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Innateness in cognitive science

Richard Samuels

Philosophy Department, King's College London, Strand, London, WC2R 2LS, UK

Innateness is one of the central concepts of cognitive science; but it is also a source of considerable confusion. In this article, I survey recent attempts to understand the notion of innateness as it figures in cognitive science and indicate which is likely to prove most fruitful. One approach draws directly on our 'commonsense' views about innate traits. Another aims to characterize innateness in terms of concepts drawn from biology, such as genetic determination. Yet neither strategy has met with much success. This could indicate that a satisfactory account of innateness needs to make use of the conceptual resources of cognitive science itself. A proposal that takes this suggestion seriously is outlined, and an appeal is made for a more systematic assessment of the role and significance of the notion of innateness to cognitive science.

Innateness hypotheses have played a pivotal role in the development of cognitive science and have been invoked to explain a broad array of psychological phenomena, including theory of mind [1], arithmetic [2,3], folk physics [4] and language [5,6]. In spite of their prominence, however, it remains obscure how such hypotheses – and the notion of innateness on which they depend – ought to be understood.

Troubles with the notion of innateness are hardly novel. As far back as the 18th century, the empiricist philosopher David Hume complained that it was both ill-defined and permitted those incautious enough to use it to 'draw out their disputes to a tedious length, without ever touching the point in question.' [7]. Yet the need for a satisfactory account of innateness has become even more pressing in recent years. One reason is that the emergence of novel experimental techniques, especially in developmental neuroscience, has made it harder to determine what should count as evidence for or against innateness [8–11]. Perhaps even more importantly, however, the very idea of innateness has increasingly come under attack from those – such as developmental systems theorists – who view it as scientifically unnecessary or even incoherent [12,13]; and this attitude is very much reflected in large regions of contemporary biology where talk of innateness has fallen into disrepute [14].

Such considerations provide cognitive scientists who aim to characterize our innate cognitive endowment with a strong motive to clarify the notion of innateness on which such inquiries depend. In this article I survey and assess current efforts to understand innateness. Although no entirely satisfactory account exists as yet, I maintain that, contrary to what many appear to suppose, the notion of innateness used in cognitive science may turn out to be neither identical to familiar commonsense conceptions of innateness nor borrowed from other scientific disciplines, such as genetics or developmental biology. Instead, the notion used by cognitive scientists may reflect the specific explanatory concerns and theoretical commitments of cognitive science itself.

Innateness and commonsense

In contrast to earlier attempts to understand innateness [15], recent efforts have been largely unconcerned with 'ordinary language conceptual analysis' – that is, roughly speaking, with characterizing the meaning of our 'commonsense' concept of innateness. The rejection of this project is twofold. First, the newer accounts tend to focus on the notion of innateness as it figures in science – in particular, cognitive science – as opposed to ordinary discourse. Second, they are far less concerned with defining the meaning of the term 'innate' than with explaining its role and significance within the sciences. The default assumption is that scientific practices *track* some theoretically important property and that the goal of an account of innateness is to identify what that property might be. Even so, many familiar proposals draw on the commonsense connotations of the term 'innate'; and it is important to see why such claims are unsatisfactory as accounts of the notion used in cognitive science.

Innateness as non-acquisition

A familiar claim about innate traits is that they are not acquired. On this view, for example, the thesis that universal grammar is innate amounts to the claim that it is a non-acquired cognitive structure. As stated, however, this account is unsatisfactory, although not because it is false, but because it is vacuous. The problem is that there are lots of different notions of acquisition and it is far from clear which is relevant to understanding innateness. To characterize innateness in terms of non-acquisition thus merely trades one problem for an equally difficult one – namely, explicating the relevant sense in which innate traits are not acquired.

By way of illustration, consider the following 'minimal notion' of acquisition: a characteristic is acquired by an object (e.g. an organism) if and only if there is some period of time when the object has the characteristic in question but some *prior* period when it does not. This is a perfectly sensible notion of acquisition and yet clearly insufficient for drawing the innate/non-innate distinction because, in this minimal sense, all cognitive structures are acquired. Human cognitive structures are traits of biological

Corresponding author: Richard Samuels (richard.samuels@kcl.ac.uk).

