

# INNATENESS

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As Paul Griffiths [2002] puts it, “innateness” is associated with different clusters of related ideas where each cluster depends on different historical, cultural and intellectual contexts. In psychology innateness is typically opposed to learning while the biological opposite of innate is ‘acquired’. ‘Acquired’ and ‘learned’ have different extensions. Learning is one way to acquire a character but there are others. Cuts and scratches are unlearned yet acquired; if we could acquire languages by popping a pill, then languages would be unlearned yet acquired according to the wide biological application of the term [Sober, 1998]. Further, in psychology and philosophy innateness is often associated with both “universality” (or species-specificity), and, relatedely, innate traits are often thought to be “fixed” or “unmodifiable”. But, biologists recognize a range of developmental patterns that a specific trait may take. Some are universal, but others are not, as in the case of innate diseases. Some are “fixed” in the sense that once we develop them we have them for the rest of our lives; some innate diseases are like this, but others, are modifiable. Sober [1998] cites a case of an Egyptian vulture that when first confronted with an ostrich egg and a stone, will break the egg with the stone, but if the vulture repeatedly comes to find broken eggs to be empty, it will eventually stop breaking eggs. These examples lend support to Griffiths’s thesis, since the concept of innateness in psychology appears to be in several ways distinct from the concept of innateness in biology.

By Griffiths’s lights a reasonable conclusion to be drawn from the different meanings of “innate” is that an attempt to provide an account of innateness that crosses distinct disciplinary contexts is bound to conflate distinct biological properties and hence produce a confusing and unhelpful notion. He proposes that for each distinct context “innate” should be replaced with a term that more precisely identifies the relevant biological feature in question: “If a trait is found in all healthy individuals or is pancultural, then say so. If it has an adaptive-historical explanation, then say that” (p. 82). Griffiths’s proposal has the further benefit of relieving the disciplines from invoking the “folk” concept of innateness which carries with it a false metaphysic of essentialism that Griffiths says misdescribes the identity relations in the biological world (p. 72).

Yet contrary to the spirit of Griffiths’s proposal, in psychology and biology there is a strategy, let us call “biologizing the mind”, that, roughly, subsumes psychological concepts under biological models. As a broad strategy, biologizing the mind has been quite successful. Jerry Fodor and Noam Chomsky are two well-known practitioners. Specifically on biologizing innateness, Fodor writes: “Skin

color really is largely innate... much as everyone had hazily supposed. Likewise birdsong in a lot of cases; likewise the Babinsky Reflex. And it seems unlikely that the notion of innateness according to which such claims are true will prove dispensable for the larger purposes of biology" [Fodor, 2001]. Chomsky writes, "... let us consider the problem of designing a model of language acquisition... The problem is quite analogous to the problem of studying the innate principles that make it possible for a bird to acquire the knowledge that expresses itself in nest-building or in song-production" [Chomsky, 1966]. And again,

In modern terms, that means restructuring Platonic 'remembrance' in terms of the genetic endowment, which specifies the initial state of the language faculty, much as it determines that we will grow arms not wings, undergo sexual maturation at a certain stage of growth if external conditions such as nutritional level permit this internally directed maturational process to take place, and so on [Chomsky, 1993, 519].

Both Chomsky and Fodor have clearly staked a claim in a practice that Griffiths deems unhelpful, to define the psychologist's concept of innateness in biological terms. In this essay I further explore this option. My contention with Griffiths is that it is not always true that defining a concept of innateness that crosses distinct disciplinary boundaries produces a confusing and unhelpful notion. In the case of cognitive linguistics a biologically grounded conception of innateness turns out to be extremely helpful in clarifying Chomsky's thesis that Universal Grammar is innate and particular languages are triggered rather than learned from the linguistic cues children are exposed to. Contending Griffiths's thesis in this way serves as a foil to the broader task assigned to the essays in this handbook. I will survey several biological accounts of innateness and its related concept, "triggering". I will defend a relational concept of innateness whereby innate traits are defined within a particular environmental range and refer to canalized developmental pathways. I will further argue that "triggered" traits are traits whose canalized development is initialized by a particular environmental cue.

#### INNATENESS AS GROWTH

Chomsky's biologicizing extends to his theory of language acquisition where, he thinks, children quite literally 'grow' languages:

'Language learning is not really something that the child does; it is something that happens to the child placed in an appropriate environment, much as the child's body grows and matures in a predetermined way when provided with appropriate nutrition and environmental stimulation' (p. 520).

Perhaps ascribing a character to 'growth' is all that is required to underwrite the biological concept of innate. The opposite of growth, then, is what appears by a non-growth process. On this view we could read Chomsky's work on language acquisition as suggesting that innateness refers to what grows as opposed to what is learned.

