The Vernacular Concept of Innateness

Paul Griffiths, Edouard Machery, Stefan Linquist[·]

Abstract

The proposal that the concept of innateness expresses a 'folk biological' theory of the 'inner natures' of organisms was tested by examining the response of biologically naive subjects to a series of realistic scenarios concerning the development of birdsong. Our results explain the intuitive appeal of many of the existing philosophical analyses of the innateness concept. They simultaneously explain why all such analyses are subject to compelling counterexamples. We conclude that philosophers need to think more clearly about what they are trying to achieve when 'analysing' the concept of innateness.

1. **Innateness and Folk Biology**

It is a truism that the term 'innate' is vague and ambiguous. According to ethologist Patrick Bateson, "At least six meanings are attached to the term: present at birth; a behavioral difference caused by a genetic difference; adapted over the course of evolution; unchanging throughout development; shared by all members of a species; and not learned. … Say what you mean (even if it uses a bit more space) rather than unintentionally confuse your readers by employing a word such as innate that carries so many different connotations" (Bateson, 1991, p. 21-22). The rejection of the term 'innate'

[·]Acknowledgements: Griffiths and Linquist were supported by Australian Research Council grant FF0457917. We thank Patrick Bateson, Ron Mallon, Matteo Mameli and Shaun Nicholls for helpful comments on an earlier draft.
Address for correspondence: Paul Griffiths School of Philosophical and Historical Inquiry University of Sydney NSW 2006, Australia
Email: P.E.Griffiths@exeter.ac.uk

on these grounds has a long and distinguished history in behavioral biology (Lehrman, 1953; Hinde, 1968; Tinbergen, 1963), although some think that the harm done by these ambiguities has been exaggerated (Marler, 2004, p. 25-33). More recently, Matteo Mameli and Bateson have systematically reviewed the scientific use of the term 'innate' and identified no less than twenty-six proposed definitions. They judge eight of these to be both genuinely independent definitions and potentially valuable scientific constructs (Mameli and Bateson, 2006, p. 177-8). They conclude that unless it can be demonstrated that the eight properties picked out by these definitions are highly correlated with one another, something which they doubt on empirical grounds, we should accept that the term 'innate' is confusing and unhelpful.

The term 'innate' nevertheless remains popular in psychology and cognitive science. Some philosophers have proposed that in these contexts it is primarily a device to say 'not my department – ask a biologist' (Samuels, 2002). But others continue to propose analyses of the concept of innateness, designed to show that there is a single, coherent notion of innateness that either does or should underlie the use of the term in the sciences of the mind (recent examples include Mallon and Weinberg, 2006; Ariew, 2006; Khalidi, 2007). These analyses are typically subject to intuitively compelling counterexamples from the proponents of alternative analyses (see Section 5).

Our aim in this paper is to provide some solid evidence about the pre-scientific or vernacular understanding of term 'innate'. As Mameli and Bateson (2006, p. 156) note, this has not previously been the subject of rigorous empirical investigation. In the remainder of this section we outline some ideas about 'folk biology', and in Section 2 we make a specific proposal about the structure of the vernacular innateness concept based

on these ideas. Section 3 reports an 'experimental philosophy' (X-phi) study testing this proposal. In Section 4, we argue that our results explain the intuitive appeal of many of the existing analyses of the concept. They simultaneously explain why all such analyses are subject to compelling counterexamples. In Section 5, we consider some replies and objections. We conclude that philosophers need to think more clearly about what they are trying to achieve when 'analysing' the concept of innateness.

The vernacular concept of innateness finds its home in a broader folk biology. It is closely related to other concepts such as instinct and human nature. These are all part of pre-scientific efforts to describe and reason about the living world, efforts that are often described as making up a folk theory. 'Folk theory' is a fancy name for the views that non-scientists hold, either explicitly or implicitly, on topics that are also topics of scientific inquiry. For example, there is a folk physics of heat, according to which heat is a physical quantity more or less directly measurable by the intensity of subjective sensations of heat. In this conception of heat, the wooden handle of a snow-shovel is warmer than the metal shovel itself, and the marble slab in a fishmonger's shop is cooler than the wooden stand on which it rests. These beliefs give rise to the (correct) advice to hold the shovel by the handle and the (incorrect) advice that food will stay fresh longer if kept on the marble slab. The folk physics of heat served people fairly well until they developed technologies that required distinctions between temperature, quantity of heat and conductivity, and the folk theory persists today alongside the scientific theory. To use another example, folk dynamics is the body of beliefs which people unreflectively hold about the movement of three-dimensional, medium-sized objects. People tend to explain the movement of an object that has been thrown by ascribing to it some kind of impetus

(Clement, 1983; McCloskey, 1983). Needless to say, impetus-like forces have no place in Newtonian and post-Newtonian physics.

Just as there are commonsense ideas about heat and dynamics, there are commonsense ideas about biology. Prominent amongst these is the idea that some traits are expressions of the inner nature of animals and plants, whilst other traits result from the influence of the environment. For example, dogs are bred for their colour and for their temperament, both of which are presumed to be part of their nature and thus inherited, but they are not bred for their attachment to a particular family, which is presumed to be the result of experience. The idea that living things have inner natures that make them the kind of organism that they are is intimately linked to the very idea of heredity. The hereditary traits of an animal are those that are passed on as part of its nature. Natures also explain the stability of some traits within a single lifetime – we do not expect a black sheep to grow white wool after shearing, because the colour of its wool is part of its nature.[1] Like the folk theory of heat, folk-biological ideas work reasonably well for hunting, farming, and traditional stockbreeding. They are not adequate, however, for the purposes of scientific biology. The ecological and evolutionary trajectories of populations cannot be understood with a folk theory of heredity, and it is not possible to understand development using the folk theory of inner natures.

For over 20 years, psychologists and anthropologists have investigated the structure and development of folk biological concepts across a range of different

[1] It may be that an organisms' nature can be altered by the environment in which it finds itself. Lamarckian theories of heredity which make this assumption seem to be highly intuitive. But this is a special, deep kind of alternation different in kind from the usual ways in which organisms are affected by the environment. Certain deeply ingrained habits become 'second nature' to people. In a typical Lamarckian theory, like that of Darwin (1872), it is only behaviors which are deeply ingrained for several generations that eventually become part of an organism's hereditary nature.

cultures.[2] Although many key issues remain unresolved, a consensus has emerged that a core set of biological beliefs are commonly held by the folk. We briefly outline the aspects of folk biology that, we suggest, are the likely source of people's vernacular conception of innateness.