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organisms and it is entirely plausible to maintain that there is a point sufficiently early in development when humans lack any cognitive structures whatsoever. (A blastula is, for example, a ball of cells altogether lacking in cognitive characteristics.) In which case, if innate traits are just the ones that are not acquired (in the minimal sense), then there are obviously no innate cognitive traits whatsoever.

Of course, the conclusion to draw is not that innateness claims are trivially false or that they cannot be characterized in terms of some notion of (non-) acquisition. Rather, all that follows is that something more *substantial* than the minimal notion is required. But what more is needed? What additional constraints are required to develop a satisfactory account of innateness? This is, in effect, the issue that all accounts of innateness need to address.

Innateness as presence at birth

One familiar suggestion is that innate traits must satisfy certain temporal constraints: in particular that they must be present at birth or 'inborn'. (This is tantamount to claiming that innate traits are the ones that are acquired, in the minimal sense, by the time of birth.) Yet despite its long philosophical heritage and inclusion in dictionary definitions, this view is unsatisfactory. For although presence at birth may be evidence of innateness, it is strictly speaking neither necessary nor sufficient. It is not sufficient because prenatal learning is possible [16,17]. In which case, the paradigmatic example of traits that are not innate – namely, learned traits – can be present at birth.

Nor is presence at birth necessary for innateness because, as Descartes observed almost four centuries ago, innate characteristics can be acquired (in the minimal sense) quite late in development. This point is commonly made by analogy with non-psychological traits – such as pubic hair and other secondary sexual characteristics – that are plausibly innate but clearly not present at birth. According to nativists in cognitive science, what goes for morphological traits is true of psychological ones as well. Alan Leslie and his collaborators have maintained, for example, that the innateness of a theory of mind mechanism is wholly consistent with the thesis that it develops postnally [18]. Similarly, concept nativists very frequently endorse the view that innately specified concepts can be the product of postnatal maturation [5,19].

Innateness as the product of internal causes

Another common claim is that innate characteristics are the products of *internal* causes as opposed to external or environmental ones [20]. In their influential book *Rethinking Innateness*, for example, Jeffrey Elman and his co-authors maintain that a trait is innate if and only if it is 'the product of interactions internal to the organism' [9].

Literally construed, however, this proposal is unsatisfactory. Like virtually all contemporary theorists, nativists wholeheartedly accept the Interactionist Thesis that cognitive characteristics are caused jointly by both internal and environmental factors [21,22]. Indeed, this is little more than a banal truism that holds for all human traits. A foetus does not develop arms and legs, for example, without exchanging oxygen, water and nutrients with its mother; and a neonate does not develop teeth and hair without breathing, drinking and eating: all of which involve interaction with an environment external to the organism.

In addition to these merely nutritive contributions, however, nativists very frequently insist that the environment – and indeed environmentally derived information – has a more specific role to play in the development of innate cognitive structure. In particular, a common claim by nativists is that environmental factors act as inputs to 'triggering' processes – roughly speaking, 'brute-causal', non-psychological processes that eventuate in innate cognitive structures [23]. It is, to be sure, notoriously unclear what triggering is supposed to be [24]; and no doubt this is a failing on the part of nativists. But it is one thing to accuse nativists of insufficient clarity and quite another to insist that they hold the deeply implausible view that environmental factors play no role in the development of innate traits. The former accusation is warranted; the latter merely turns nativism into a strawman: a position that is easily refuted but accepted by no one.

Innateness and biology

If commonsense seems unlikely to furnish cognitive science with a satisfactory notion of innateness, then perhaps we should look to contemporary biology. To anyone with even a passing awareness of recent 'nature–nurture' debates, this might appear an attractive strategy. In particular, it might seem that contemporary biology has constructed – or, at any rate, is close to constructing – a notion of genetic determination that permits a thoroughly modern and scientific account of innateness [19].

Alas, matters are not so straightforward. Although biology in general and genetics in particular are central to the study of human cognition, it is not at all clear that they yield an unproblematic notion of genetic determination that maps smoothly onto the concept of innateness used by cognitive scientists. Instead, what one finds in biology is an altogether messier situation: one in which the notion of genetic determination remains both vague and highly contentious whereas other, more precisely defined genotype–phenotype relations fail to map smoothly onto the notion of innateness.

