©2008 The Institute of Mind and Behavior, Inc.
The Journal of Mind and Behavior
Winter and Spring 2008, Volume 29, Numbers 1 and 2
Pages 1–16
ISSN 0271–0137

The Central Problem of Cognitive Science: The Rationalist–Empiricist Divide

Henry Plotkin

University College London

One of the oldest and most fundamental distinctions and disputes of classical epistemology is that between the rationalists and empiricists. In recent decades, partly due to the increasing influence of evolutionary thought in psychology, the argument has become central in cognitive science as well, but it will remain empirically intractable until further advances occur in neurogenetics, neuroscience, and how these tie in to fundamental psychological mechanisms and processes.

There is much pleasure when contemporary science begins to answer old philosophical questions. This is because philosophy has always comprised systematic thought on the most fundamental problems of existence, and thus stands at the centre of all scholarship. So, when science, directly or indirectly, resolves such fundamental problems, that is a cause for rejoicing. A major epistemological issue for classical philosophy has long been whether certain states of mind, specifically what we would now call cognitive states, truthfully represent the world — the certainty that we can have that what we know approximates to what is. Descartes, for example, in the seventeenth century, warned of the difficulties of attaining knowledge in the face of the uncertainties of mind states which might be the products of dreams, hallucinations or evil demons. The theory of evolution allows us to use science to discard Descartes' philosophical fears. The argument goes along the following lines.

Animals are not autotrophs, and hence cannot, like plants, trap the energy of the sun into their own structure to fuel the processes of life (though a small number of organisms can exploit an alternative energy source in simple mineral substances). Thus most multicellular animals during the last 400 million

---

Parts of this article were published first in Henry Plotkin's *Necessary Knowledge*, ©2007, Oxford University Press, Oxford, United Kingdom, reprinted by permission. Requests for reprints should be sent to Henry Plotkin, 10 Manorcrofts Road, Egham, Surrey TW20 9LU United Kingdom. Email: vicky.plotkin@btopenworld.com years have needed to eat plants or other animals that eat plants in order to gain access to the sun's energy. Since animals and plants are more unevenly distributed in space than are sunlight and air, most animal species have evolved mobility, and the ability to locate these discrete packages of energy. Co-ordinating movement relative to these energy sources was the principal selection force for the evolution of sensory systems in early multicellular animals with differentiated nervous systems. The further evolution of associative learning, which allows the coupling of sensory inputs to track cause–effect relationships, was a refinement to the means of locating restricted energy resources. In this purely analytical sense, animals that have evolved the ability to learn can be said to have knowledge about restricted features of their world (Plotkin, 1994). Since the lives of animals that have evolved the capacity for learning literally depend upon such knowledge, hundreds of millions of years of evolution will have led to knowledge forms, products of associative learning, no matter how simple, that have a reasonably high degree of accuracy relative to these restricted features of the world. This must be so, for if it were not the learners would not have survived and their lineages not evolved the capacity for such learning. If for "accuracy" one substitutes the more philosophical term "truth," then learning in most animals that have that ability is a partially true internalization of the causal structure of their world. Contrary to the fears of many philosophers, we can place considerable trust in the knowledge we gain through our cognitive mechanisms. Such knowledge may only ever be partial and incomplete, but its "truth" is sufficient to maintain the life of its possessors.

Here, then, is an answer to one philosophical problem. But there is another, closely related, major issue in classical epistemology which is less easy to argue for or against, and for which the empirical evidence remains ambiguous. This concerns the sources of knowledge: specifically, whether we come into the world with innate knowledge, or whether all knowledge is the product of experience. This is the distinction between rationalist and empiricist epistemological doctrines. In general, psychology has inclined strongly towards empiricism. But in the last few decades two forms of rationalism have risen to the fore and now stand as strong challenges to empiricism.

Outline of the Philosophical Positions

The Sophists, a school of ancient Greek philosophy that preceded Plato, doubted whether human knowledge could ever be true. Plato, in contrast, certainly did believe that we humans could have, and do have, true knowledge, but it is knowledge of a particular form and derives from a particular source. Plato believed that true knowledge lies in understanding those aspects of the world that are unchangeable, the ideas or "forms" of the world. Such ideas or forms are not revealed by ordinary sense experience, which merely provide specific instances of the world and not the order of the forms that lie behind such instances. True knowledge, that which lies behind such instances, can only be achieved by recollection through training in logic and mathematics. In short, true knowledge is something that we are born with, it is innate, not something that we acquire. The latter, what we learn via the senses, is fleeting and untrustworthy. For Plato the source of knowledge lies in lives previously lived. As will be seen, just as modern evolutionary science provides an answer to the problem of whether knowledge can ever be claimed to have truth value, so that same science now makes clear sense of Plato's position, even if at first blush it seems mystical nonsense.