One widely documented feature of folk biological categories is that they are hierarchically structured (Berlin, Breedlove, and Raven, 1973; Atran, 1990; Berlin, 1992). People everywhere identify (at least) three general levels of biological classification: a 'generic species' category (e.g., dogs and cedars), a super-ordinate category of biological domains (e.g., animals and plants), and a subordinate category of species varieties (e.g., particular breeds or strains). From a cognitive point if view, not all levels of this taxonomy are equally significant. The generic species rank is of particular importance. Membership in a generic species is associated with what psychologists call 'psychological essentialism' (Medin and Atran, 2004). People are psychological essentialists when they believe that membership in a biological kind is associated with a particular *causal essence* or *inner nature* – that is, some property or set of properties that define membership in a kind and cause members of the kind to possess kind-typical properties (Medin and Ortony, 1989; Atran, 1990; Gelman, 2003). The hypothesis that people are unreflectively essentialist is associated with at least two closely related beliefs that have been identified across a wide range of cultures.[3] First, adults believe that membership in a species is a permanent property of an organism that is inherited by

[2] (See, particularly, Carey, 1985; Keil, 1989; Atran, 1990; Medin and Atran, 1999, 2004; Astuti, Solomon, and Carey, 2004; Inagaki and Hatano, 2006)

[3] Some have challenged the claim that postulating a belief in causal essences was necessary to explain these phenomena (Strevens, 2000; Rips, 2001; Ahn et al., 2001). Be it as it may, the psychological phenomena themselves—a belief in a persistent species membership and a belief in inherited properties whose development is impervious to external influences —are not controversial.

descent and that is not affected by changes to its appearance. For example, when asked to imagine a raccoon that has been surgically modified to look and smell like a skunk, adults maintain that the animal is still a raccoon (Keil, 1989; see also Rips, 1989; Atran et al., 2001 with Yukatek adults; Sousa, Atran, and Medin, 2002 with Brazilian adults). Second, and most important for our purposes, people believe that the development of species-typical traits does not depend on environmental influences. For example, when asked to imagine a cow that has been raised by a family of pigs, adults assume that the cow will display the normal bovine traits (e.g. mooing instead of oinking) (Atran et al., 2001; Sousa, Atran, and Medin, 2002). In addition to psychological essentialism, Scott Atran (1995) has also proposed that folk biology has another core feature: the tendency to explain traits teleologically. That is, people tend to explain the traits possessed by animals and plants by asserting that these traits have a purpose.

The suggestion that humans share a core set of folk biological beliefs raises a host of controversial issues. There is some debate over the exact point in development at which these beliefs emerge, for example, and the extent of their cross-cultural similarity remains a matter of ongoing investigation.[4] There is also a lingering question about the nature of the underlying psychological mechanism. Some argue that psychological essentialism and the tendency to explain traits teleologically are generated by a domain-specific module (Atran, 1995), whilst others attribute the formation of psychological essentialism to a more general-purpose reasoning ability (Gelman and Hirschfeld, 1999), and yet others attribute the formation of the tendency to explain traits teleologically to our disposition to provide intentional explanations (Kelemen, 1999, 2004). Importantly,

[4] On developmental and cultural issues, see (Keil, 1989; Gelman and Wellman, 1991; Atran et al., 2001; Sousa, Atran, and Medin, 2002; Astuti, Solomon, and Carey, 2004).

none of these more controversial issues bear on the hypothesis being investigated here. What is important for our purposes is that early on and across cultures, people believe that organisms possess inherited 'inner natures' that [1] cause them to possess species-typical properties, [2] whose development is resistant to environmental influences, and [3] that are functional (they have a purpose). Following Griffiths (2002), we hypothesize that the vernacular conception of innateness has its origin in these folk biological beliefs. That is, when the folk believe a trait is innate, what they believe is that it is an expression of an organism's inner nature, and hence that the trait will possess all or some combination of the three features of species-typicality, developmental fixity, and purposive function (hereafter: 'Typicality', 'Fixity,' and 'Teleology').

2. The Three-Feature Theory of Innateness

According to Griffiths (2002, p. 71), it is part of folk biology that three features are particularly associated with traits that are expressions of the inner nature that organisms inherit from their parents. These features are:

1. Fixity – the trait is hard to change; its development is insensitive to environmental inputs in development; its development appears goal-directed, or resistant to perturbation.
2. Typicality – the trait is part of what it is to be an organism *of that kind;* every individual has it, or every individual that is not malformed, or every individual of a certain age, sex or other natural subcategory.

3. Teleology – this is how the organism is *meant* to develop; to lack the innate trait is to be malformed; environments that disrupt the development of this trait are themselves abnormal.

Griffiths described these three features in such broad terms in order to capture shared elements of the very different ideas about the inner natures of living things that are found in different human societies.[5] Consider, for example, the feature which we have called 'Teleology'. The Darwinist will understand this as evolutionary design, whereas the creationist will understand it as God's intention. Each seeks to make sense in their own terms of an intuitive sense that an organism is *meant* to be a certain way whether or not it actually turns out that way. In the seventeenth century, the anatomist William Harvey dealt with the same fundamental intuition by supposing that the "idea or form" of the organism provided by the male parent is sometimes misinterpreted by the "formative faculty" of the female parent's womb (Harvey, 1989, p. 578). It is the underlying intuition shared by all three theorists that we regard as an expression of folk biology, and in particular of the folk-biological conception of inner natures.

We cannot sufficiently stress that we are *not* proposing to define innateness with a set of necessary and sufficient conditions called Typicality, Fixity and Teleology. The three-feature theory has a similar status to accounts of specific concepts developed by psychologists and cognitive anthropologists. It treats the vernacular concept of innateness as a cognitive structure (or a mental representation) that has its origin in folk biology. If the three-feature theory is correct, then the cognitive structure that underpins the use of

[5] In his 2002 paper Griffiths referred to the three features as 'developmental fixity,' 'species nature,' and 'intended outcome'. In this paper we use the handier terms 'Fixity,' 'Typicality,' and 'Teleology,' and we reserve the term 'nature' for the broader idea that organisms have an underlying nature of which innate traits are an expression.

the term 'innate' is an implicit theory that views organisms as having inner natures which are expressed in traits that are likely to be Typical, Fixed and Teleological.

The aim of the present study is to test the three-feature theory by examining how people actually apply the concept of innateness. The three feature theory makes claims about folk biology, not about the ideas that people derive from scientific biology. Thus, the study asks specifically whether *non-scientists* use the innateness concept in the manner predicted by the three-feature theory. If innateness judgments are indeed influenced by these three features in the way we have suggested, then two predictions should follow:

1. The association of each of the three features with a trait increases the likelihood that subjects will identify that trait as innate.
2. All three features will contribute *independently* to subjects' judgments about whether a trait is innate.

Note that prediction two is stronger and more risky than prediction one. It is a direct consequence of our hypothesis that the three features in question (Typicality, Fixity, and Teleology) contribute *additively* to judgments about whether some trait is innate. Suppose that we are wrong, and that people only take one feature – Fixity, for example – to be characteristic of traits which express inner natures. But, suppose also that people use the other two features as suggestive cues for whether the defining feature is present (perhaps because they believe that the corresponding properties tend to co-occur). This alternative to the three-feature theory predicts an interaction among the three features. Direct evidence that the trait is not Fixed will reduce the influence of evidence that the trait is Typical or Teleological on the final judgment about its

innateness. An analogy may make this point clearer: seeing a Prada logo on a handbag strongly influences the judgment that it is a Prada handbag. But independent evidence that it is *not* a Prada bag – for example, the fact that it is being sold in a street market in Jakarta for the equivalent of one U.S. dollar – reduces the influence of the logo on judgments about the brand.

We should also stress that we not proposing that only three, simple cues affect judgments of innateness. It seems clear, for example, that being present at birth and not being learnt are cues which people use to identify traits as innate. But we suggest that these and many other specific cues can be understood in terms of the three broad intuitive aspects of innateness which we have identified. The significance of presence at birth and not being learnt, for example, is that they provide evidence that the trait is insensitive to the environment and is developing as if guided by some internal goal—that is, evidence that the trait has the folk-biological feature that we have labeled 'Fixity.'