Innateness as genetic determination

According to genetic accounts of innateness, a phenotypic trait is innate (for a particular organism) only if it is determined by genetic factors. But how are we to understand the notion of genetic determination? Historically, there have been two dominant proposals: a 'causal account' on which traits are genetically determined if caused (in the appropriate way) by genetic factors [25,26], and a 'representational account' on which traits are genetically determined if represented in (or encoded by) the genes [22,27]. Neither strategy has met with much success.

The principal problem with the causal approach is that no one has been able to explain what the *appropriate* causal relation between genes and innate traits is supposed to be. The obvious candidate is that innate traits must be caused entirely by genetic factors. This is, for example, a view that the ethologist Konrad Lorenz sometimes appeared to endorse [25]. But the folly of this proposal has long been recognized, as complex biological traits are not caused by genes alone but depend on interactions between genetic and non-genetic factors [28]. This is simply a variant of the Interactionist Thesis mentioned earlier. Moreover, other attempts to characterize genetic determination in terms of genetic causation have been similarly unsuccessful [29,30].

Nor have attempts to provide a representational account of genetic determination proven any easier. The least contentious, although still far from straightforward, sense in which genes represent anything, is the familiar thesis that DNA contains a 'coded representation' of proteins [31]. Yet even if such claims are relatively unproblematic, what is required is not merely an account of how genes code for proteins, but an account on which genes can represent complex phenotypic traits, such as cognitive structures. As developmental systems theorists are fond of pointing out, however, no such notion of representation appears to exist [12]. Suppose, for example, one adopts an account of representation on which a gene (or suite of genes) represents a phenotypic trait if and only if the trait causally covaries with it. This is, in effect, an application of the standard mathematical notion of information. But this proposal is unsatisfactory because it seems overwhelmingly likely that all traits causally covary with both genetic and environmental factors, in which case all traits will be represented in both the environment and the genome [30]. So the question is: What alternative notion of representation (information or coding) would capture an appropriate notion of genetic representation? At present, no satisfactory proposal exists (but see [32] for a useful discussion of recent efforts and [33] for a recent informational approach to innateness that aims to avoid the sort of problem discussed here).

Innateness as developmental invariance

Problems with the notion of genetic determination have led some theorists to explore alternative ways in which the conceptual resources of biology might be brought to bear on understanding innateness. Among the most common of these are so-called 'invariance accounts' (for further proposals see Box 1). Such proposals differ in detail, but they all share the idea that innate traits are developmentally invariant with respect to some appropriate range of environments. The philosopher of biology Elliott Sober provides a representative formulation when he suggests that 'a phenotypic trait is innate for a given genotype if and only if that phenotype will emerge in all of a range of developmental environments', roughly, the *normal* environments for organisms with that genotype [34].

The invariance account possesses several notable virtues. For example, it captures the commonly held view that innate traits are developmentally stable. Moreover, in conjunction with widely held assumptions about intra-species genotypic similarity, it explains why innate traits are often universal in the sense of being possessed by all (normally functioning) members of the species. Still, the account is not without its problems. In particular, it appears to have the highly implausible consequence that traits can be both learned and innate – a result that is strongly at variance with the notion of innateness as used by cognitive scientists. The problem arises in the case of traits that are highly invariant, although only because the environmental conditions required to learn them are ubiquitous. So, for instance, it is plausible to maintain that pretty much every human acquires the belief that

Box 1. Other biologically inspired accounts of innateness

The main text omits several biological accounts of innateness that have been suggested in recent years. In what follows I briefly consider two such proposals: the view of innateness as canalization and the view that innateness can be characterized in terms of the notion of heritability from quantative genetics.

Innateness as canalization

On this view, a trait of an organism (with a given genotype G) is innate to the extent that it is 'canalized' in organisms with G; and the trait is canalized to the extent that its development is insensitive to the range of environmental conditions under which it emerges [39,40]. So, for example, my possession of legs is (highly) innate on this view because, for organisms with the same genotype as me, the development of legs is highly insensitive to variation in environmental conditions.