The rejection of learning models of language acquisition in favor of a growth model is the paradigm of the "biologicizing the mind" movement, but, in the context of the paradigm, an account of innateness that distinguishes growth from non-growth is unilluminating in roughly the same way that the gene/environment dichotomy has been. It is a near truism of development that every case of trait growth involves both genes and environments; genes alone or environments alone produce nothing [Lewontin, 2000]. If innateness refers to what the genes do alone then nothing is innate. Likewise, all traits grow. If we ascribe innateness to things that grow then every growing thing is innate. In all these cases we beg the further question—what sort of growth is involved? To illustrate the point, consider three different ways songbirds might develop their species-specific song (adopted from Sober [1998], who in turn cites Gould and Marler [1991]). Type 1 songbirds produce their characteristic song even if the bird is reared in silence. Type 2 birds produce their song only after sessions of call and response with a 'tutor': they attempt to mimic the song of any tutor even if the tutor happens to be a member of another species. As for Type 3 songbirds, all that is required to produce their song is contact with some song or other. They do not require a tutoring period; they require only exposure to some song. They will not respond to silence. Songs from other species or even other bird-like songs suffice to "trigger" their song capabilities. Presumably, computer generated songs suffice. Although it makes no philosophical difference to our example it might be more biologically realistic to add that Type 3 songbirds acquire their song in this unusual manner only within a 'critical' period of development. (A more realistic example will be given later — for now I seek a stark contrast afforded by the semi-fictional example). All three types of birdsong involve growth. If innateness means growth rather than non-growth, then innateness ascriptions will fail to pick out interesting differences between the three types of birdsong development. As a reasonable first approximation we would likely attribute "innateness" to Type 1 but not Type 2 or Type 3 songbirds since the latter two require an auditory cue for their development. But, there is a significant difference in auditory requirements between Type 2 and 3 songbirds. Invoking Chomsky's "poverty of stimulus" argument, the contact call is too impoverished to explain how Type 3 songbirds come to develop their song.

Songbird types	How species-specific song is produced
Type 1	In silence
Type 2	Requires extended call and response tutoring
Type 3	Silence is not sufficient, tutoring not necessary; all that is required is contact to some auditory cue or other

We can critique Samuels's [2002] account of innateness on similar grounds. He avers that innateness in psychology is a psychological primitive: it refers to a character whose origins are explained by biology rather than psychology. I agree that shifting the explanatory burden to biology captures the spirit of the "biologizing the mind" movement in the cognitive sciences. Yet, as a theory of innateness, Samuels's proposal is incomplete. Perhaps (and just for the sake of argument — I think Samuels's proposal is no different than the one aforementioned proposal by Chomsky) Samuels's account could capture the difference between Type 1 and Type 2 songbirds since Type 2 (appears) to learn its song while Type 1 appears to grow it; hence we would ascribe "innateness" to Type 1 and withhold it from Type 2. But since the difference between Type 1 and Type 3 is presumably explained fully within biology rather than cutting across the psychology/biological domains, Samuels's account would ascribe "innateness" to both of them despite their developmental differences. So, Samuels's account of innateness is too weak. It fails to capture the stark contrasts in types of growth as illustrated by the birdsong example.

I propose that an appropriate account of biological innateness that applies to our psychological terms ought to be grounded in *developmental* biology, not just biology *simpliciter*. The intuition seems to comport with standard and traditional practice. What drives our interest in Plato's slave boy is that his geometric abilities seem to be something he has "in" him as opposed to being acquired by some outside influence. What distinguishes the three types of birdsong development is how they react to specific environmental cues. Yet, as I implied when I pointed out the shortcomings of the gene/environment dichotomy, if an appropriate account of innateness is to be appropriately grounded in development, there are certain facts from developmental biology that ought to be attended. Just as no trait is the product of genes alone, no system can develop without the inclusion of *some* environmental input. Type 1 songbirds, just like Plato's slave boy, require some environmental cues. Language learning, as the Chomsky quote above indicates, requires 'appropriate nutrition and environmental stimulation'. Place humans or songbirds naked on Mars and they will not develop, *period*.

So, if we want to determine whether a character is innate or acquired we ought not ask whether it develops independently of environmental interactions, *period*. But, we can ask a different question, *what difference does the presence or absence of certain environmental factors have on development of the trait in question?* Or, we can ask a qualitative question: what difference does fluctuating amounts of an environmental factor have on development? The second question is related to the first. If fluctuations of a certain environmental factor makes no difference to development it might be because the factor is unnecessary for development. Then again, it may be because we have not tested environmental fluctuations extreme enough to register a developmental change. Nonetheless, the lesson is the same in both cases: if we constrain our innateness ascriptions to indicate what the environment does not do to influence development then instead of uttering either biological truisms or falsehoods we might pick out interesting differences in the way

traits grow. Of course it is crucial that we pick out the right environmental factors, those that exhibit *differences* in growth patterns. We get a range of different answers when we ask what difference auditory cues make to the development of birdsong: from "nothing", as in Type 1 birdsong to an auditory cue, to "the developmental pathway is particularly sensitive to auditory inputs", as in Type 2 birdsong. In-between are developmental pathways, like Type 3 whereby the duration of the tutoring period makes no difference to the outcome — Type 3 birds' development is robust as long as it is exposed or "triggered" to some cue or other.