In asserting that we come to knowledge by reason alone, and that sensory experience is not to be trusted, Plato's epistemology is called rationalism. There have been other proponents of this school of thought, most famously Descartes himself some one and a half millenia later. Unlike Plato (of course), Descartes was a devout Christian. He believed in God, and as an extension to his arguments regarding the certainty of knowledge, he concluded that only some things might thus be known with certainty. These are one's own existence (in the form of the famous *cogito ergo sum*), the existence of God, the complete assurance that God does not deceive us, and that God makes available to us certain knowledge in mathematical form. Knowledge from the senses can never be "clear" and "distinct," and hence can never be certain. Apart from the role of a Deity as the source of certain knowledge, Descartes' rationalist position closely resembles that of Plato.

Critics of the rationalist stance argued that Plato's forms and Descartes' innate ideas were merely personal intellectual fixations with what is neither material nor sensible. They do not accord with ordinary experience where knowledge gained from our senses works well enough, it was argued, and in the new age of scientific understanding, for that is when these criticisms began to gather, knowledge from the senses is what philosophers should be considering. An alternative approach to epistemology was thus deemed necessary which was to be one based on ordinary experience and behaviour but modelled on the way science operates by way of observation. Thus was born empirical philosophy of knowledge, with John Locke, though not its first proponent, the first to provide a consistent analysis of what can be known if one rejects the rationalist notion of innate knowledge.

The rejection of innate knowledge is the single consistent and central idea of all empirical epistemology. For Locke the mind at birth is a "white paper, void of all characters, without any ideas." Some half a century later David Hume asserted that sensory impressions always precede ideas. For Hume this had the force of a law and was his denial of the existence of innate ideas. What we have in our minds *as knowledge* begins at our sensory surfaces and nowhere else. Different empirical philosophers provided different forms of analysis as to how knowledge relates to sensory experience, and, very importantly for philosophers (though as pointed out above an issue that science has now settled), how that knowledge relates, if at all, to what is out there in the world causing those sensations. On the other hand, the denial of innate knowledge was, as Fodor (1998) rightly points out, not a denial of innate psychological processes and structures. Hume in particular believed that an understanding of knowledge rests ultimately on a science of the human mind, and the way that the mind works is certainly set by "human nature" which is already present at birth. In his arguments against our perception of cause–effect relationships, he famously asserted that our inferences of such relationships are a product of how our minds work — by force of habit. But such habit, which for Hume was a specific capacity for forming associations based on particular features of our perceptions, are a necessary product of human nature. The contents of our minds, the ideas we have, are not innate. But the capacity to have them certainly is. Indeed, unlike Locke, who would have no truck with the innate, in his *Enquiries Concerning Human Understanding*, Hume stated that "if by innate be meant, contemporary to our birth, the dispute seems to be frivolous; nor is it worthwhile to enquire at what time thinking begins." Innate is "what is original or copied from no previous perception" and can only be interpreted to mean the nature of the mind at birth.

This distinction, between the content of our minds and the processes and mechanisms that allow content to exist, is not trivial. Some contemporary cognitive scientists (for example, Elman et al., 1996; Karmiloff–Smith, 1998) seem to assume that classical empirical philosophers argued against all things innate; as if psychological processes and mechanisms only come into existence when sensation begins. Yet no philosopher has ever denied the existence at birth of a mind conforming to human nature, whatever they might have meant by that. It was the existence of what Elman et al. term representational knowledge of the world at birth that the empiricists denied.

The New Rationalists

Evolutionary theory had the power to change everything in psychology and what was to become cognitive science, even though it has taken well over a century for something like clarity and consistency to emerge (Plotkin, 2004). What it provided was the conceptual machinery by which what might be innate could be set alongside what might be acquired, together with understanding as to how these might be related to one another. Initial confusion in the nineteenth century arose from two theories of evolution, the one Lamarckian and the other Darwinian — and the tendency for Darwin himself increasingly to use Lamarckian notions. Herbert Spencer ran with Lamarck's theory to argue that what could be individually acquired by learning formed the basis for the evolution of instincts, which are innate behaviours that must be part caused by innate representational knowledge. That is, instincts had their origins in learned behaviours based on acquired representational knowledge. Darwin, by contrast, in his *Origin of Species* (1859), provided a clear argument, at least in its first edition, for instincts as evolved behavioural patterns, the products of natural selection like all other corporeal structures. But twelve years later, in *The Descent of Man*, he wrote with unusual confusion on the relationship between learning and instinct. Limitations of space prevent any account of the kind of ordered thinking that slowly emerged after Darwin's death through the work of the likes of Conway Lloyd Morgan and James Mark Baldwin, which can be found elsewhere (Plotkin, 2004). Suffice it to say that, whatever such advances were — and they were considerable — the rise of behaviourism from around 1913 outlawed serious theoretical advances in just those areas of psychology, like learning, where evolutionary ideas had begun to shed some light. Over half a century of shameful theoretical muteness was to pass before this was to occur again, and then it came from the unexpected direction of ethology.