The canalization account is a close relative of the invariance approach and, as such, inherits the virtues of that approach. Moreover, by requiring that the development of innate traits is *insensitive* to environmental variation – as opposed to merely invariant across environments – it appears to avoid the objection that I leveled against the invariance account (but see [41], for a discussion of this claim). Even so, the canalization account has been criticized on several grounds. One common concern is that it threatens to trivialize debate over innateness [24]. In brief, the worry is that assessments of canalization depend on what sorts of environmental variability one takes to be relevant to the process at hand; and this, in turn, appears to depend on the explanatory interests of those who use the concept of canalization in the first place. The concern is thus that disputes over innateness end up merely reflecting differences of explanatory emphasis.

Innateness as high heritability

On this view, a trait is innate if and only if it is highly heritable – roughly speaking, variation within the population with respect to this trait is disproportionately due to genetic differences as opposed to environmental ones.

On the face of it, this account is an attractive one because it both preserves the intuition that innate traits are in some way determined by the genes and accords well with the tendency of cognitive scientists to invoke heritability studies – especially on twins – in support of innateness hypotheses [6]. Yet while high heritability might be evidence of innateness, I deny that it *defines* what innateness is. Perhaps the most obvious problem is that high heritability is not necessary for innateness [42]. This is clearest in the case of traits – such as opposable thumbs in humans – that are near fixation and so possessed by all 'normal' members of a population. As standardly defined, heritability is the proportion of overall phenotypic variation that is due to genetic variation (i.e. V_g/V_p). So, where there is no phenotypic variation (as with opposable thumbs) the denominator V_p is zero and the heritability of the trait is not even defined. The obvious response is to enlarge our population to include organisms that do not possess the trait. But this can lead to some highly implausible consequences. Suppose, for example, that humans only lack opposable thumbs when a drug taken by the mother during pregnancy disrupts fetal development [40]. In such cases, phenotypic variation is due to environmental differences. Hence, the trait will have a low heritability and not be innate (see [40] for further discussion of the problems).

water is wet under normal environmental conditions and, moreover, that we learn it. But if this is so, then the belief that water is wet can be both learned and innate on the invariance account: a conclusion that might suffice to show that the account is untenable [35].

Innateness and cognitive science

If the above arguments are to be believed, then the prospects of providing an account of innateness in terms of genetic determination are unpromising, and the invariance alternative yields consequences that are at odds with how the notion of innateness functions in cognitive science. This clearly does not exhaust the full range of ways in which biological concepts might be invoked to characterize innateness (see Box 1 for further examples). But the track record to date is rather bleak, and this might suggest the need to look elsewhere for an account of innateness. In the remainder of this article, I consider the possibility that the notion of innateness used by cognitive scientists should be understood (at least partially) in terms of concepts that derive from psychology or even from cognitive science itself.

Innateness as not learned

This suggestion is hardly a novel one. Indeed, among the most common characterizations of innate traits is that they are the ones that are not learned. This view has some notable strengths, such as explaining why learned traits are not innate and why learnability arguments – arguments purporting to show that a given trait cannot be learned – support innateness hypotheses. But there are also some obvious worries with this formulation. A first and, I think, relatively minor one is that it yields counterintuitive results when applied to non-psychological traits. A patch of sunburn, for example, is not learned and yet it is surely not innate either. But even if we restrict our attention to those traits that concern us most – namely cognitive traits – the account will only be of use if some appropriate notion of learning can be identified, and this is not a straightforward task because the term 'learning' turns out to be almost as slippery as 'innateness' [35].

Innateness as psychological primitiveness

A more recent but closely related suggestion is that innate cognitive structures are 'psychologically primitive' in (roughly) the sense that they are not acquired by cognitive/psychological processes [24,35]. To put the proposal in a slightly different way: although innate cognitive structures are acquired in the minimal sense, it is not at the cognitive/psychological level(s) of explanation – but some lower (biological) level – that an account of *how* they are acquired is to be found. In short, innate cognitive structures are the ones whose acquisition psychology cannot explain.