What is the consequence of the truism of development, that no trait develops by genes alone or environment alone, on the common folk practice of treating the innate/acquired distinction as an absolute dichotomy? One consequence supports Griffiths's eliminativism: the truism demonstrates the inadequacy of the innate/acquired (or innate/learned) dichotomy so we should urge a change in the folk's terminology, in this case, replace the absolute dichotomy, with a more nuanced distinction regarding the degree to which a trait responds to specific cues. I favor another approach. Rather than eliminating folk usage we ought to clarify it. Perhaps innateness is dichotomously opposed to acquired in roughly the same way that a warehouse might be said to be "empty" despite it containing light bulbs and molecules. Here I am employing Dretske's conception of "relative absolutes" [Dretske, 1981]. The empty/non-empty distinction, like the innate/acquired distinction serves the pragmatic aim of picking out relative differences. Accordingly, what counts for assessing the emptiness of a warehouse might not count for assessing the emptiness of my pocket, a park, or a stadium. In each of these cases "empty" applies *relatively*. That is, the emptiness of a warehouse is relative to a certain standard, i.e., devoid of all relevant things. Likewise the innateness of Type 1 birdsong is relative to a certain set of auditory conditions as indicated in the contrast to other types of birdsong. What counts for innateness for traits in distinct environmental circumstances depends in each case on the contrast at issue. Nevertheless, for the pragmatic aim of picking out real developmental differences between organisms, innateness is dichotomously opposed to acquired in the same way that "empty" is dichotomously opposed to "non-empty": it picks out a relatively absolute term.

I have just introduced a pragmatic consideration here. Let me clarify. I am claiming that the innate/acquired distinction serves the explanatory role of picking out developmental differences between organisms (whether they be distinct types or individuals). This is consistent with my earlier claim that we cannot, on pain of a developmental truism, distinguish innate/acquired without specifying an environmental context. At this point, one might wonder, what is the value of distinguishing the three types of birds in terms of innateness/triggering/acquired? Some critics have pointed out (e.g., [Bateson and Mameli, forthcoming]) that innate ascriptions are dispensable in the light of a deep causal analysis of the developmental processes that each bird undergoes. I agree. If the question is 'how do these birds acquire their song?' then we ought to prefer a detailed causal story

rather than a rough innate/triggered/acquired distinction. But, to sometimes prefer a detailed causal story is not to undermine the value of innateness ascriptions that identify distinct developmental patterns. For instance, it is important to determine the exact nature of Type 3's trigger (a specific cue? a specific tone?) for the sake of fully explaining how Type 3 birdsong develops. But the exact nature of the trigger is not important for the sake of distinguishing Type 2 songbirds from the others (unless more information about the environmental trigger reveals that it contains a richer set of information from which growth may be sensitive).<sup>1</sup>

To put innate ascriptions in their place, that is, to recognize their explanatory value has a limit, it is not sufficient to dismiss the explanatory value of innate-ascriptions all together. Recently the BBC reported (May 15, 2005)<sup>2</sup> on a series of experiments on canaries that reveal a remarkable pattern. Typically canaries learn their song by copying adults; the tutoring process can take up to eight months. By simulating the tutoring period the experimenters managed to teach canaries to mimic non-canary computer generated songs. Yet, when injected with testosterone (simulating breeding conditions) the canaries dropped all of their learned songs and started singing *traditional* canary songs. Equally surprising, canaries that were raised without tutors sang their traditional songs when injected. The BBC report concludes:

“counter-intuitively, although they spend a long time labouring over new songs, listening carefully, imitating and perfecting, young canaries do not actually seem to need it. Once adult, they can sing just fine without it. ‘We don’t have a full answer for this,’ Professor Gardner told the BBC News Website”.

Notice that the investigators are surprised that canary song development involves a variety of developmental patterns depending on environmental circumstances. Yet, they are even more surprised that some canaries can trigger their song from testosterone! How do they acquire *song* from such an informationally impoverished cue? Contrast triggered song development with the more ordinary developmental pattern — learning their song from a tutor. The upshot is that the discoveries of the distinctive developmental patterns that can be described in terms of “innate/acquired/triggered” is *newsworthy*. That is not to say that the investigation has ended. On the contrary, the discovery warrants further investigation of the developmental (and maybe even evolutionary) causes of the triggering phenomenon as Gardner, the lead investigator, points out.<sup>3</sup> Yet as a description of the phenomena to be explained innateness and triggering ascriptions are useful. They need not be misleading or wrongheaded as Griffiths insists.

<sup>1</sup> The debate between Chomsky and his non-innatist critics turns on the nature of the children's linguistic cues, are they mere triggers or are they rich enough to learn from?

<sup>2</sup> The report can be found at this website: <http://news.bbc.co.uk/go/1/hi/fr/-/2/hi/science/nature/4544777.stm>. I thank Elliott Sober for bringing the article to my attention.

<sup>3</sup> [Gardner *et. al.*, 2005].

In this sense innate ascriptions serve a similar explanatory role as do fitness ascriptions in evolutionary biology. If we seek causes of a particular evolutionary event, say, why a population of fruitflies evolved a fuzzy thorax, then the causal details will provide a deeper explanation than an explanation that employs the fact that those flies with fuzzier thoraxes enjoyed a higher relative reproductive rate than their variants. But it does not follow that fitness explanations have no explanatory value. They serve well to describe evolutionary patterns. Further, some commentators claim that fitness explanations unify disparate evolutionary phenomena under one description [Sober, 2000; Ariew, 1996]. You do not achieve that sort of unity by citing causal details since the causal details underlying the evolution of fuzzy thoraxes are completely distinct from the causal details underlying the evolution of Saguaro cacti (for more on fitness and unifying explanations, see [Ariew, 2003]). Perhaps the same can be said about the use of the concept of innate in the cognitive sciences. In some explanatory contexts we should prefer a detailed causal story, in others, such as the case of the difference between the three sorts of developmental patterns exhibited in the bird case, we ought to prefer the blunt distinction that the “innateness”/“triggered”/“acquired” labels provide.