Konrad Lorenz was one of the founding fathers of ethology, and as a staunch evolutionary biologist was untouched by the absurd prohibition behaviourist psychology had placed on the understanding of behaviour in the light of evolutionary, or any other, theory. For ethologists, evolution was the central conceptual plank of their science. However, Lorenz was also a Kantian, and in 1941 he had considered Immanuel Kant's notion of the a priori in the light of evolutionary biology. Kant had argued that humans are possessors of a priori intuitions about time and space and a priori categories dealing with quantity, quality, modality and relation. By definition, such a prioris are innate. They are part of our minds at birth, prior to experience. In this sense Kant was a rationalist. However, Kant acknowledged that sensory experience is an important part of what we know, such sensory experience being filtered and moulded by our intuitions and categories. In that sense, Kant was also an empiricist. And unlike the scepticism, sometimes extreme scepticism, of the empirical epistemologists, he also acknowledged that there is a world to be known, comprising what he referred to as "things in themselves." But, and this is a big but, Kant did not believe that our a priori intuitions and categories were related in any meaningful way to the properties of the "things in themselves." Our inborn intuitions and categories are the means by which we make sense of the external world, but all "things in themselves" are essentially unknowable.

As an evolutionist, Lorenz argued that Kant had been wrong to assert that there are no necessary relationships between our, or any animal's, a priori intuitions and categories and the world in which we live. Such innate features of mind had to be products of long histories of natural selection, and as such there had to be a connection. "Is it at all probable that the laws of our cognitive apparatus should be disconnected with those of the real external world?" (Lorenz, 1941, 1982, p. 122). His answer was an emphatic negative. Our cognition has to bear a positive relationship to the experienced world. Thus can Plato's rationalism be seen in the light of contemporary science. Some knowledge is innate and does indeed derive from previous lives. The transmission, though, is genetic and not, as Plato believed, a form of reincarnation.

Lorenz had been writing in 1941 in very general and unfocussed terms. In response to the fierce criticisms (e.g., Lehrman, 1953) of his earlier distinctions between instincts and learned behaviours, he later (Lorenz, 1965) extended his stance in a very specific way. Lehrman and others had accused Lorenz of creating a damaging conceptual dichotomy between instinct and learning which did not accord with findings from studies of behavioural development in animals. For the critics, most behaviour could not be causally dissected in this way. The same behaviours are the product of both innate factors *and* learning, as well as more general developmental processes. This was the standard interactionist position in the nature–nurture debate. In his 1965 monograph, Lorenz countered with a significant insight. He pointed out what no-one had noticed before, which is that learning is almost always adaptive in outcome. He considered this to be "astonishing" and highly significant. It was proof, he claimed, that learning is itself a product of evolution, and hence learning as an adaptation must itself be innate. The innate component of learning he described with the phrase "innate teaching mechanisms" to capture what is now referred to as constraints on learning, even though at that time there were no empirical accounts of learning constraints. It is important to note that Lorenz was not claiming merely that the mechanisms underlying learning are innate. He was asserting that some representational knowledge is innate, because that is what points the learning mechanisms at the specific features of the world that must be learned. Reports of learning constraints were soon to appear in the literature (Garcia and Koelling, 1966) and in less than 20 years were filling entire volumes (for examples see Bolles and Beecher, 1988; Marler and Terrace, 1984). For reasons outside of science (Plotkin, 2004), Lorenz is now given little credit for his insight, but the idea of evolved constraints on learning was original to him, and was a seminal contribution to cognitive science.

It might be that Fodor is guilty of slight overstatement when he asserts that "most cognitive scientists still work in the tradition of empiricism and associationism, whose main tenets haven't changed much since Locke and Hume" (1998, p. 203). It is certainly the case, though, that psychology in general, and learning theory in particular, during much of the twentieth century could be so characterized. From Pavlov and Thorndike through to Hull and Skinner, general process theory of one sort or another had dominated with the central assumption that learning was a general process, the same process, caused by the same cognitive mechanisms in all learners, human and non-human, and that within each species, all knowledge is gained by way of some single learning mechanism. Even Piagetians, working outside of the intellectually crippling confines of behaviourism, adopted a general process view. This is why Lorenz's 1965 insight was so revolutionary, and why constraints in animal learning received so much attention. It provided sound justification for the view that learning need not, indeed was unlikely to be, a general process; and that its specificity and difference in different species is the product of evolution.

Several strands in human cognitive science and the emerging evolutionary psychology of the 1980s and 1990s then wove together the theoretical divide that we have today, with the new empiricists, mostly developmental and neurocomputational empiricists on the one side, and the new rationalists (in Fodor's phrase) on the other. One of these strands that formed the basis for the new rationalism was the very important and influential work of Chomsky (1959, 1980, 2000) and other members of the generative grammar school. Whilst the details have changed, Chomsky's central thesis has been that language is the product of an innate organ of mind that is responsible for the acquisition of every and any spoken human language, as well as sign language in the deaf. Chomsky's position has not gone unchallenged (for example, Deacon, 1997), but the influence of so powerful and stark a nativist position has been immense. One implication of any strong nativist stand is that what is innate must be genetically part-caused, and that whatever these genetic components might be, that they are a product of evolution. For much of the last five decades Chomsky himself has maintained a distant neutrality on the issue of the evolution of language. Others have not (Calvin and Bickerton, 2000; Pinker, 1994); developing coherent arguments for language being the product of evolution by natural selection. Recently Chomsky himself has written in broad terms on whether and how language can be placed within an evolutionary context (Hauser, Chomsky, and Fitch, 2002).