3. Testing the Three-feature Theory of Innateness

3.1. Materials

To test the prediction that Fixity, Typicality and Teleology are additive factors positively affecting judgments of innateness, we studied whether people judge eight examples of birdsong to be innate behaviors. We chose birdsong because it offers the opportunity to find real, or at least realistic, examples of the eight possible combinations of the three factors under consideration (Table 1). There are over nine thousand species of birds and song learning has been the focus of intense investigation since the groundbreaking work of William Thorpe and Peter Marler in the1950s (for an accessible introduction, see

Marler and Slabbekorn, 2004). Although the participants in our experiment had no expertise in biology or in any behavioral science, we hope to use these materials in later studies with scientists and feedback from scientists involved in other 'experimental philosophy' studies suggests that they are unwilling to devote time and effort to thinking about unrealistic cases (Griffiths and Karola Stotz, personal communication).

In four cases, we used a bird which is known to acquire its song in a manner corresponding exactly to one of the boxes in Table 1. We failed to find a bird for the remaining four cases. For these remaining cases we used a speciose genus where some species are known to acquire their song in a manner very close to what we required. We invented a new species of that genus which fitted our requirements, and made up plausible common and scientific names for that species. One of our species is the Pale-headed Thornbird *(Phacellodomus pallida).* Unless you are a keen birder with expertise in the relevant region, we doubt that you can tell whether this is one of the real species.

Table 1: The Eight Possible Combinations of Fixity, Typicality and Teleology

	Typical	**~Typical**
Fixed	**Design feature (Teleology)** *Combination 8*	**Design feature** *Combination 6*
	Accident (~Teleology) *Combination 7*	**Accident** *Combination 4*
Plastic	**Design feature** *Combination 5*	**Design feature** *Combination 2*
	Accident *Combination 3*	**Accident** *Combination 1*

The eight probes describing the examples of birdsong each have the same structure. The probe begins with a standard paragraph about research on birdsong, designed to convince subjects that there is a wealth of well-established scientific knowledge about birdsong. The next paragraph begins with one or two sentences naming a specific bird and providing some neutral information about it. This is designed to convince subjects that this is a real animal. The remainder of this paragraph states

whether the song of the male of this species is Fixed, Typical, Teleological or their opposites, using one of each of these pairs of statements:

Fixed/Plastic

0. Studies on _____ show that the song an adult male produces depends on which songs they hear when they are young.

1. Studies on _____ show that the song an adult male produces does not depend on which songs they hear when they are young.

Typical/~Typical

0. Studies also show that different males in this species sing different songs.

1. Studies also show that all males of this species sing the same song.

Teleology/~Teleology

0. Close observations of these birds reveal that the males' song is not used to attract mates nor to defend territories. Scientists therefore agree that this feature of the bird has no real function, like the appendix in humans.

1. Close observations of these birds reveal that the males' song attracts mates and helps to defend their territory. Scientists therefore agree that this feature of the bird has a real function, like the heart in humans.

To control for order effects, we presented the information about Typicality, Fixity, and Teleology in three different orders—Typicality-Fixity-Teleology (order 1), Teleology-Typicality-Fixity (order 2), Fixity-Teleology-Typicality (order 3)—resulting in 24 different probes.[6]

To illustrate, the probe describing a species of bird in which birdsong is not-Typical, is Fixed, and has a Function, with the items presented in order 1, read as follows:

[6] Probes and full datasets are available at http://philsci-archive.pitt.edu (not posted until article is accepted)

Birdsong is one of the most intensively studied aspects of animal behaviour. Since the 1950s scientists have used recordings and sound spectograms to uncover the structure and function of birdsong. Neuroscientists have investigated in great detail the areas of the brain that allow birds to develop and produce their songs. Other scientists have done ecological fieldwork to study what role song plays in the lives of different birds.

The Alder Flycatcher (*Empidonax alnorum)* is a migratory neo-tropical bird which breeds in southern Canada and the northern USA. Studies on the Alder Flycatcher show that the song an adult male produces does not depend on which songs they hear when they are young. Studies also show that different males in this species sing different songs. Furthermore, close observations of these birds reveal that the males' song attracts mates and helps to defend their territory. Scientists therefore agree that the bird's song has a real function, like the heart in humans.

On a 7-point scale, 1 meaning strongly disagree and 7 meaning strongly agree, how would you respond to the following statement?

'The song of the male Alder Flycatcher is innate.'

It should be noted that a substantial amount of interpretation is involved in reducing the three hypothesized features associated with innateness to these three information items. Our interpretation of Fixity reflects the general tenor of the birdsong literature, in which the songs of sub-oscine passerine birds are traditionally described as

'innate' because, unlike the oscine passerines, their development does not depend on exposure to correct song. Our interpretation of Typicality ignores the idea that a variable song might be an evolved polymorphism like eye colour. Our interpretation of Teleology as having a 'real function' was driven by the need to remain neutral between evolutionary and creationist conceptions of teleology. The examples of organs that have and do not have a 'real function' (respectively, heart and appendix) were included to ensure that subjects interpreted 'real function' in the sense we intended. It seems plausible that typical North American subjects will be familiar with these two examples.

3.2 Subjects and Procedure

255 individuals taking classes at the University of Pittsburgh took part in the experiment. 10 subjects were not native speakers of English and 1 subject did not specify whether she was a native speaker of English. These 11 subjects were removed from the data set, resulting in a sample of 244 subjects (mean age: 20.9; range: 18-40; 50.8% males). In classroom settings, subjects were randomly assigned to one of the 24 probes (Table 2).

Table 2: Number of Subjects per Combination per Order

		Order			Total
		1	2	3	
Combination	1	12	10	6	28
	2	19	9	6	34
	3	15	9	6	30
	4	15	10	4	29
	5	16	11	3	30
	6	15	9	7	31
	7	17	9	6	32
	8	17	8	5	30
Total		126	75	43	244

Subjects read a single probe. They had to answer the innateness question by circling a numeral on a 7-point scale, anchored at 1 with 'totally disagree' and at 7 with 'totally agree'. Subjects were also asked to fill a short demographic questionnaire. This asked for their education level in biology and in psychology as well as for their general propensity to favour 'biological' over 'environmental' explanations of human behavior. We found no meaningful relation between either our subjects' education level in biology

and in psychology or their propensity to favour biological over environmental explanations and their answer to the innateness question.

3.3 Results

To test the three-feature theory of innateness, we performed a standard multiple regression analysis between the dependent variable (answer to the innateness question) and the three predictor variables (Typicality, Fixity, Teleology).[7] Taken together, the three predictors significantly predict subjects' answer to the innateness question ($F(3, 240) = 13.62$, $p < .001$). These three predictors explain a moderate portion of the variance, $R^2 = .15$ (adjusted $R^2 = .14$). This corresponds to a medium effect size (Cohen, 1992).

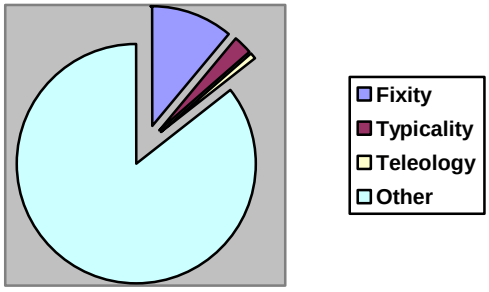
Among our three predictors, Typicality (B = 1.18; β = .33, $t = 5.55$, $p < .001$) and Fixity (B = .59; β = .17, $t = 2.81$, $p < .01$) each significantly predicts subjects' answer to the innateness question. Teleology (B = .33; β = .09, $t = 1.16$, $p = .12$) does not significantly predict subjects' answer to the innateness question, but the trend is suggestive.

