensory Order* was an (impossible) attempt to provide a causal theory of the mind—Hayek (1994) commented:

> You could, in theory, reproduce a sort of map of how one stimulus evokes other stimuli and then further stimuli, which can, in principle, reproduce all the mental processes. I say 'in principle' because it's much too complicated ever to do it. It led me, incidentally to the distinction between an explanation of the principle and an explanation of the detail—pattern prediction, as I now know it—which I really developed in my psychological work and then applied to economics. (p. 138)

   The distinction between 'the relatively simple phenomena with which the natural sciences deal . . . [and] . . . the more complex phenomena of life, of mind, and of society' is defined by 'the minimum number of distinct variables a formula or model must possess in order to reproduce the characteristic patterns of structures of different fields (Hayek, 1967, p. 26). The similarity between Hayek's definition of complexity and that given in the context of Charles Darwin's theory of evolution (see Dawkins, 1986, pp. 2–13) is striking, but not surprising. Hayek (1967) cites Darwin's theory of evolution as 'the best illustration of a theory of complex phenomena which is of great value, although it merely describes a general pattern whose detail we can never fill in' (p. 31).

9. This illustration is taken from Dennett (1995, p.102). Another contrasts simple chemical and complex biological patterns:

> . . . the physical laws governing the actual *chemical* interaction of the genetic elements making up the code (the nucleotides) are deterministic. No deterministic laws at the chemical level could alone, however, explain the sustained code change that was initiated and then stabilized over long periods as a result of complex selectional events on whole animals in unique environments. (Edelman, 1995, p. 204)

10. 'Human individuals, created through a most improbable sequence of events and severely constrained by their history and morphology, can still indulge in extraordinary imaginative freedom. They are obviously of a different order from nonintentional objects. They are able to refer to the world in a variety of ways. They may imagine plans, propose hopes for the future, and causally affect world events by choice. They are linked in many ways, accidental and otherwise, to their parents, their society, and the past. They possess 'selfhood', shored up by emotions and higher-order consciousness. And they are tragic, in so far as they can imagine their own extinction' (Edelman, 1995, p. 205).
11. The catallaxy is an order wherein there is no common purpose; its essential characteristic is that of free exchange rather than (as within a goal-oriented organization) that of optimal choice.

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