Another important strand was Fodor's *The Modularity of Mind* (1983), early on in which he asserts that "Descartes' doctrine of innate ideas is with us again and is (especially under Chomsky's tutelage) explicitly construed as a theory about how the mind is (initially, intrinsically, *genetically*) structured into psychological faculties or 'organs.' I am inclined to view this Cartesian revival as very nearly an unmixed blessing" (p. 3, italics added). Fodor's position was the result of what had become one of the central tenets of cognitivism, Chomsky's (1980) poverty of the stimulus argument, and a long established characteristic of human perception.

The poverty of the stimulus argument (see Laurence and Margolis, 2001, for a recent review) asserts that the output of some computational process, for example perception, contains more information than the proximal stimulus, the input, and hence that the increase in the information of the output must be coming from features of the computational mechanism itself: "Poverty of the Stimulus Arguments show that the organism must contribute information to perceptual integrations; 'perceptual inferences' just *are* the computations that effect such contributions. Now, this information that the organism contributes — the premises, as it were, of its perceptual inferences — must include not just sensory specifications of current proximal inputs but also 'background knowledge' drawn from prior experience or innate endowment; for what the Poverty of the Stimulus Arguments show is precisely that sensory information alone underdetermines perceptual integrations" (Fodor, 1985, p. 3, italics in the original)

As will be immediately clear to every reader, "prior experience *or* innate endowment" sets the scene for further argument, though Fodor himself, and before him Chomsky when applying the argument to language learning, clearly voiced support for the notion of innate knowledge in these perceptual processes and mechanisms. A few paragraphs further on in his précis of the 1983 monograph, Fodor explicitely noted that the background knowledge of perception is "largely innately specified" (p. 4).

The characteristic of perception that Fodor drew on was the persistence of illusions in the face of knowledge or belief that the illusion is a perceptual error. This led him to assert that perception is encapsulated from cognitive processes such as reasoning, and from other characteristics of perception he derived the notion of a general architecture of the mind in which a number of different input modules are computationally separated from more general cognitive mechanisms, as well as from each other. Such modules are domain-specific, computationally dedicated, fast processing and associated with specific neuroanatomical mechanisms and loci. Fodor was not concerned with providing an exhaustive listing of modules, nor of the specific characteristics of a module. His task was to present a general theory of the architecture of mind: ". . . no facts now available contradict the claim that the neural mechanisms subserving input analysis develop according to specific, endogenously determined patterns under the impact of environmental releasers. This picture is, of course, quite compatible with the view that these mechanisms are instantiated in correspondingly specific, hardwired neural structures. It is also compatible with the suggestion that much of the information at the disposal of such systems is innately specified . . ." (Fodor, 1983, pp. 100–101). Thus, not only is the "content" of each module partly innate in origin, and hence genetically part-caused, but the overall functional architecture of the brain/mind, insofar as it is modular, is innate too. In this, Fodor *was* specific, as well as in limiting modularity to perception.

The modularity thesis became central to cognitive science, even if the exact nature of that modularity was contested, with different cognitivists presenting different ideas as to just what a module is (Barsalou, Simmons, Barbey, and Wilson, 2003; Coltheart, 1999; Premack and Premack, 2003; Uttal, 2001). But certainly in Fodor's hands, it was innatist or nativist in form; what he would later call an instance of the "new rationalism" (Fodor, 1998). It should also be noted that Fodor has never been a friend to evolutionary, especially neoDarwinian, explanations in cogntitve psychology. Thus the contemporary rationalists in cognitive science take two forms. On the one hand, there are those, like Fodor, who advance a strong nativist position, but detach themselves from any accompanying theory of evolution to account for whatever is being claimed as innate; on the other, there are those with a powerful commitment to evolutionary forces of some kind as the origins of innate knowledge.

Another significant contribution to the new rationalism began in the 1980s with the methodological innovations of the dishabituation paradigm allowing infants to be tested earlier than had been previously possible. Causal understanding (Leslie, 1995), intuitive physics (Baillargeon, Kotovsky, and Needham, 1995; Spelke, Phillips, and Woodward, 1995), numerical competence (Wynne, Bloom, and Chiang, 2002), and the capacity to imitate (Meltzoff and Moore, 1983) have been reported in neonates (in the case of imitation), 12–14 week old infants (physics and physical causation) and 20 weeks (number). Such findings are not isolated. In general a large, and growing, body of well-controlled experimental observations point to infants displaying knowledge at a very early age, with some interesting details, like small sex-differences, enhancing the general feeling of developmentalists that the findings are systematic and robust. How such results are to be understood, though, is another matter. Some (see below) take a new empiricist position, arguing that the knowledge that these experiments reveal is the result of learning. Others, for example Pinker (1997) and Butterworth (1999), are inclined to the view that infants so young that their sensory systems are restricted, their movements uncoordinated, who are incapable of reasoning and have spent a large proportion of their postnatal lives asleep, could not have acquired such knowledge through learning. Such knowledge is innate, present at birth. They are modern-day psychology's Kantian a prioris; the realization of Lorenz's learning constraints that direct the infant's attention to specific and constant features of the world. Nobody denies that learning may also be occurring, but it is learning that provides an increasing overlay to knowledge of some form already present at birth.