We also used hierarchical multiple regression to test the independent contribution of each predictor. Typicality was entered in the first block, Fixity in the second block, and Teleology in the third block. The results are similar to the previous analysis (Figure 1). Typicality explains 2.5 percent of variance in subjects' answer to the innateness question, which is significant ($F(1, 242) = 7.14$, $p < .01$). When Fixity is added in the second step, it explains an additional 10.8 percent of variance, a significant increase (F(1,

[7] The assumptions of multiple regression were tested. The predictors are linearly related to the dependent variable, there was no multicollinearity, and the error is normally distributed and uncorrelated with the predictors.

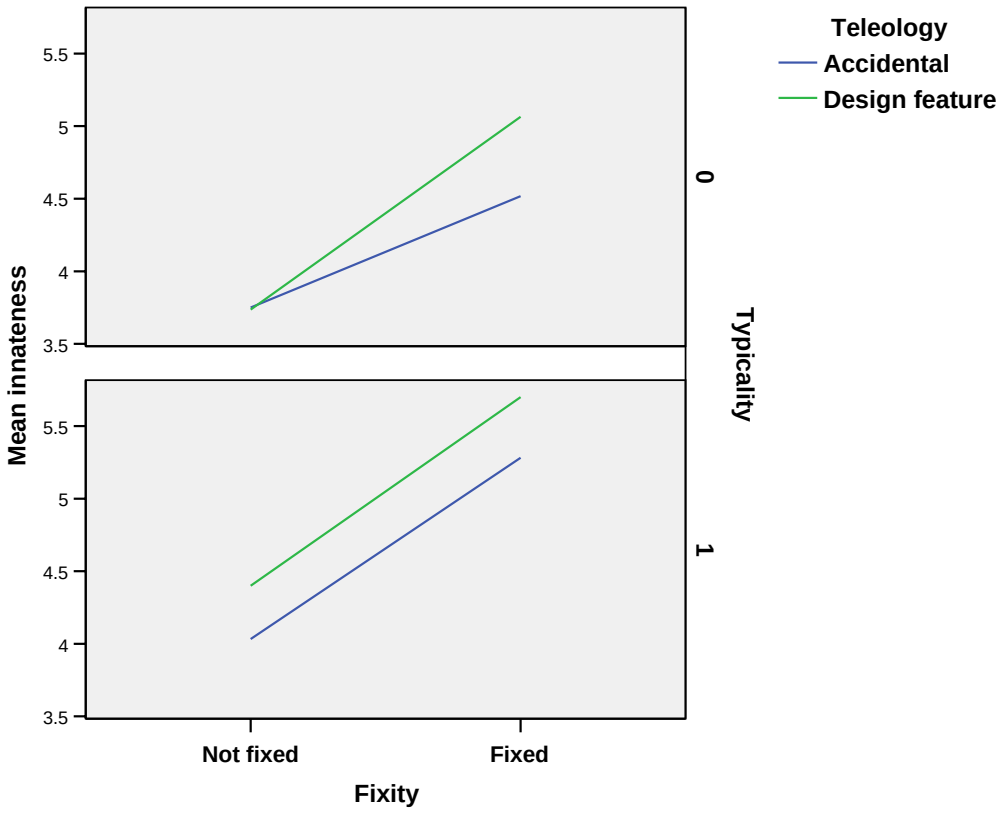
241) = 30.20, $p < .001$). When Teleology is added in the last step, it explains an additional .9 percent of variance, a non-significant, but suggestive, increase ($F(1, 240) = 2.43$, $p = .12$).

Figure 1: Proportion of the Variance Independently Predicted by Fixity, Typicality and Teleology.



To study the interactions between our three predictors, we used an ANOVA with Fixity, Typicality, and Teleology as factors. As expected from the two previous analyses, we found a main effect of Fixity (Fixed > ~Fixed, $F(1, 236) = 29.86$, $p < .001$) and Typicality (Typical > ~Typical, $F(1, 236) = 7.63$, $p < .01$). There was no significant effect for Teleology ($F(1, 236) = 2.41$, $p = .12$) and, importantly for our purposes, no interaction (see Figure 2).

Figure 2: Subjects' Mean Answer to the Innateness Question as a Function of Typicality, Fixity and Teleology.



Note that the strong effect of Fixity on Mean Innateness is not significantly influenced by Universality or Function, indicating that these three features do not interact.

Finally, to study the effect of outliers, we eliminated the data points that were above and beyond two standard deviations from the mean in each combination. 5 data points were removed. We performed again a standard multiple regression analysis between the dependent variable and the three predictor variables. The results were overall very similar to our previous analyses. Taken together, the three predictors significantly

predict subjects' answer to the innateness question ($F(3, 235) = 19.89$, $p < .001$). These three predictors explain a greater portion of the variance than in the previous regression analysis, $R^2 = .20$ (adjusted $R^2 = .19$). Again, Typicality and Fixity, but not Teleology, significantly predict subjects' answer to the innateness question.

3.4 Discussion

The three-feature theory of innateness is substantially, though not perfectly, supported by these results. Together, the three predictors explain 14% of the variance in subjects' answers to the innateness question.

Typicality and Fixity independently explain part of the variance in subjects' answers to the innateness question. There is also no interaction between these two predictors. Thus, whether a trait is typical of a given species and whether the development of this trait is canalized are two independent features that influence people when they decide whether a trait is innate.

Fixity turned out to be a more important factor than Typicality. Typicality alone explains only 2.5% of the variance in subjects' answers to the innateness question, while when Fixity is added to Typicality, it explains an additional 11% of the variance. Thus, when people decide whether a trait is innate, the Fixity of a trait matters more than its Typicality.

The three-feature theory of innateness is only partially supported by our results, because Teleology turned out not to be a significant predictor of the variance in subjects' answer to the innateness question. Thus, we found no clear evidence that the functional significance of a trait is a relevant factor when people decide whether this trait is innate.

We see three obvious mutually exclusive explanations of this result. First, we may simply be wrong in assuming that the function of a trait is one of the cues that people use to decide whether this trait is innate. In support of this first explanation, one might argue that by contrast to the folk expectations that some biological traits are both species typical and developmentally canalized, the folk expectation that biological traits have a function does not originate in folk biology. True, adults and children do provide teleological explanations of the physiological traits possessed by animals. But, if, as some psychologists have argued (Kelemen, 1999, 2004), the tendency to explain teleologically does not originate in folk biology and if folk biology is the source of the vernacular concept of innateness, function might not be a cue used by the folk to decide whether a trait is innate.

A second, alternative explanation is that, while it is part of folk-biology that innate traits are how organisms are 'meant to be' (Teleology), this is not adequately expressed by the claim that innate traits have a function. Griffiths's original (2002) proposal was inspired by the widespread assumption that an organism which fully expresses its inner nature is somehow better than one which does not, and that only ill-effects can come from interfering with the expression of an organisms' true nature. The original meaning of ‘monster’ (*terata)* is, after all, an organism in which the form of the species has failed to impress itself on recalcitrant matter. These ideas may simply not be adequately represented by the information we provided about whether a trait has a function.