#### CHOMSKY'S POVERTY OF STIMULUS

There is a notable resemblance between Type 3 birdsong and the development of specific grammar rules in human children. All come to acquire their rich linguistic abilities despite the poor quality and quantity of the linguistic cues they receive from their linguistic communities. As I mentioned earlier, Chomsky calls the phenomenon the “poverty of stimulus” or “POS”. For children, the cues are impoverished in at least two ways. First, children are exposed to a limited amount of grammar (yet their grammatical abilities are seemingly infinite). Second, the linguistic data to which a child is exposed contains errors without any indication of what distinguishes ‘proper’ from ‘improper’ grammar. The result is that any theory that postulates that a child's ability to acquire language is directly proportional to the amount of language he or she hears, e.g. a learning theory, is false.

The case of ‘Simon’, a child born deaf but raised by hearing parents provides a good example of POS among humans. Simon's parents had a poor grasp of the grammatical rules associated with American Sign Language (ASL) since they had to learn ASL relatively quickly once they found out about their child's condition. Despite Simon's early exposure to ASL being imperfect and crude, remarkably, Simon's own abilities to sign in ASL developed nearly ‘normally’ [Pinker, 1994, 39]. Even in the degraded linguistic environment whereby Simon's parents violated basic ASL grammatical rules, Simon was able to develop the ‘correct’ grammatical rules. The case of Simon demonstrates that despite exposure to significantly different samples of data, different children in the same linguistic community end up adopting essentially the same linguistic intuitions. Thus, it is plausible to suppose along with Chomsky that they innately possess essentially the same grammar

(more specifically, innate in the context of language cues in the environment of the learner).

Over the years, Chomsky has provided alternative theories of language acquisition that accounts for the POS phenomenon. The latest is most interesting for our purposes. Accordingly, children grow a language by utilizing an 'innate' grammar module, a 'Language Acquisition Device' (or 'LAD') that encapsulates all the possible grammar principles (a.k.a. 'universal grammar') against particular linguistic cues. Rather than learning from those cues, the cues set a 'switch' in a child's mind that leads to the adoption of the particular language of her community. Chomsky's description of the function of the 'switchbox' is worth quoting in full:

'The initial state of the language faculty consists of a collection of subsystems or modules... each of which is based on certain general principles. Many of these principles admit of a certain limited possibility of variation. We may think of the system as a complex network associated with a switch box that contains a finite number of switches. The network is invariant but each switch can be in one of several positions, perhaps two: on or off. But when the switches are set in one of the permissible ways, the system functions, yielding the entire infinite array of interpretations of linguistic expression' [Chomsky, 1993].

Distinguish between the development of LADs and the development of particular languages. Chomsky asserts that LADs are innate: every child has the network of switches available to them by the time they encounter linguistic cues. Loosely, the development of the LAD is like the development of Type 1 birdsong. Both develop independently of any linguistic cue. But, the development of specific grammar rules, like the development of Type 3 birdsong, is "triggered". While linguistic cues are required for their development, the cues are too impoverished to explain how the birds develop their full-blown song from them. Likewise it seems to Chomsky that the linguistic cues help set the switches from which specific grammar rules develop without the further need of linguistic output.

For an example of how linguistic cues trigger grammar growth, consider that in English, nouns, verbs, adjectives, and prepositions precede their objects. The opposite is true for Japanese. English is called a 'head-first' language, while Japanese is 'head-last'. According to Chomsky [1993, 529] simple sentences can sufficiently set the switch for children. The sentence 'JOHN ATE AN APPLE' may suffice to set the switch for English (as a head-first language), and the equivalent to 'JOHN AN APPLE ATE' sets the switch for Japanese. Chomsky concludes, "To acquire a language, the child's mind must determine how the switches are set, and simple data must suffice to determine the switch settings, as in this case" (p. 529).

Undoubtedly the analogy between linguistic and songbird development is limited. For one, Type 3 birds develop their song despite exposure to cues from birds of different species, while development of a particular language requires that the cues of the linguistic community are specific to that language. But the point of

ascribing innate/acquired to a trait is to provide a rough distinction between distinct developmental pathways. The difference concerns how the developing system reacts, in this case, to specific environmental cues, and in other cases, to amounts and quality of environmental cues. In this respect Type 3 songbirds and language development on Chomsky's theory are similar in that neither could, in the face of the POS, learn their cues from the environmental inputs. Put in another way, Chomsky's POS argument seems to be that a "triggering" model of language growth (like Type 3 birdsong) better predicts child development given the POS than a learning model (like Type 1 birdsong).

