MASSIMO PIATTELLI PALMARINI

# Reflections on Piaget

## Chomsky, Fodor, Epigenetics and the Baldwin Effect

*[Received May 1, 2016 – Accepted December 23, 2017]*

Summarizing the main points of the Royaumont debate between Jean Piaget, Noam Chomsky and several other key participants, several issues are highlighted as being still relevant today. The main focus here is the theory of syntax, the fixation of basic concepts and language acquisition, explaining why some suggestions then made by Piaget, Inhelder, Céllerier and Papert do not stand the evidence and the theoretical developments accumulated since the debate. Piaget's focal interest in epigenetics and the Baldwin effect is critically re-examined in the light of many crucial developments in genetics, epigenetics and the evo-devo revolution. It is stressed that Piaget was right in his critique of canonical neo-Darwinism and that his observations of inherited acquired traits in the mollusk *Lymnea stagnalis* were correct, in spite of perplexities unjustifiably raised by the biologists then participating in the debate (the present author, alas, included). A plea for a better, future post-Darwinian integration between evolution and psychology is offered.
**Keywords:** Baldwin Effect, Basic Concepts, Epigenetics, Innatism, Language Acquisition, Syntax.

### 1. The opening of the debate

In the opening of the Royaumont debate between Jean Piaget and Noam Chomsky that I had the privilege of organizing in October 10-13, 1975 (Piattelli Palmarini, 1994, 1979, 1980)[1] Piaget stresses the following in his introductory paper: there is a central representational capacity (the semiotic function). It develops at around two years of age and it applies to different domains (language being one of them). There is a dynamic psychogenesis, whose working is the focal object of our concern. «The functioning of intelligence alone is hereditary and creates structures only

*Massimo Piattelli Palmarini, University of Arizona, Department of linguistics, Department of psychology and cognitive science program, Tucson, Arizona, 1103 E. University Boulevard, Phone: Phone: 520-626-6913; massimo@email.arizona.edu*

[1] Giorgio Graffi's excellent contribution to this volume is complementary to mine. He also reconstructs the development of some ideas preceding the debate, while I mostly concentrate on follow-ups. There is some overlap between our contributions, which I have tried to minimize, but not eliminate altogether. His biblio references and mine are also largely complementary.


ISSN 1120-3404 ISSNe 2035-357X

through an organization of successive actions performed on objects» (LL, 23)[2]. He pleaded neither for empiricism, nor preformationism, but rather for a dynamic constructivism.

Piaget so had previously described his own work (as reprinted in 1977): «My central aim has always been the search for the mechanisms of biological adaptation and the analysis and epistemological interpretation of that higher form of adaptation which manifests itself as scientific thought» (Piaget, 1977, p. xii). It is to be stressed that, by "adaptation", Piaget meant a complex mental operation, not what that term means in neo-Darwinism. In fact, as his collaborator Guy Cellérier specified during the debate, Piaget had a "gentleman's disagreement" with Darwin. This statement was received by some of us (notably Monod, Jacob, Changeux and myself) with manifest perplexity. I will go back to this issue later on. Piaget had also said: «The essential functions of the mind consist in understanding and in inventing, in other words, in building up structures by structuring reality» (Piaget, 1971, p. 27).

In the opening of the debate, he stressed that the driving force of "cognitive action" (sic) is "assimilation", not "association". Association is passive and unstructured, while assimilation is active, and mediated by the "schemes of the subject". It is a "functional process of integration". These mechanisms are "completely general" and are already visible from birth.

Facts and observations are always conceptualized by the subject. Behaviorism is wrong. «The action of a stimulus presupposes the presence of a scheme, which is the true source of the response» (LL, p. 24).

Piaget offered a «dynamic Kantism» (*verbatim*, in the debate). And added: «There is no genesis without structures, there are no structures without genesis» (LL, p. 150).

There is a continual construction (a psychogenesis), with fixed stages[3]. A logic of actions, then relations of order between actions, then interlocking of schemes, intersections, organization of space, causality. Reversibility and conservation come later. Mathematical concepts are the cornerstones (combinatorial lattices, morphisms, metrics, topological invariants etc.). Each construction is logically and factually necessary to build the subsequent one in the sequence. The structured set of cognitive operations of each stage contains the previous one as a proper subset. We have an epigenesis[4],

[2] Here and in what follows I am citing from the published English translation of Piaget's interventions in the volume and from published translations of his other work.

[3] These four stages are well known: (1) The Sensorimotor Period (birth to 2 years). (2) Pre-Operational Thought (2 to 6/7 years). (3) Concrete Operations (6/7 to 11/12 years). (4) Formal Operations (11/12 to adult).

[4] This notion is central in Piaget's work and it's presently covering a whole domain of inquiry in biology and genetics (References too numerous to list. For a comprehensive advanced textbook see Allis *et al.*, 2007). I will go back to it in what follows. For an analysis of how and

an ascent in the power of the operations. (For example, a set of repeated additions engenders a multiplication).