There is a third, simpler explanation that is also consistent with the three-feature theory of innateness. In our probes, when we gave information about the functional

significance of birdsong, we compared birdsong to a biological organ *both* when birdsong was functional *and* when it was not. We compared birdsong to the heart in the former case and to the appendix in the latter case. Now, subjects might believe that the heart and the appendix are both innate traits of humans. If this is the case, our very probes inadvertently suggested that function was irrelevant to decide whether a trait was innate. This explanation can easily be tested, by eliminating the comparisons from our current probes. We intend to do this test in a follow-up study. For now, we note that this third explanation is tentatively supported by the fact that in spite of comparing both functional and non-functional birdsong to a human organ, the relation between subjects' answer to the innateness question and the predictor function was not far from significance. Furthermore, Figure 2 shows that whether a trait was functional did influence subjects' answer to the innateness question, except when the trait was neither universal nor canalized.

Our three predictors taken together explain 14 percent of the variance in subjects' answer to the innateness question (19% when the outliers were removed from the data set), corresponding to a medium effect size (Cohen, 1992). One might wonder why they do not explain a larger part of the variance if the three-feature theory of innateness is true. There are at least three mutually consistent, explanations of this moderate effect.

Because some subjects might have not have known the meaning of 'innate', they might have answered randomly or given the answer 4 (the middle of the scale) independently of the combination they were presented with. These data points could not be removed from the data set. Moreover, some subjects might have been reticent to apply

the term ‘innate’ to behaviors, because they might have believed that only psychological capacities or traits are innate—not behaviors.

Finally, and most important, some subjects might have had some background beliefs about birdsong. They might have been told in high school or college, or they might have read, that birdsong is innate or, alternatively, that it is learned. This might have led them to answer the innateness question independently of the three elements of information that had been given to them. As a result, the answer of these subjects probably contributed to the proportion of the variance that is not accounted by the three predictors under consideration. Given that many subjects have probably at least some inchoate beliefs about whether birdsong is innate or not, the medium effect size in our findings is actually quite surprising.

This explanation suggests the following line of research. If our three predictors failed to explain a larger part of the variance because some subjects had some background beliefs about the innateness nature of birdsong, our three predictors should explain a larger proportion of variance in subjects’ answer to the innateness question, if birdsong were replaced by a behavior that subjects have never heard of. To prevent subjects to answer on the basis of their background beliefs, psychologists working on induction typically use what they call ‘blank predicates.’ These are made-up predicates that refer to fictional properties such as ‘require biotin for protein synthesis’ (Osherson et al., 1990). Similarly, in future research, we intend to replicate our experiment, replacing the behavioral trait ‘birdsong’ with a ‘blank’ behavioral trait for which subjects would have no or few background beliefs.

4. Implications for Existing Analyses of Innateness

Our results explain some aspects of the philosophical literature on innateness. Each analysis fixes on one or two aspects of the vernacular concept of innateness, leaving itself open to counterexamples which appeal to intuitions derived from the other aspects.

4.1 Analyses of Innateness Based on Typicality[8]

Stephen Stich's seminal paper 'The idea of innateness (1975) contained a number of tentative suggestions about the structure of the concept. One is that an innate trait might be defined as one that a person will manifest in the normal course of human development. Stich offered a counterexample to this analysis: universally held beliefs, such as the belief that water quenches thirst, will count as innate on this analysis whereas intuitively they are acquired (Stich, 1975, p. 9). André Ariew has offered another counterexample: humans acquire a typical gut flora during development, but these bacteria are intuitively acquired rather than innate features of humans (Ariew, 1999, p. 133). Ariew has also suggested that Stich's analysis derives its plausibility from the assumption that if a trait is species-typical, then there is some mechanism that ensures its presence (Ariew, 2006, p. 10). Following this critical tradition, we will treat Stich as suggesting that a trait is innate just in case it is typical of normal development. In the same vein, other authors have suggested that 'innate' means 'shared by all members of the species' (Bateson, 1991).

The proposal that a trait is innate just in case it is typical of normal development appeals to the folk biological idea that traits which express an organism's inner nature will typify that species. Our results show clearly that judgments of innateness are

[8] Recall that the capitalized terms Typicality, Fixed, and Teleological refer to the elements of folk-biological theory discussed in Sections two and three, and are being used here strictly in this, stipulated sense.

influenced by information about Typicality, so it is unsurprising that suitably chosen thought experiments evoke intuitions that favour this analysis. However, our results also show that judgments of innateness are influenced by information about Fixity, so it is equally unsurprising that the thought experiments listed above, both of which make salient the dependence of typical traits on interaction with the environment, evoke intuitions hostile to the analysis.

4.2 Analyses of Innateness Based on Teleology

Another popular analysis of innateness suggests that a trait is innate if its development is guided by 'inherited information' rather than 'environmental information.' This was also suggested by Stich (1975, 13-16), but has been defended primarily by Muhammad Ali Khalidi (2002; 2007). Both Stich and Khalidi restrict the analysis to innate cognitive traits: '…a belief (concept, idea, capacity) may be considered to be innate to the degree that it would emerge as the result of an impoverished stimulus' (Khalidi, 2002, p. 269). Both Stich and Khalidi were unaware that this account of innateness was at the heart of Konrad Lorenz's 1965 book *Evolution and the Modification of Behaviour.* It replaced Lorenz's much criticized 1937 account of innateness based on the deprivation experiment.[9] Any analysis along these lines must specify what is meant by 'information', something which is not at all obvious (Stich, 1975, p. 15). Lorenz identified 'information' in this context with adaptive fit. He saw no reason to restrict the analysis to cognitive traits, since all adaptive traits 'fit' the environment and hence can be said to contain information about that environment. If a person has calluses on their palms rather than on the backs of their hands, then these calluses contain information about where their skin

[9] For more on Lorenz's 1965 theory, see (Browne, 2005).

gets rubbed. If they form calluses on their palms more easily than on the backs of their hands (or if, like the ostrich, they are born with calluses already formed in convenient places) and if these traits fit their future environments, then those traits contain information about what the future environments will be like. This anticipatory information, Lorenz argues, must have been in the genome, and must have been absorbed from ancestral environments.

Lorenz's analysis can readily be expressed in information-theoretic terms, with the environment as the signal source and the organism as the receiver. Organisms need to reduce their uncertainty about what demands the environment will place on them and to develop in a way that meets those demands. There are two ways to do this. One is gather information during development. The water flea *Daphnia pulex* monitors chemical traces of predators as it develops and grows defensive armour if predators are indicated. The other way is to inherit information from your ancestors. The sickle cell allele, a costly trait which confers resistance against malaria, carries information about the prevalence of malaria in the ancestral environment and thus, probably, in the environment of the organism which inherits it. To the extent that the functional adjustment of a trait to its environment is explained by 'inherited information' of this kind, Lorenz argued, the trait is innate.

Stripped of its colourful language, the 'inherited information' analysis amounts to the claim that a trait is innate if its fit to the environment can only be explained by evolutionary adaptation (or by divine providence, if you swing that way). There would seem to be two ways to explain the intuitive appeal of this analysis. First, it may reflect an inchoate assumption that if something is an adaptation, then it must be Fixed and/or

Typical. Second, it may be part of folk biology that traits which are part of an organism's inner nature are design features, representing how the organism is meant to develop. Our data showed only a weak, suggestive effect for Teleology in driving judgments of innateness, but it is certainly too soon to dismiss the idea that Teleology matters for folk judgments about innate traits. However its appeal is to be explained, the analysis is open to counterexamples based on Typicality or Fixity. For example, the massively over-grown jaw typical of the inbred Hapsburg royal family was innate - the Hapsburg's were innately hideous - but this was not an adaptation.