To sum up so far: I began the discussion of birdsong, language development, and POS with a statement of what, from a developmental biological point of view, could possibly ground the distinction between "innate" and "acquired". I suggested that the distinction depends on what certain environmental cues can or cannot do to effect growth of the trait in question. Auditory cues have no effect on the development of Type 1 birdsong, yet, in contrast, species-specific auditory cues are required for development of Type 2 birdsong. Type 3 songs require some auditory cue but the effect of the cue does not serve (as it does for Type 2 birdsong) to shape the end state. Rather, in the case of Type 3 songbirds the auditory cue serves as a "trigger". If Chomsky is right, we have a similar situation for language development. The development of LAD does not depend on linguistic cues while the development of specific grammar rules require some set of rather specific cues. Yet, in the face of POS, the cues appear to serve as a "trigger" to set switches of an LAD switchbox rather than as a source from which the languages are shaped or "learned".

#### CANALIZATION AND THE EPIGENETIC LANDSCAPE

Next, we need a general account in biology that adequately captures the following intuitions: a) that innateness means more than unlearned, b) that a biological conception refers to biological development, and c) an adequate account captures relevant developmental differences between traits that get their trait independent of linguistic cues (like type 1, and LAD) and those that require some linguistic cue or other, whereby the cue is too impoverished to explain the output (like Simon, type 3 and the head first/head last grammar rules).

Elliott's Sober's proposal [1998, 795] is a good start. "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". In short, innateness amounts to phenotypic invariance across a range of environmental conditions. If what I've argued earlier is correct, that innate ascriptions on the biological model should indicate what the environment can or cannot do to affect the development of a trait, then Sober's invariant account is on the right track. In the context of auditory cues, Type 1 birdsong capabilities are more invariant than Type 2 or Type 3 birdsong, because Type 1 birdsong emerges in an extra environment, where auditory cues are absent. The type that develops the trait in the absence of the condition in the environment

would be said to be more invariant, and, on Sober's account, more innate.

Three related problems emerge from Sober's account. First, Sober's account leaves open the question how does one distinguish the ranges of environmental variation that are relevant to assess the innateness of a trait and the ranges that are not? Some take this to be a serious shortcoming [Mameli and Bateson, 2005; Cowie, 1998; Prinz, 2002]. Every developing trait will be sensitive to some environmental variation and insensitive to others, hence, a consequence of Sober's account is that a trait is innate with respect to some environmental conditions and non-innate with respect to others. Sober admits this *lacunae*, though he questions whether there is a uniquely correct answer to what counts as the appropriate environmental range. He avers, "maybe the range is determined pragmatically. It is difficult to see how the latter conclusion can be evaded" (p. 795). Yet, there is a sense in which despite the pragmatic or explanatory aims, certain environmental conditions distinguish real developmental differences. Let me say more here. I have argued that innate ascriptions in biology serve to distinguish between how various developmental systems react to specific environmental cues. The difference between the three types of birdsong is determined by how they react to auditory cues. Further, as the canary example illustrates, individuals possess a variety of potential developmental outcomes. When canaries contain some level below a threshold of testosterone in their systems their song development requires a tutoring period. But, when the need to procreate becomes urgent (when testosterone levels are above the threshold) the same canaries develop their song without the need for a tutoring period. The lesson learned here is that there are real developmental differences between organisms and even contingently within organisms with respect to how they will react to certain environmental cues. Ever since the work of C. H. Waddington in the 1950s, developmental biologists have recognized that context dependency is an important feature of developmental systems. A developmental system responds to certain environmental cues by changing its expression patterns. Waddington called this the phenomenon of the "reactive genome". In the contemporary literature the phenomenon is termed "tertiary induction" [Gilbert, 2004, 350]. If picking out these real differences is the point of innate ascriptions, then perhaps there is a principled answer to the question what counts as an appropriate environmental range, namely, the ranges in which the expression patterns become insensitive to environmental perturbations, like in the case of testosterone induced canaries, or Type 1 songbirds. Waddington called the process of buffering against environmental cues "canalization". Perhaps we should amend Sober's account accordingly and identify innateness with canalization [Ariew, 1996; 1999].

The canalization amendment is significant for another reason, it solves a second problem with Sober's account. 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. Yet, Sober's account fails to recognize the difference (the following is from

[Ariew, 1999]). For example, consider the intestinal bacterium, *clostridium difficile* (*c. diff.*), that we humans invariably acquire in the food and drink we consume (the example comes from [Wendler, 1996]). *C. diff.* is invariantly acquired, that is, it emerges in all of a range of human environments. Hence, on Sober's account the presence of *c. diff.* is innate. But its invariance is due to a specific environmental condition that is everywhere humans are since it is present in the food and water that humans drink. Hence, intuitively, *c. diff.* is acquired, not innate. Note, the appropriate environmental range that picks out the difference is only conceptually possible, the environment where humans develop without food or water. If human stomachs contained *c. diff.* in environments where no *c. diff.* is present then likely humans have a canalized developmental pathways to insure its presence in the stomach. If the idea that *c. diff.* development is canalized sounds too improbable, think about Type 1 songbirds developing — the lesson is the same — the fact that their song develops independent of auditory cues suggest that Type 1 birds song development is canalized or buffered against the absence or presence of auditory cues.