Piaget's ladder:
The roots of logico-mathematical structures:
Reflective abstraction (abstraction réfléchissante)
Reflected abstraction (abstraction réfléchie)
Operations of a lower level are grouped, thematized, reorganized at a more abstract level, first implicitly, then explicitly. Abstraction and generalization are interdependent.

Insufficiencies, gaps and unsolved problems cry out for completions, re-equilibrations, filling-in at higher level.

Language is an application of the "semiotic function", a specific domain of this function.

## 2. Piaget challenged Chomsky's innatism

If one fails to perceive the roots of these capacities in the vast process of adaptation and self-organization of life in general (and even before life), then one resorts to innatism, and then one has to go all the way down to protozoa. But this is a hopeless task. It makes the evolution of language "inexplicable". Generality wins hands down against species-specificity. Mere chance cannot explain necessity. Innatism is, in turn, based on a more general process: Auto-equilibration.

The forms of equilibration, according to Piaget, are:

(1) Assimilation: Linear velocity and angular velocity are assimilated (common space-time relations in spite of superficial differences).

(2) Sub-systems interlock into super-systems: Compensatory adjustments between partial negations and partial affirmations, between direct and inverse operations, with reciprocities.

(3) builds on (2), but constructs novel global systems. Compensatory steps of integration into a new totality, with enrichment. Cognitive equilibration is "accretive" (*majorante*), with a passage from the exogenous to the endogenous. The biological equivalent is the "phenocopy"[5]. There are, according to Piaget, exact parallels in the history of science.

why epigenesis is so central in Piaget's work, see the exhaustive dissertation by Sara Campanella (2012) and Giorgio Graffi's contribution to this volume.

[5] The French geneticist and Nobelist François Jacob reacted critically to this notion, offering a rather reductive interpretation from biology proper. If you swamp a female embryo with testosterone, then the adult female will resemble a male, you have a phenocopy. I will go back to this later on. For an exhaustive analysis, the reader is suggested to read the very fine dissertation by Sara Campanella (Campanella, 2012) and Giorgio Graffi's contribution to this volume.

## 3. Chomsky's reaction, there and then

«Investigation of the human language has led me to believe that a genetically determined language faculty, one component of the human mind, specifies a certain class of "humanly accessible grammars". Within a given speech-community children with varying experience acquire comparable grammars, vastly underdetermined by the available evidence». This is a formulation of the Poverty of the Stimulus (POS), a notion introduced by Chomsky in the Fifties and already fiercely resisted by philosophers like Nelson Goodman, Willard Quine and Hilary Putnam (see his contribution to the Royaumont proceedings and Chomsky's reply), condemning the "innateness hypothesis", with this meaning the idea that nothing is innate, except maybe Quine's quality space and other extremely simple and organism-independent elements[6].

In later years, POS will be un-persuasively criticized by several authors[7]. Chomsky then added that there are also "performance systems" for putting this knowledge to use. Very little is known about these. «My guess would be that, as in the case of grammars, a fixed, genetically determined system of some sort narrowly constrains the form that they [i.e. the performance systems] can assume» (LL, p. 35).

On Piaget's argument "to the protozoa", Chomsky says that the evolutionary development of language is, no doubt, yet unexplained. But it is not, contrary to Piaget's claim, "inexplicable". Genetic endowment is responsible for the cerebral cortex, the eye, the arms. Protozoa don't have these either, but this does not stop us from attributing these biological traits to genetic determination. Hypotheses about the genetic components of bodily organs are refutable. So are those concerning language. No circularity, no "question-begging".

On "sensorimotor intelligence", Chomsky says that no substantive proposals «offer any hope of accounting for the phenomena of language that demand explanation. Nor is there any initial plausibility to the suggestion, as far as I can see» (LL, p. 101). He then adds that we want to attempt to delimit certain cognitive domains, each governed by an integrated system of principles of some sort. «It is, surely, a legitimate move to take language to be one such domain, though its exact boundaries and relations to other domains remain to be determined» (LL, p. 37). We do that exactly as we would for some organ of the body.

[6] I am grateful to Noam Chomsky for specifying this point (personal communication, January 2017).

[7] See for instance: Chater, Reali, and Christiansen (2009); Perfors, Tenenbaum, and Regier (2006, 2011); Reali and Christiansen (2005). See also footnote 12. For a counter-critique, see Berwick, Chomsky, and Piattelli Palmarini (2013).

On the development of language, Chomsky adds: «If E is the linguistically relevant experience available to a child and Ss the linguistic steady state of the adult of that community, we construct hypotheses on the «function mapping E into Ss» (LL, p. 38).