4.3 Analyses of Innateness Based on Fixity

A third class of analyses identifies innateness with Fixity: innate traits are those like the Hapsburg jaw which are hard to change. This view has been ably defended by Andre Ariew, who argues that traits are innate to the extent that they exhibit environmental canalisation (Ariew, 1996, 1999, 2006). The concept of canalisation derives from the mid-20th century embryologist and theoretical biologist Conrad H. Waddington. A trait is genetically canalised to the extent that it will develop despite variations in the organism's genome. It is environmentally canalised to the extent that it will develop despite variation in the organism's environment. It is canalised *simpliciter* to the extent that both of these are true (Griffiths, 2006). Innateness-as-canalisation is a matter of degree. A trait is more innate the more environmental parameters its development is buffered against and the wider the range of variation in those parameters against which it is buffered.

Our data suggest that intuitions about innateness respond more strongly to information about Fixity than to information about Typicality or Teleology. Innateness-

as-canalisation should therefore fit people's intuitions about innateness better than other analyses.[10] Despite this, however, analyses which identify innateness with Fixity remain subject to intuitive counterexamples that trade on intuitions derived from those other features. Consider the penile reflexes of the rat. Celia Moore (1992; 1984) has shown that the spinal cord nuclei of male rats differ from those of female rats in ways that allow the male to use his penis during copulation. These neural differences result from differences in gene expression in the developing spinal cord of the rat pup, which in turn result from differences in the amount of licking of the genital area by the mother, which in turn results from greater expression of a chemical that elicits maternal licking in male pups. According to innateness-as-canalisation, these experiments show that the rat's ability to copulate is not innate:

> 'Distinguish between two reasons why the trait appears invariantly in an environmental range: the first, because an environmental condition is developmentally required yet is found everywhere the system develops; the second, because the system develops independently of the environmentally condition. Innateness should be identified with the second sort of invariance, not the first.' (Ariew, 2006, p. 10)

We do not think that intuitions about the penile reflex case follow this prescription. Our data support this hunch. One of our examples of birdsong is the Black-

[10] We believe that this reveals something important about the concept of innateness vis-à-vis other concepts that reflect the underlying folk-theory of biological natures, such as the concepts of instinct and of human nature. These concepts may place different weightings on the three aspects of the folk-conception of biological natures which we described above. The readiness with which people speak of diseases as 'innate' already suggests that Teleology is not as heavily weighted in innateness as it is in instinct or human nature. It would seem perverse to express a strongly hereditarian view of autism, for example, by saying that autistic behaviors are 'instinctive'. If this suggestion about alternative weightings is correct it should be possible to demonstrate this in future research by comparing the application of the different concepts to the same set of examples. We intend to study this issue in future research.

Capped Chickadee *(Parus atricapillus)* (combination 5 in Table 2). Despite the wide geographic range of the chickadee, its morning 'fee-bee' song is invariant throughout the species. But males must be exposed to species typical song in order to acquire that song themselves. With this probe we gave subjects exactly the evidence Ariew takes to show that a trait is not innate – 'an environmental condition is developmentally required yet is found everywhere the system develops' – but our subjects regard the song as innate. Their modal answer was 5 on our 7-point scale and our analysis shows that their responses were influenced by the information that the song is Typical.

Our data showed that people rely on the typicality of a trait and on its universality to decide whether it is innate. More tentatively, people may also rely on whether the trait has a function. In this section we have shown that many proposed analyses of the concept have focused on one of these three features, and have left themselves open to counterexamples which rely on intuitions about innateness derived from the other two features. Some more recent analyses seem to draw on two features, which naturally increases their adequacy (e.g. Mallon and Weinberg, 2006). An analysis that could survive the philosophical activity of offering intuitive counterexamples unscathed, however, would have to include at least Fixity and Typicality, might also have to include Teleology, and would have to weight the different features correctly against one another.

5. Objections and Replies

5.1 We are Analysing *Scientists*' Concept, Not the Folk Concept

Philosophers committed to one of the accounts of innateness discussed in Section 4 may object that they are not trying to analyze the folk concept of innateness. Rather, they

might be attempting to analyze the concept of innateness used by scientists or by some specific group of scientists. For example, Samuels (2002) describes his project as an attempt to analyze the concept of innateness used by cognitive scientists, particularly in the controversies spurred by Chomsky's poverty of stimulus argument.

We are sympathetic to the project of understanding how scientists think about innateness. But if this is the really the project Samuels and others are engaged in, their methods suffers from serious shortcomings. Philosophers often use thought experiments that tap into their own or the folk's intuitions. Both Samuels (2002) or Mallon and Weinberg (2006) make some use of intuitions about examples. If their goal really is to analyze scientists' concept of innateness, this common methodology should be abandoned. Why would philosophers' or the folk's unreflective judgments about innateness matter to how, say, generative syntacticians think about innateness? Philosophers also regularly rely on outlandish thought experiments, such as the spontaneous acquisition of the capacity to read or understand Latin after having ingested the famed Latin pill (Fodor 1975; Samuels 2002; Mallon and Weinberg 2006). This kind of thought-experiment is probably of little use for understanding scientists' concept of innateness, because the intuitions (if any) triggered among scientists by these thought-experiments may have little to do with the concept of innateness they rely on as scientists.

When they are not dealing with intuitions elicited by thought-experiments, philosophers assume that their analysis of a scientific concept is supported if it casts some light on some scientific episode involving that concept or on some body of scientific literature (e.g., the writings of some prominent scientist). For instance, an analysis of the concept of innateness in cognitive science is supported if it casts some light on the

debates spurred by Chomsky's poverty of stimulus argument or on Chomsky's writings. This method is certainly valuable, particularly to study the concepts entertained by scientists in the past or the concepts formed by some specific scientist. But, it also has some major shortcomings. Several different accounts of the concept of innateness might cast some light on the relevant scientific episode(s) and writings. When this happens, it is unclear how we can choose between these accounts in a principled manner. Furthermore, this methodology is irreducibly subjective. There is no way to measure how well an account of a given concept illuminates a scientific episode or a body of scientific literature. So, once again, disagreements often cannot be settled.

By contrast, the method we used in this article to study the folk concept of innateness can be naturally expanded to study scientists' concept(s) of innateness. Scientists' judgments about the innateness of birdsongs can be surveyed in the same way as we surveyed folk judgments. In contrast to philosophers' attempt to cast some light on specific scientific episodes, such surveys can systematically and objectively examine the cues scientists use when they apply a concept. Furthermore, in contrast to the strange thought experiments often favored by philosophers, biologically realistic probes, such as the probes we developed, can be used. Indeed, we plan in future research to survey the judgments of psychologists, biologists, linguists, and others, using the very probes we used in the present study.

5.2. We are Trying to *Reform* the Folk Concept, Not Analyse It

Some philosophers see themselves as reforming the folk notion of innateness in order for this notion to play a useful role in science or in some specific science. Although he

sometimes appeal to untutored intuitions in the way we have just objected to, Ariew (1996, 1999, 2006) is best understood as proposing to identify innateness with Fixity (environmental canalization) because such a reformed concept of innateness would be useful in biology and psychology.