There is another line of argument used to support the new rationalism. Many linguists have noted the constancy and seeming universality in the acquisition of language, irrespective of what language is being learned (Jackendoff, 1993, for just one of many examples). From the appearance of babbling, through the gradual restriction of such babbling in accordance with its specific linguistic environment, the appearance of first words, then two-word utterances of specific structure, followed by multiword speech, the rate of acquisition of vocabulary and grammatical structure, all infants and children pass through the same stages in the same sequence. Deaf children acquiring sign language pass through exactly the same stages at the same ages (Meier, 1991). Many theorists have argued that such constancy points not only to innate mechanisms, but to mechanisms with some degree of innate content of knowledge.

Similar arguments are used with regard to theory of mind (Baron–Cohen, 1995). Sensitivity to eyes and direction of gaze, dyadic interactions, sharing of attention by protodeclarative pointing, triadic representations, pretend play, the use of intentional vocabulary (words like "want" or "need"), and the understanding that others can have beliefs different from the self occurs in an invariant order and unfolds at roughly the same ages in all children studied — though the cross-cultural richness characteristic of linguistic research has yet to be attained in studies of the development of theory of mind. If such constancy is shown to be present irrespective of culture, strong claims will be made for an innate organ of mind that comes to understand that others have intentional mental states. Again, it is not just the notion of innate mechanisms, but of content. Why the sensitivity to eyes, for instance, and why the universal attention to direction of gaze? It remains to be seen whether similar constancy of development marks other forms of cognitive development, such as numeracy or intuitive physics, though Cohen and Amsel (1998) have begun to do this with causal perception.

There is, of course, the accompanying growth of information from the study of individuals with brain damage about the relative constancy of areas of the brain with specific psychological functions (Shallice, 1988), including theory of mind (Stuss, Gallup, and Alexander, 2001). Functional imaging technology is exploding with supportive data, too numerous to cite. A tiny selective sample relating specifically to theory of mind can be found in Gallagher and Frith (2003), Koechlin, Ody, and Kouneiher (2003), and Lau et al. (2004). The importance of such findings to the new rationalists lies in a seeming physical constancy in the brain of psychological mechanisms not directly related to specific sensory systems. If theory of mind is localized in the brain, it is not in the visual system, despite the importance of eyes and gaze direction in its early development.

The notion of modularity, the existence of constraints on learning and perception in humans and non-humans alike, developmental studies, and data emerging from the neurosciences, all combine to form a strong, even if still indirect, evidential base for Fodor's new rationalism. The emergence of a strong rationalism in psychology cannot really be described as new when the basis for it lies some fifty years back, but it certainly does markedly contrast with the first century of scientific psychology. What is relatively new is the sense that evolutionary psychology has made of it (see below). Science, though, is never simple, and a strong opposition to rationalism has always existed in psychology. In recent years it has emerged in a somewhat different form to traditional general process theory.

The New Empiricism in Cognitive Science

As already stated, empiricist epistemology was dominant in psychology for the first century of the new science of mind. Even the likes of William James, who accepted the importance of instinct for understanding human behaviour, did not conceive of knowledge being innately embedded in knowledge-gaining mechanisms such as learning. General process theorists like Hull and Tolman were entirely empiricist in their approaches, as were all the associationist learning theorists. Piaget too was an empiricist, though he was certainly no associationist. So the adherence to a general process empiricist stance was widespread, despite differences regarding the nature of the learning mechanism. Common too was an implicit understanding, though not an acceptance because acceptance implies overt recognition, but an implicit understanding that the brain at birth has differentiated neural structures that comprise the causal mechanisms that drive the processes of knowledge gain.

In general conception, very little distinguishes these new empiricists. For the associationists, knowledge becomes richer with age and experience through the build up of an ever more complex network of associations. Constructivists like Piaget envisaged increasing knowledge as the development of more intricate and complex concepts based upon simpler and previously, that is postnatally, acquired perceptual and cognitive precursors. Contemporary constructivism is usually based on models marked by complex hierarchical architectures. For example, Cohen, Chaput, and Cashon (2002) offer a constructivist model based on six information-processing principles. The first is an avowal that there is no "innate core knowledge" (the slate is blank at birth), but what is innate are "the architectural constraints in how (this) learning may be accomplished"; the second and third concern how higher units of knowledge are based hierarchically on those lower; the fourth and fifth argue that there is a bias to process information using the units highest in the hierarchy, with failure leading to utilization of lower units; and finally, such a structured learning system is domain-general and occurs continuously throughout life. The latter claim is one of a truly general learning process.