Samuels [2002] offers a cognitive example that serves to illustrate the same ambiguity of invariance accounts. Presumably the belief 'water is wet' is learned from our interaction with water. But, since water is everywhere humans are the belief emerges invariably in human environments. Samuels believes his counterexample warrants a rejection of all developmental invariance accounts. Yet, on the face of it, canalization picks out the appropriate distinction and properly identifies innateness with development that is independent of the environmental cue in question (see [Collins, 2004] for further discussion).

Canalization appeases a third worry I have of Sober's invariance account. Consider the three birds again. On the invariance account the difference between the birds is depicted merely as a matter of degree depending on the number of environments where song emerges. On the one end of the continuum (towards "more innate") is Type 1 birdsong, Type 2 is at the other end, and Type 3 is somewhere in the middle. Given that the three birds are being compared in a common environment, Type 3 songbirds are not just a matter of degree distinct, they are distinct in *kind*.<sup>4</sup> While unlike Type 1, Type 3 songbirds *require* an auditory cue. Yet, the nature of the relationship between the developmental system and the auditory cue is wholly unlike that of Type 2 songbirds. Type 3 as opposed to Type 2 birdsong exemplifies the POS since Type 3 are able to exhibit their species-specific song even when the auditory cue is so degraded that it could not possibly learn from it. On my view, the concept of canalization, and its related concept, the "epigenetic landscape" accounts for the relevant differences: Type 1 song development is canalized, Type 2 is not, Type 3's canalized development is "triggered" or on some auditory cue or other. To fill out the idea, let me give some background information on canalization and the epigenetic landscape from which the concept of canalization is drawn.

<sup>4</sup>In what follows I depart a bit from Ariew [1996; 1999] where canalization is merely a matter of degree.

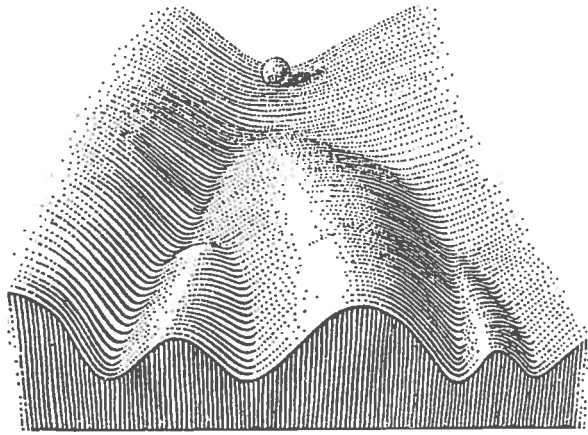


Figure 1. (taken from [Waddington, 1957])

C. H. Waddington introduced canalization to the developmental biology literature in the 1950s as a feature of his simple model of development, called the 'epigenetic landscape' (see especially Waddington [1957]). Waddington was motivated to explain a peculiar feature of development experienced by vast number of species: individuals tend to develop into one of a few distinct body types despite the great environmental and genetic variation between them.

In Figure 1, the ball represents a developmental system at some stage. The branching system of 'canals' (or Waddington's term, 'creodes') represent possible pathways the system might encounter within an environmental range. Depending on some number of environmental or genetic factors, the developmental system will be 'nudged' down one or another 'canal'. The depth of the canals represent the degree to which the development of the end state is hard to change, disrupt or impair in the face of further genetic or environmental perturbations. Once the system reacts to the initiating cue the development of the end state is more or less 'fated', barring extreme environmental conditions.

There are two sorts of canalization: the degree to which a system is so buffered against *genetic* perturbations is the degree to which it is 'genetically canalized'. The degree to which a system is so buffered against *environmental* perturbation is the degree to which it is 'environmentally canalized' (for more details see [Waddington, 1957]). For our purposes, since innateness is meant to reflect what the environment does not do to effect development of the end state, I propose innateness is associated with environmental and not genetic canalization. From here on out when I say "canalization" I am referring to "environmental canalization".

Looking at the epigenetic landscape in Figure 1 there appears two ways to characterize the extent to which a system is canalized. A developmental system

may be canalized to a greater degree if it produces its end state across a greater environmental range than the other. That is, one trait is more canalized than another if the one is more developmentally invariant than the other. It is this sense of canalization that accounts for the invariance effect that is central to Sober's account of biological innateness. But better than a mere invariance account the effect is grounded in a real developmental pathway.

Canalized systems might also be compared by the degree to which fluctuating environmental conditions affect development of a trait already in a canal or "chreode" (this is represented in Figure 1 by the highness of the canal walls). It is this consideration, how fluctuating environmental conditions affect development that is the extra feature missing in Sober's invariance account. Consider Figure 2:

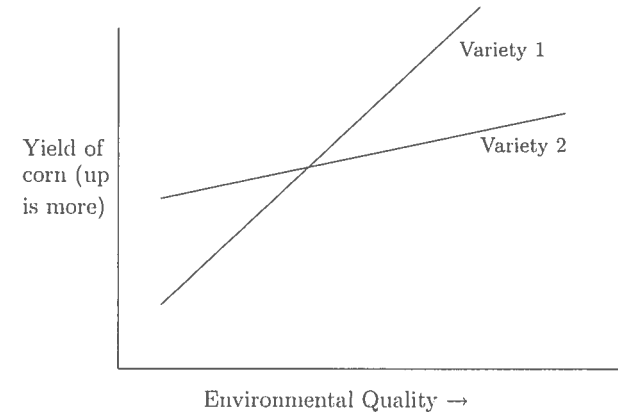


Figure 2.