We are unconvinced by this project. Suppose the point of reforming the folk concept of innateness is really to provide biologists with a useful concept. First, biologists and psychologists already have such a concept, namely the concept of canalization, and they already have a word that expresses that concept, namely 'canalized.' As Bateson (1991) and Griffiths (2002) have already asked, if your goal is to mean canalized when you say 'innate,' why not just say 'canalized'? Furthermore, our findings show that by 'innate,' the folk do not merely mean 'canalized'. By using the term 'innate' instead of 'canalized,' biologists who follow Ariew's reformist suggestion would systematically increase the risk of miscommunication between themselves, other biologists, and the public at large. When Robin Andreasen (1998) and Philip Kitcher (1999) proposed to reform the concept of race so that the word 'race' would become synonymous with the word 'clade' (or with the expression 'breeding population'), Joshua Glasgow (2003) and others were quick to note that since the term 'race' as used by the folk has specific connotations, this proposal would lead to dangerous misunderstandings among the lay consumers of science. A similar argument applies to reformist proposals for 'innate,' although the anticipated danger is obviously less catastrophic.

5.3 Innateness is a 'Homeostatic Property Cluster'

We have argued that the innateness concept is associated with three logically independent features. It might still be a valuable construct if those three were bound together reliably,

so that each was to some extent a predictor of the others. Innate traits might be like market economies – each different in various ways, but similar enough to be worth distinguishing as a type from command economies. It is natural here to appeal to Richard Boyd's influential idea of a 'homeostatic property cluster' (Boyd, 1991). Many scientific categories, Boyd argues, refer to a cluster of properties none of which need be present in every instance of the category, but whose regular co-occurrence reflects causal processes which connect them in various ways. Although they do not use Boyd's terminology, Mameli and Bateson (2006) have provided the most substantial discussion of this idea to date. As discussed above, they identified eight viable scientific constructs that have been proposed as explications of the vernacular idea of innateness. They call these the 'i-properties.' They argue that it will be useful to retain the term 'innate' only if the eight 'i-properties' are highly correlated with one another. If they are not, then the retention of the term can only lead to confusion and fallacies of ambiguity, as Bateson suggested fifteen years earlier. Mameli and Bateson maintain that the links between the i-properties are matters for empirical investigation and that until there is good evidence that the i-properties are highly correlated scientists should eschew the term 'innate,' since its continued use hides the fact that we do not know whether the i-properties are highly correlated.

The fact that the term 'innate' is an expression of folk biology should make us even more suspicious of its continued appeal. In our experience, philosophers presented with standard critiques of the concept of innateness from behavioral biology are rarely impressed because it seems intuitively obvious to them that the various aspects of innateness, whilst theoretically separable, all go together. But this intuition is merely an

expression of the folk theory of inner natures which philosophers, as much as anyone else, make use of in their everyday lives. It is not at all obvious that Fixity, Typicality and Teleology are closely related. There are innumerable well-researched examples of disassociations that, from a folk biological point of view, appear paradoxical (Michel and Moore, 1995; Bateson and Martin, 1999). Moreover, there are sound theoretical reasons why we might *expect* these three features not to be associated. Amongst these are:

1. Natural selection has no particular bias towards producing traits that are species-typical (monomorphic). Many important traits in humans and other organisms are genetically maintained polymorphisms, either as a result of frequency dependent selection or as a response to variation in the environment across the species' range (ecotypes). Natural selection also frequently produces phenotypic plasticity, in which the developmental system responds to the environment with a range of traits, as in the example of the water flea *Daphnia pulex* given above. Conversely, developmental constraints give rise to species-typical traits which are not adaptations.

2. Natural selection does not select for mechanisms which buffer traits against variation in the environment unless variation of that kind regularly occurs in the environments in which the species lives. In fact, any buffering mechanism which is not actively being used will tend to decay by mutation. One example is the inability of humans and their relatives to synthesise ascorbic acid (vitamin C). The ascorbic acid synthesis pathway was disabled by mutation during the long period in which our fruit-eating ancestors had no chance of developing vitamin C deficiences (Jukes and King, 1975). As Terence Deacon has nicely put it, organisms are in 'addicted to' innumerable aspects of their environments, from ascorbic acid, to gravity, to social interactions (Deacon, 1997). In

less colourful terms, the development of evolved traits assumes the presence of an 'ontogenetic niche' (West and King, 1987) which supports and enables the normal expression of the genome.

6. Conclusion

We have shown experimentally that judgments of innateness are independently influenced by two features, Fixity and Typicality, with the former weighted more heavily than the later. We have produced suggestive evidence that a third feature, Teleology, may also play a role. We have argued that existing philosophical analyses of the innateness concept are inadequate because they try to make do with only one of these features and ignore the weighting issue. We conclude more broadly that the project of 'conceptually analysing' an idea like innateness faces a dilemma. If conceptual analysis aims to capture the concept used by the folk or by some specialist community, empirical methods are more powerful than the traditional 'method of counterexamples.' If it aims to replace the existing concept with a more coherent, partly stipulative, 'explication' of that concept, then whether a proposed explication seems intuitive to ordinary speakers of English becomes a very minor issue. We doubt it is wise to use the term 'innate' to denote any such explication, but if the aim of philosophical analysis is explication then its method should be to assess the epistemic value of various proposed explications, in the manner of Mameli and Bateson (2006). It seems to us that far too much of the philosophical literature still wants to have it both ways on this issue, declaring that is in the business of explicating the concept of innateness for the purposes of science whilst appealing to intuitions about whether some trait is innate to support one analysis over another.

Paul E. Griffiths

School of Philosophical and Historical Inquiry

University of Sydney

Edouard Machery

Department of History and Philosophy of Science

University of Pittsburgh

Stefan Linquist

Biohumanities Project

University of Queensland

References

Ahn, W.-K., C. Kalish, S. Gelman, D. Medin, Luhmann, C., and S. Atran, et al. 2001: Why essences are essential in the psychology of concepts. *Cognition*, 82, 59-69.

Andreasen, R. O. 1998: A new perspective on the race debate. *British Journal of Philosophy of Science*, 49, 199-225.

Ariew, A. 1996: Innateness and Canalization. *Philosophy of Science*, 63, S19-S27.

Ariew, A. 1999: Innateness is Canalization: In Defense of a Developmental Account of Innateness. In V. G. Hardcastle (ed), *Where Biology Meets Psychology: Philosophical Essays*. Cambridge, Mass.: MIT Press.

Ariew, A. 2006: Innateness. In M. Matthen and C. Stevens (ed), *Handbook of the Philosophy of Science*: Elsevier.

Astuti, R., G. E. A. Solomon, and S. Carey. 2004: *Constraints on Conceptual Development: A Case Study of the Acquisition of Folkbiological and Folksociological Knowledge in Madagascar*: London: Blackwell Publishing.

Atran, S. 1990: *Cognitive Foundations of Natural History: Towards an Anthropology of Science*. Cambridge and New York: Cambridge University Press.

Atran, S. 1995: Causal constraints on categories. In D. Sperber, D. Premack and A. J. Premack (ed), *Causal Cognition: A Multi-Disciplinary Debate*. Oxford, England: Clarendon Press.