Associationism was rejuvenated in the 1980s by the veritable explosion of connectionist computational modelling (Rumelhart and McClelland, 1986), which subsequently appeared in theories of cognitive development (Elman et al., 1996; Quartz and Sejnowsky, 1997). The Elman et al. model is especially noteworthy as it combined the skills of neural net modellers, a developmental biologist and distinguished developmentalists and cognitive scientists. Such approaches might be called developmental empiricism, but as constructivists they differed from the likes of Cohen in explicitly accepting a degree of innate specification in cognitive systems at birth that go beyond the mechanisms of cognition themselves. The tone was set by Karmiloff–Smith (1992): ". . . Nature specifies initial biases or predispositions that channel attention to relevant environmental inputs, which in turn affects subsequent brain development" (p. 5). A later analysis argued that "in normal development there are distinct, domain-specific, skeletal predispositions for discriminating stimuli relevant to language, face processing, and theory of mind" and "with the massive early experience of superimposed inputs (i.e., face, voice, and human interaction all take place in a superimposed fashion), these predispositions gradually take over privileged circuits in the brain that become increasingly specialized and progressively interconnected" (Karmiloff–Smith et al., 1995, p. 203). It should be noted that when Lorenz introduced the notion of innate teaching mechanisms 30 years before, one of the possible mechanisms he most emphasized was attentional.

A seminal contribution advancing the case for connectionism and a rapprochment with nativism came from Clark (1993) who advocated a "minimal nativism." He argued that "the space of possible ways in which knowledge might be innate in a system is very large and includes some subtle cases" (p. 180). Like Karmiloff–Smith, Clark considered modularity to arise out of a developmental sequence, modularization: "It has become increasingly clear that, for certain complex problem domains, connectionist learning algorithms will prove efficient only if they operate on a highly prestructured system" (p. 183); but instead of "building in large amounts of innate knowledge and structure, build in whatever minimal set of biases and structure will ensure the emergence, under realistic environmental conditions, of the basic cognitive modules and structures necessary for early success and for subsequent learning" (p. 185). This could be achieved by relatively minor constraints in neural networks, such as slight adjustments in weight assignments in network connections, and also in overall structure of inputs to specific network characteristics, and how the outputs of one network might serve as inputs to another level of network. Elman et al. (1996) are particularly good in demonstrating the importance of modelling hierarchically interacting levels of computation.

But whether such developmental empiricists really do present a picture that is substantially different from classical philosophical empiricism is debateable. Elman et al. may deny Locke's white paper, but simultaneously they deny Kant's a prioris: ". . . the tabula rasa approach is doomed to failure . . . all connectionist models have prior constraints of one sort or another. What we reject is *representational* nativism" (p. 365). Well, as Fodor (1998) points out, that was exactly what the classical empiricist position was.

But it remains the case that there is a contradiction, a deeply serious contradiction, between a denial of representational nativism on the one hand, but an acceptance of innate attentional biases or innate differential weightings within networks on the other. It is this: How can some feature of a cognitive system which biases attention, or differentially weights input, be considered as anything other than a form of representation of some aspect of the world? If human infants are predisposed to attend to faces rather than to elbows, and if that predisposition takes the form of attending differentially to a particular configuration of horizontal lines which occur regularly within the neonates' highly limited visual space, then that configuration is a specific aspect, a *representation*, albeit it a highly reduced and fragmentary representation, of something in the world of infants, viz. the faces of its caretakers. For Elman et al., representational knowledge is a specific setting within a neural network that corresponds to a specific linguistic utterance, or a specific attribution of a particular intentional mental state. But no new rationalist has ever claimed that innate knowledge carries this degree of specificity, and that includes the supporters of generative/transformational grammar and the most die-hard of contemporary evolutionary psychologists.

Does Evolutionary Theory Offer a Resolution?

Evolutionary psychology has been quick to adopt a generally strong rationalist position with regard to cognition (Pinker, 1997; Tooby and Cosmides, 1992). The eager embracing of the modularity concept with its accompanying domain-specificity of cognition advanced Fodor's original new rationalism into a specific evolutionary stance asserting that if cognitive modules are part-genetically caused, then an obvious extension to this position is the assumption that some proportion of the suites of genes involved will be products of evolution, since the information coded into those genes, transformed into cognitive mechanisms with specific structure *and content*, are adaptations (or exaptations) that increase fitness. None of this denies the crucial importance of developmental processes in the realization of such evolved cognitive structures, nor does it deny that development plays a central and highly complex role in putting such evolved cognitive constraints in place in the phenotype. All that it asserts is that it is bringing cognition into line with evolutionary theory by making commonplace neoDarwinian assumptions.