Variety 2 corn plants produce their yields more robustly than variety 1 corn plants. Variety 2 yields are less sensitive than Variety 1 yields to fluctuations in environmental quality. In this case 'fluctuations' refer to varying conditions *already present* in the environment. Indeed, the factors that determine environmental quality need to be present for any corn plant to grow; no plant will grow without some amount of soil.

The difference between the two varieties of corn plant yields is similar in kind to the difference between Type 2 and 3 birdsong where all *require* an auditory cue while each type reacts differently to the environmental quality (auditory cue). Type 3 songbirds tolerate a larger range of auditory cues, including completely degraded ones. That is why we might be tempted to distinguish the relation between development and the cue in this case as "triggered" growth. In contrast, Type 2 songbirds are sensitive to the quality of the auditory cues. Type 1 songbirds would exhibit a completely flat line since it is insensitive to any amount of fluctuation. Yet what is distinctive about Type 1 songbirds is not represented in the

graph, more than being insensitive to fluctuations, its development is completely independent of auditory cues.

Mameli and Bateson usefully distinguish between “developmental canalization” and “post-developmental canalization”. Accordingly, “a phenotype P is developmentally canalized if an evolved mechanism M exists to ensure that P develops in the face of certain perturbations, and post-developmentally canalized if an evolved mechanism M exists to ensure that P is not modified by the occurrence of certain events after its development is complete” (p. 18). The difference between developmental canalization and post-developmental canalization is another feature of the epigenetic landscape. Some developmental systems are sensitive to environmental cues only during a critical stage of development. According to Chomsky, there is a critical stage for the development of languages. I built a critical period into the description of Type 3 songbirds. The concept that the developmental landscape features forks in the road depending upon certain environmental cues given at crucial stages is an important insight for “eco-devo” a burgeoning field of development. Examples abound: the sex of snapping turtle depends on temperature at the embryo stage, at one temperature the turtle embryo becomes male, at another it becomes female. Ant larvae develop into either sterile workers or fertile queens depending on the diet they are fed (see [Gilbert, 2004]). We wouldn’t want to say that queen development is canalized against diet, since whether a larva will develop into a queen or sterile worker is particularly sensitive to diet. But, once the special diet is fed and all other environmental conditions are held constant, then queen development rolls down a canalized pathway with very high walls on the epigenetic landscape. The distinction comports well with innate ascriptions. The difference between queens and sterile workers is not wholly innate, it would seem, because the diet plays the crucial difference. But ‘acquired’ does not seem to capture the appropriate distinction either. The cue seems too impoverished to explain the radical difference between queens and sterile workers given a particular diet at a particular time. And furthermore, once the special diet is introduced, queens invariantly develop. ‘Acquired’ implies a relationship between larva and diet that would resemble something closer to Variety 1 corn plants — the longer the diet the more likely the larva develops into a queen. Instead the developmental profile of queens is more like Variety 2 corn plants. Once diet is introduced, queen development is robust. We could say that the difference is a matter of degree (as Sober might say), but “canalization that is triggered on diet” seems to capture the innateness intuitions better.

I favorably mentioned Mameli and Bateson’s distinction between “developmental canalization” and “post-developmental canalization” but the difference between Mameli and Bateson’s approach and mine concerns their insistence that innateness refers to evolved canalized mechanisms. Presumably they mean “evolved by natural selection” to indicate a pathway that is advantageous to the individual. I agree with Mameli and Bateson that a virtue of the canalization account of innateness is that it can be assimilated to the idea of natural selection (see also [Ariew, 1996; 1999]). Yet, making adaptation a necessary condition for canalization grounded

innateness is too restrictive. As Mameli and Bateson themselves point out some fitness-detrimental diseases develop along canalized pathways. Yet, since disease development does not evolve for the benefit of the individual victims, Mameli and Bateson think that disease development is a counter-example to the canalization account. But, the counter-example is effective in the context of their *desiderata* that includes as a necessary condition for a trait to be innate that it is the product of natural selection.

I reject the evolutionary *desiderata* on independent grounds. Consider a distinction made famous by Ernst Mayr between proximate causes and ultimate causes whereby the proximate causes explain (among other things) the development of the trait in question. Ultimate causes are cited to explain how developmental systems of the type in question have come to evolve. Presumably, the development patterns of all three songbirds evolved, and perhaps they are all adaptations (evolved by natural selection). Regardless, the most important feature of the distinct birdsong types is best invoked by their proximate causes — each bird presents a distinct sort of developmental pattern. Innate ascriptions pick out those differences. Whether our language abilities are the products of natural selection or not is one question, but it isn’t the relevant question linguists are asking when they want to know what sort of developmental processes are involved when children acquire languages.

Mameli and Bateson were motivated to include “evolution” as a condition for innateness on the canalization model to solve a problem of providing a principled distinction between what counts as the relevant environmental range and what does not (p. 18). Mameli and Bateson think the lack of a principled distinction is a problem for invariance accounts like Sober’s. (They wrongly interpret my 1999 account as an invariance account despite my explanation to the contrary.) What I have been arguing with the disease example is that there ought not be any further condition for a canalized based account of innateness that canalized buffering mechanisms have to benefit the individual.