One central reason for developing this psychological primitiveness account of innateness is to handle the sorts of difficulties that plague other accounts (see [35] for detailed discussion). But another reason is that it might help to explain the peculiar significance of innateness hypotheses to cognitive science. As mentioned earlier, many areas of biology have dispensed with the notion of innateness altogether – in large measure because it no longer plays any useful theoretical role [14]. Why then should it continue to have a foothold in the cognitive sciences? One possibility is that this is an unfortunate oversight that should be remedied immediately [12]. But if the present proposal is correct, then the notion of innateness in fact functions to frame two issues of genuine importance to psychology and cognitive science. First, it delimits the scope of psychological explanation: once we know that a given structure is innate, we also know that our scientific psychology should not – indeed cannot – be expected to explain how it was acquired and that we must instead look to biology or some other science for an explanation. Second, discovering which structures are innate also furnishes us with the resources – the 'building blocks' – from which to construct developmental psychological theories. Such theories must, on pain of regress, presuppose the existence of structures whose acquisition is not explained by psychology. So, if we know that a given structure is innate, then it can be invoked by psychological theories to explain the development of other psychological traits.

In its present form, however, the psychological primitiveness account still will not do. One problem too complex to consider here is that the account presupposes some appropriate distinction between psychological/cognitive levels of explanation and other levels of scientific explanation; and although it is widely assumed in cognitive science that some such distinction exists, it is far from straightforward how best to draw it. A second problem that I will discuss briefly is that, in its present form, the proposal over-generalizes by incorrectly characterizing some cognitive structures as innate even though no one would count them as such. This problem is clearest in the case of psychological effects that result when environmental insults produce brain lesions. In such cases, cognitive scientists are not at all inclined to view the outcomes as innately specified even though the explanation is likely to be a neurobiological rather than a psychological one.

How might this over-generalization problem be addressed? One plausible response is to add an extra clause to the account, such as the following 'normalcy condition': A cognitive structure is innate for a given organism only if they would acquire it in the normal course of events. No doubt, there is much that could be done to clarify what counts as 'a normal course of events' [15,36], and perhaps this might be done by invoking the notions of developmental invariance or canalization discussed earlier in the article. For present purposes, however, I leave such matters of detail to one side and focus instead on two more general points. First, adding a normalcy condition seems like the right *kind* of strategy for addressing the over-generalization problem. This is because the cases that seem to pose a problem for the primitiveness view (e.g. psychological effects resulting from environmentally produced brain lesions) are clear instances of abnormal development.

Second, although it would be desirable to provide a more precise account of normalcy, I suggest that the task is no more pressing in the present context than it is in most

Box 2. Questions for future research

- What role does (and should) the notion of innateness play in cognitive science?
- Should the notion of innateness admit of degree (i.e. be such that traits can be more-or-less innate) or should it be an all-or-nothing affair?
- Innateness is associated with a wide range of characteristics including, presence at birth, universality and not being learned. How do these various characteristics relate to each other and to the notion of innateness itself?
- As we have seen, there are numerous apparently distinct accounts of innateness. How do they relate to each other? Might it turn out that they can be combined in fruitful ways? Might it even turn out that some are mere notational variants as opposed to genuinely distinct proposals?

other areas of science. My reason for saying this is that all sciences – with the possible exception of physics – typically assume some largely unarticulated set of normal conditions in formulating their laws and generalizations. In the jargon of philosophy, they are *ceteris paribus* generalizations that apply only when all else is equal [37,38]. Much the same is likely to be true of innateness hypotheses in developmental psychology and other areas of cognitive science. In effect, they are generalizations that, like virtually all other scientific generalizations, tacitly assume some set of background normal conditions. On this view, notions of normalcy are no more important to understanding innateness hypotheses in cognitive science than they are to understanding hypotheses in geology, economics or, for that matter, aerodynamics.

Conclusion

In this article I reviewed some of the more prominent accounts of innateness and sketched their various strengths and weaknesses (see also Box 2 for other questions relating to theories of innateness). It was argued that proposals drawing on either the commonsense connotations of 'innate' or the conceptual resources of biology are unlikely to prove satisfactory, and that this might indicate that the notion of innateness used by cognitive scientists is not simply borrowed from elsewhere but internal to cognitive science itself. Finally, a specific account of innateness was outlined – the psychological primitiveness account – that takes this suggestion seriously. Although I do not expect the reader to be convinced by the above brief comments, I do hope to stimulate a more systematic debate about innateness; one that does not simply reiterate firmly entrenched opinions on the matter, but critically assesses the role and significance that the notion of innateness does and should have for cognitive science.

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