But does it do anymore than that? The answer is surely yes. At the beginning of his *Neural Darwinism* Edelman (1987) pondered the problem of the world as an "initially unlabeled place. The number of partitions of potential 'objects' or 'events' in an econiche is enormous if not infinite" (p. 3). In order to deal with this seemingly overwhelming difficulty "nervous systems evolved to generate individual behaviour that is adaptive within a species' econiche in relatively short periods of time" (pp. 3–4). "Relatively short periods of time" is the important point. If animals, capable of acquiring knowledge by learning in order to utilize the resources of their world, came into it only with innate mechanisms that are not pointed to specific features of the world, without content of some kind, then general learning processes that come to learn the things that matter to the learner's survival and reproduction on the basis of chance alone, and within an unpredictable timeframe, would be biologically untenable. *Such unguided general learning processes simply would not work with the sufficient certainty that successful cognition requires*. The whole point of cognition, after all, is rapidly to put in place adaptive behaviours (Plotkin, 1994). The role of innate representational knowledge is to narrow the search space within which cognition occurs, so that evolved cognitive mechanisms can operate quickly and effectively. That is the very selection pressure that drives the evolution of cognition in the first place.

Empiricist developmentalists may counter by asserting that constraints are not denied, but that it is from developmental processes that they originate. That, however, is only a half-truth. Development begins at conception, and whilst niche construction (Odling–Smee, Laland, and Feldman, 2003) in many species, and culture (Plotkin, 2002) in a small number of species, complicates the picture, it is only via genes that a link is provided to an evolutionary past — a past of immensely greater time span in which may accumulate the fragmentary representational knowledge that makes cognition fast and effective.

Yet, neither the new rationalists nor the new empiricists have absolutely clinching empirical data to support one position and topple the other. No matter how early knowledge appears after birth, it could always be the product of some associative or constructivist learning process, it might be argued. So where do we go from here? In his intellectual autobiography, Popper (1976) described Darwinism as "not a testable scientific theory, but a metaphysical research programme — a possible framework for testable scientific theories" (p. 168). He was later to retract the claim because evolutionary theory certainly is more than that. It is a specific framework for a range of testable theories, and one of its hypotheses is that as the science of molecular biology advances it will show specific linkage between genetics and brain structures and functions, on the one hand; and on the other, cognitive neuroscience, as it in turn advances, will show that such structures and functions have some minimal innate representation.

Plato and Descartes may not have been completely right. But an evolutionary perspective suggests that they were not nearly as wrong as *tabula rasa* empiricism. Something like Lorenz's Kantian a prioris will be shown to exist as our science grows into maturity with increasing understanding of neurogenetics and cognitive neuroscience. Therein *will* lie the clinching evidence, but we will have to wait a while for it.

References

Baillargeon, R., Kotovsky, L., and Needham, A. (1995). The acquisition of physical knowledge in infancy. In D. Sperber, D. Premack, and A.J. Premack (Eds.), *Causal cognition* (pp. 79–116). Oxford: Clarendon Press.

Baron–Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind.* Cambridge, Massachusetts: The MIT Press.

Barsalou, L.W., Simmons, W.K., Barbey, A.K., and Wilson, C.D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Science, 7*, 84–91.

Bolles, R.C., and Beecher, M.D. (Eds.) (1988). *Evolution and learning.* London: Erlbaum.

Butterworth, B. (1999). *What counts: How every brain is hardwired for math.* New York: Free Press.

Calvin, W.H., and Bickerton, D. (2000). *Lingua ex Machina: Reconciling Darwin and Chomsky with the human brain.* Cambridge, Massachusetts: The MIT Press.

Chomsky, N. (1959). A review of B.F. Skinner's *Verbal Behavior. Language, 35*, 26–58.

Chomsky, N. (1980). *Rules and representations.* New York: Columbia University Press.

Chomsky, N. (2000). *New horizons in the study of language and mind.* Cambridge: Cambridge University Press.

Clark, A. (1993). *Associative engines: Connectionism, concepts, and representational change.* Cambridge, Massachusetts: The MIT Press.

Cohen, L.B., and Amsel, G. (1998). Precursors to infants' perception of causality. *Infant Behavior and Development, 21*, 713–731.

Cohen, L.B., Chaput, H.H., and Cashon, C.H. (2002). A constructivist model of infant cognition. *Cognitive Development, 17*, 1323–1343.

Coltheart, M. (1999). Modularity and cognition. *Trends in Cognitive Science, 3*, 115–120.

Darwin, C. (1859). *On the origin of species by means of natural selection or the preservation of favoured races in the struggle for life.* London: Murray.

Darwin, C. (1871). *The descent of man.* London: Murray.

Deacon, T. (1997). *The symbolic species.* London: Penguin Press.

Edelman, G.M. (1987). *Neural Darwinism: The theory of neuronal group selection.* New York: Basic Books.

Elman, J.L., Bates, E.A., Johnson, M.H., Karmiloff–Smith, A, Parisi, D., and Plunkett, K. (1996). *Rethinking innateness: A connectionist perspective on development.* Cambridge, Massachusetts: The MIT Press.

Fodor, J.A. (1983). *The modularity of mind.* Cambridge, Massachusetts: The MIT Press.

Fodor, J.A. (1985). Précis of the modularity of mind. *The Behavioral and Brain Sciences, 8*, 1–5.

Fodor, J.A. (1998). *In critical condition.* Cambridge, Massachusetts: The MIT Press.

Gallagher, H.L., and Frith, C.D. (2003). Functional imaging of "theory of mind." *Trends in Cognitive Sciences, 7*, 77–83.