In summary, let us ask what do we learn about innateness from a developmental point of view? In general Waddington’s concepts provide us with a cluster of related ideas useful for making the appropriate distinctions along the innate/acquired spectrum that can be used to understand innate ascriptions in the cognitive sciences. The discovery that developmental systems have an ability to buffer development against environmental perturbations to ensure the production of an end state suggests that some innate ascriptions in the cognitive science might be biologically grounded. I think much of contemporary cognitive science, especially those moved by the “biologizing the mind” movement, implicitly or explicitly employ the concept of innateness as it relates to canalization or some aspect of the epigenetic landscape, though I have focussed my demonstration on Chomskian linguistics.

On first approximation, the epigenetic landscape describes the relation between the three types of birdsong development. Type 1 birdsong development is highly environmentally canalized across auditory cues, meaning that no linguistic cue or perturbations in the auditory signals would prevent the song from developing. In



fact, the development of Type 1 songs develop independently from any auditory cue. To translate this into an account of innateness, we might say that Type 1 birdsong is innate with respect to auditory cues. Type 2 birdsong is plastic, meaning that its development is not canalized with respect to auditory cues. In comparison, Type 3 birdsong development is contingent upon the presence of auditory cues as some stage of development. The epigenetic fork in the road represents the status of a Type 3 songbird. If an auditory cue is encountered, then its subsequent song development is canalized, otherwise, not. The canary song discussed in the BBC report has an unusual epigenetic landscape because it seems that across a wide range of environmental conditions song development is relatively plastic rather than canalized. But, the introduction of testosterone at any point in the developmental stage is enough to initiate a canalized pathway. Waddington achieved the same result with fruit flies and an unusual environmental condition. Most fruit flies develop one set of wings and a single thorax. But, some when exposed to ether at a crucial stage of development, some flies responded with a second thorax and a second pair of wings. The lesson here is that while across "normal" environmental conditions, some features might be highly canalized, but development might at the same time be sensitive to unusual or specific environmental cues such that their presence is enough to trigger another canalized pathway.

In Cowie's critique of the canalization account of innateness she writes, "the arguments from the poverty of the stimulus nativists use to defend their position do not in fact entail anything about the degree of plasticity possessed by the processes responsible for our acquisition of ideas and beliefs. For the fact that the outputs of learning might be thoroughly underdetermined by the environmental information (as poverty of the stimulus arguments contend) is quite consistent with any amount of plasticity in the learning process itself" (p. 46). Yet, if innateness is canalization as opposed to mere developmental invariance then the developmental response to an environmental trigger does in fact tell us a lot about the degree to which innateness is either innate, triggered, or acquired. Notice, Chomsky's "switchbox" model of grammar adoption dovetails nicely with the epigenetic landscape. The adoption of 'head-first' languages are "triggered" or phenotypically switched by a few linguistic cues. Once the triggering environmental cue is encountered, development of one or the other pathway is relatively unaffected by the presence or absence (or poor quality) of further linguistic cues. Perhaps post-trigger development proceeds independently of linguistic cues. If so, we would say that post-trigger development of 'head-first' or 'head-last' grammar is innate (*simpliciter*) across linguistic cues. Otherwise we would say that it is simply to some degree canalized. Either way, compared to learning models of grammar acquisition Chomsky's switchbox model predicts that the development of specific grammar rules is relatively robust. As evidence by the POS the development of specific grammar rules appears relatively unaffected by fluctuations of quality and quantity of linguistic cues, suggesting that the development of grammar rules is to some degree canalized, though it is not innate since grammar rules require certain linguistic cues.

As Chomsky has pointed out to me, in both cognitive science and biology it is useful as a first approximation to distinguish between a case where what is innate specifies in a significant way the form of the outcome from a case in which what is innate is a particular set of procedures to apply to external inputs without further indication of the outcome. Chomsky takes the former, what he has called "Rationalism" (see [1967]) to be a hallmark of canalization. In this essay I have attempted to associate the concept of innateness in the cognitive sciences, specifically in the literature surrounding Chomsky's theory of language acquisition, with the biological concept of canalization. In the spirit of Griffiths's proposal that innateness is defined loosely around a cluster of biological principles, I have shown how the canalization concept serves as a first approximation to determine differences between developmental pathways, especially on how each might react to a set of environmental cues. I proposed that the innate/acquired dichotomy can be preserved in developmental cases where canalization ensures the development of an end state even when a particular environmental cue is not present. I proposed that "triggered" traits are environmental phenotypic switches that initiate canalized pathways.

Fodor writes: 'A lot of people have Very Strong Feelings about what concepts are allowed to be innate. . . Almost everybody is prepared to allow RED in, and many of the liberal-minded will also let in CAUSE or AGENT. . . But there is, at present, a strong consensus against, as it might be, DOORKNOB or CARBURETTOR. I have no desire to join in this game of pick and choose since, as far as I can tell, it hasn't any rules' [Fodor, 1998, 28]. I hope that I have shown that indeed there are rules.

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