Atran, S., D. Medin, E. Lynch, V. Vaparansky, U. E. Edilberto, and P. Sousa. 2001: Folkbiology doesn't Come from Folkpsychology: Evidence from Yukatek Maya in Cross-Cultural Perspective. *Journal of Cognition and Culture*, 1, 3-42.

Bateson, P. 1991: Are there principles of behavioural development? In P. Bateson (ed), *The Development and Integration of Behaviour: Essays in honour of Robert Hinde*. Cambridge: Cambridge University Press.

Bateson, P., and P. Martin. 1999: *Design for a Life: How behavior and personality develop*. London: Jonathan Cape.

Berlin, B. 1992: *Ethnobiological Classification*. Princeton, NJ: Princeton University Press.

Berlin, B., D. Breedlove, and P. Raven. 1973: General principles of classification and nomenclature in folk biology. *American Anthropologist*, 74, 214-242.

Boyd, R. 1991: Realism, anti-foundationalism and the enthusiasm for natural kinds. *Philosophical Studies*, 61, 127-148.

Browne, D. 2007. *Konrad Lorenz on Instinct and Phylogenetic Information* [Electronic Journal]. The Rutherford Journal: The New Zealand Journal for the History and Philosophy of Science and Technology 2005 [cited 23rd March 2007]. Available from http://www.rutherfordjournal.org/article010104.html.

Carey, S. 1985: *Conceptual Change in Childhood*. Cambridge, Mass.: MIT Press.

Clement, J. 1983: A conceptual model discussed by Galileo and used intuitively by physics student. In D. Gentner and A. L. Stevens (ed), *Mental Models*. Hillsdale, NJ: Erlbaum.

Cohen, J. 1992: A power primer. *Psychological Bulletin*, 112, 155-159.

Darwin, C. 1872: *The Expressions of Emotions in Man & Animals*. 1st ed. New York: Philosophical Library.

Deacon, T. W. 1997: *The Symbolic Species: The Coevolution of Language and the Brain*. New York: W.W. Norton.

Gelman, S. 2003: *The Essential Child: Origins of Essentialism in Everyday Thought*. New York: Oxford University Press.

Gelman, S., and H. Wellman. 1991: Insides and essences: early understandings of the non-obvious. *Cognition*, 38, 213-244.

Gelman, S. A., and L. A. Hirschfeld. 1999: How Biological is Essentialism? In D. L. Medin and S. Atran (ed), *Folkbiology*. Cambridge, Mass.: MIT Press.

Glasgow, J. M. 2003: On the new biology of race. *The Journal of Philosophy*, 9, 456-.

Griffiths, P. E. 2002: What is Innateness? *The Monist*, 85, 70-85.

Griffiths, P. E. 2006: The Baldwin Effect and Genetic Assimilation: Contrasting explanatory foci and gene concepts in two approaches to an evolutionary process. In P. Carruthers, S. Laurence and S. Stich (ed), *The Innate Mind: Culture and Cognition*. Oxford: Oxford University Press.

Harvey, W. 1989: *The Works of William Harvey*. Translated by R. Willis. Edited by A. P. Fishman, *Classics in Medicine and Biology*. Philadelphia: University of Pennsylvania Press.

Hinde, R. A. 1968: Dichotomies in the study of development. In J. M. Thoday and A. S. Parkes (ed), *Genetic and environmental influences on behaviour*. New York: Plenum.

Inagaki, K., and G. Hatano. 2006: Young children's conception of the biological world. *Current Directions in Psychological Science*, 15, 177-181.

Jukes, T. H., and J. L. King. 1975: Evolutionary loss of ascorbic acid synthesizing ability. *Journal of Human Evolution*, 4, 85-88.

Keil, F. C. 1989: *Concepts, Kinds and Cognitive Development*. Cambridge, Mass.: Bradford Books/MIT Press.

Kelemen, D. 1999: Functions, goals and intentions: Children's teleological reasoning about objects. *Trends in Cognitive Sciences*, 12, 461- 468.

Kelemen, D. 2004: Are children "intuitive theists"? Reasoning about purpose and design in nature. *Psychological Science*, 15, 295-301.

Khalidi, M. A. 2002: Nature and Nurture in Cognition. *British Journal for the Philosophy of Science*, 53, 251-272.

Khalidi, M. A. 2007: Innate cognitive capacities. *Mind & Language*, 22, 92-115.

Kitcher, P. 1999: Race, ethnicity, biology, culture. In L. Harris (ed), *Racism*. Amherst, NY: Humanity.

Lehrman, D. S. 1953: Critique of Konrad Lorenz's theory of instinctive behavior. *Quarterly Review of Biology*, 28 (4), 337-363.

Mallon, R., and J. Weinberg. 2006: Innateness as closed-process invariantism. *Philosophy of Science*, 73, 323-344.

Mameli, M., and P. Bateson. 2006: Innateness and the sciences. *Biology and Philosophy*, 22, 155-188.

Marler, P. 2004: Science and birdsong: the good old days. In P. Marler and H. Slabbekorn (ed), *Nature's Music: The Science of Birdsong*. Dordrecht and London: Elsevier.

Marler, P., and H. Slabbekorn, eds. 2004: *Nature's Music: The Science of Birdsong*. San Diego and London: Elsevier.

McCloskey, M. 1983: Intuitive physics. *Scientific American*, 248, 122-130.

Medin, D., and S. Atran. 2004: The native mind: Biological categorization and reasoning in development and across cultures. *Psychological Review*, 111, 960-983.

Medin, D., and S. Atran, eds. 1999: *Folk Biology*. Cambridge MA: MIT Press.

Medin, D. L., and A. Ortony. 1989: Psychological essentialism. In S. Vosniadou and A. Ortony (ed), *Similarity and anological reasoning*. Cambridge: Cambridge University Press.

Michel, G. F., and C. L. Moore. 1995: *Developmental Psychobiology: An interdisciplinary science*. Cambridge, MA: MIT Press.

Moore, C. L. 1984: Maternal contributions to the development of masculine sexual behavior in laboratory rats. *Developmental Psychobiology*, 17, 346-356.

Moore, C. L. 1992: The role of maternal stimulation in the development of sexual behavior and its neural basis. *Annals of the New York Academy of Sciences*, 662, 160-177.

Osherson, D., E. Smith, O. Wilkie, A. Lopez, and E. Shafir. 1990: Category-based induction. *Psychological Review*, 97, 85-100.

Rips, L. J. 1989: Similarity, typicality, and categorization. In S. Vosniadou and A. Ortony (ed), *Similarity and Analogical Reasoning*. Cambridge: Cambridge University Press.

Rips, L. J. 2001: Necessity and natural categories. *Psychological Bulletin*, 127, 827-852.

Samuels, R. 2002: Nativism in Cognitive Science. *Mind and Language*, 17 (3), 233–265.

Sousa, P., S. Atran, and D. Medin. 2002: Essentialism and folkbiology: Further evidence from Brazil. *Journal of Cognition and Culture*, 2, 195-223.

Stich, S. P. 1975: The idea of innateness. In S. P. Stich (ed), *Innate Ideas*. Los Angeles: University of California Press.

Strevens, M. 2000: The naive aspect of essentialist theories. *Cognition*, 74, 149-175.

Tinbergen, N. 1963: On the aims and methods of ethology. *Zietschrift für Tierpsychologie*, 20, 410-433.

West, M. J., and A. P. King. 1987: Settling nature and nurture into an ontogenetic niche. *Developmental Psychobiology*, 20, 549-562.

Word count: 10,563