Garcia, J., and Koelling, R.A. (1966). Relation of cue to consequence in avoidance learning. *Psychonomic Science, 4*, 123–124.

Hauser, M.D., Chomsky, N., and Fitch, W.T. (2002). The faculty of language: What is it, who has it, and how did it evolve. *Science, 298*, 1569–1579.

Jackendoff, R. (1993). *Patterns in the mind: Language and human nature.* Hemel Hempstead, Hertsfordshire, United Kingdom: Harvester Wheatsheaf.

Karmiloff–Smith, A. (1992). *Beyond modularity.* Cambridge, Massachusetts: The MIT Press.

Karmiloff–Smith, A. (1998). Development itself is the key to understanding developmental disorders. *Trends in Cognitive Sciences, 2*, 389–398.

Karmiloff–Smith, A., Klima, E., Bellugi, U., Grant, J., and Baron–Cohen, S. (1995). Is there a social module? Language, face processing, and theory of mind in individuals with Williams Syndrome. *Journal of Cognitive Neuroscience, 7*, 196–208.

Koechlin, E., Ody, C., and Kouneiher, F. (2003). The architecture of cognitive control in the human prefrontal cortex. *Science, 302*, 1181–1185.

Lau, H.C., Rogers, R.D., Haggard, P., and Passingham, R.E. (2004). Attention to intention. *Science, 303*, 1208–1210.

Laurence, S., and Margolis, E. (2001). The poverty of the stimulus argument. *The British Journal of the Philosophy of Science*, *52*, 217–276.
Lehrman, D.S. (1953). A critique of Konrad Lorenz's theory of instinctive behavior. *Quarterly Review of Biology*, *28*, 337–363.
Leslie, A.M. (1995). A theory of agency. In D. Sperber, D. Premack, and A.J. Premack (Eds.), *Causal cognition* (pp. 121–141). Oxford: The Clarendon Press.
Lorenz, K. (1941). Kant's Lehre vom apriorischen in Lichte geganwärtiger Biologie. *Blätter für Deutsche Philosophie*, *15*, 94–125.
Lorenz, K. (1965). *Evolution and modification of behavior*. Chicago: University of Chicago Press.
Lorenz, K. (1982). Kant's doctrine of the a priori in the light of contemporary biology. In H.C. Plotkin (Ed.), *Learning, development and culture* (pp. 121–143). Chichester: Wiley. (Reprint of the translation of the 1941 paper which first appeared in *General Systems*, *VII*, 23–35.)
Marler, P., and Terrace, H.S. (Eds.).(1984). *The biology of learning*. Berlin: Springer Verlag.
Meier, R.P. (1991). Language acquisition by deaf children. *American Scientist*, *79*, 60–70.
Meltzoff, A.N., and Moore, M.K. (1983). Newborn infants imitate adult facial gestures. *Child Development*, *54*, 702–709.
Odling–Smee, F.J., Laland, K.N., and Feldman, M.W. (2003). *Niche construction: The neglected process in evolution*. Princeton: Princeton University Press.
Pinker, S. (1994). *The language instinct: The new science of language and mind*. London: Penguin Press.
Pinker, S. (1997). *How the mind works*. London: W.W. Norton.
Plotkin, H. (1994). *The nature of knowledge*. London: Penguin Press.
Plotkin, H. (2002). *The imagined world made real*. London: Penguin Press.
Plotkin, H. (2004). *Evolutionary thought in psychology: A brief history*. Oxford: Blackwell.
Popper, K. (1976). *Unended quest*. London: Fontana.
Premack, D., and Premack, A. (2003). *Original intelligence: Unlocking the mystery of who we are*. New York: McGraw–Hill.
Quartz, S.R., and Sejnowsky, T.J. (1997). A neural basis of cognitive development: A constructivist manifesto. *The Behavioral and Brain Sciences*, *20*, 537–556.
Rumelhart, D.E., and McClelland, J.L. (Eds.). (1986). *Parallel distributed processing: Explorations in the microstructure of cognition*. Cambridge, Massachusetts: The MIT Press.
Shallice, T. (1988). *From neuropsychology to mental structure*. Cambridge: Cambridge University Press.
Spelke, E.S., Phillips, A., and Woodward, A.L. (1995). Infants' knowledge of object motion and human action. In D. Sperber, D. Premack, and A.J. Premack (Eds.), *Causal cognition* (pp. 44–78). Oxford: Clarendon Press.
Stuss, D.T., Gallup, G.G., and Alexander, M.P. (2001). The frontal lobes are necessary for 'theory of mind.' *Brain*, *124*, 279–286.
Tooby, J., and Cosmides, L. (1992). Psychological foundations of culture. In J.H. Barkow, L. Cosmides, and J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 19–136). Oxford: Oxford University Press.
Uttal, W.R. (2001). *The new phrenology: The limits of localizing cognitive processes in the brain*. Cambridge, Massachusetts: The MIT Press.
Wynn, K., Bloom, P., and Chiang, W-C. (2002). Enumeration of collective entities by 5-month-old infants. *Cognition*, *83*, B55–B62.