This function is LT(H, L), the Learning Theory for Humans in the domain of Language. Abstracting away from individual differences, it is «a genetically determined species character». In general, for a species O, and a domain D, we have some LT(O, D) (the recognition of human faces, for instance).

Contra "general learning": These LT(O, D) will be rather different one from the other: «we would hardly expect to discover that there exists something that might be called "general learning theory"». The prospects of such a theory are «no brighter than for a "growth theory" intermediate in level between cellular biology and the study of particular organs, and concerned with the principles that govern the growth of arbitrary organs for arbitrary organisms» (LL, p. 38).

I have to add that Dan Sperber offered the following sharp critique of the very notion of a general semiology. The idea that there can be a general science of signs and symbols is like the idea that there can be a special biology of all and only the protruding parts of the body (the nose, the fingers and what have you). He added that semiotics is a field covering, in the same breath, language and traffic symbols.

Chomsky adds the following: «Call the "initial state" $S_0$. In order to discover $S_0$, the genetically determined initial state, we focus on the properties of E and of Ss, in particular on those of Ss that are not determined by E. Elements of the steady state for which there appears to be no relevant evidence» (LL, p. 39). It's a reasonable conjecture that these are good candidates for $S_0$.

## 4. Chomsky on structural dependence

And then came Chomsky's specific instance of the "structural dependence" of syntactic operations. A straightforward, elementary, didactically efficacious (so it was hoped) example that has been radically misinterpreted later on, illegitimately isolated from a wider context and, allegedly, falsified by some authors (see a detailed account in Berwick, Chomsky and Piattelli Palmarini, 2013). Here it is:

Why are structure-dependent transformations tried out first by the child?

An operation is structure-independent, if it applies to the manifest properties of the words and the word-sequences. For instance, add the suffix -am to all words ending in a, o, or um. Or move the fourth word of the sentence to the front of the sentence.

An operation is structure-dependent if it applies conditionally, depending on some internal, hierarchical property of the architecture of the sentence[8]. For instance, acts on the sister node of an embedded NP.

The "simplest" structure independent hypothesis is not even tried out: Why? Take the formation of interrogatives:

The man is here Þ Is the man here?

Simplest hypothesis: Spot the first appearance of it in the sentence and front it, to form the interrogative.

Counter-example:

The man who is here is tall Þ Is the man who is here tall?

The man who is tall will leave Þ Will the man who is tall leave?

Not

*Is the man who here is tall?

*Is the man who tall will leave?

The formation of interrogatives is a structure dependent rule. How does the child know? The child does not even try the simplest rule first. No such errors are made by any child, the world over. Communicative efficiency is not the explanation. Such data suggest that these rules, the more complex ones (the structure-dependent ones), are part of $S_0$.

Other examples:

Each of the men likes the others.

The men like each other.

These are near-synonyms.

BUT, this is not the case with

Each of the men expects John to like the others

*The men expect John to like each other.

Chomsky then concluded that the explanation is strictly language-specific (free versus bound anaphora) and has nothing to do with sensorimotor schemata, communicative efficiency, or anything of the sort[9].

[8] The special status of structure-dependent operations in syntax and the difference with structure in-dependent operations has been, in recent years, validated by the sharp difference in their respective brain activations (Musso *et al.*, 2003). In the domain of language acquisition, Neil Smith and Stephen Crain have shown that the privileged status of structure-dependent operations is known by the child as early as testing is possible, namely as early as 3 years-old.

[9] An anonymous reviewer suggests that the reader be informed of work that, he/she thinks, offers cogent rebuttals of Chomsky's theses. These references have, accordingly, been added to the bibliography: Bickhard (1979, 1980, 1995, 2004, 2007, 2015); Bickhard and Campbell (1992); Campbell (1998); Campbell and Bickhard (1992). He/she adds, quite pertinently, that, without a major research focus on language and hardly any interest in language structure, Piaget was surely ill-equipped to handle Chomsky's arguments and rhetorical (sic) demands. Piaget was

## 5. On hill-climbing

Guy Cellérier, a close collaborator of Piaget and an expert of formalisms in artificial intelligence, offered a "compromise". Let's postulate a hill-climbing, problem-solving system, with generate-and-test method in the problem-space of grammars. There will be "substantive universals" (types of actions), and "formal universals" (general criteria for legal moves). The hill-climber possesses a minimal structure independent of the environment. There are neighborhood relations (vicinity between states), as suggested by Marvin Minsky in his 1961 essay *Steps towards Artificial Intelligence*. Then you specify how constrained the search has to be, and what is the source of these constraints.

This suggestion was later re-proposed by Steven Pinker and Paul Bloom (Pinker and Bloom, 1990)[10] and by Richard Dawkins (Dawkins, 1996). «Only a hill-climbing process, with each small step forced in the direction of forms with better vision, can guide the lineage to such a minuscule region of the space of possible forms [i.e. the formation of the eye] within the lifetime of the universe» (Pinker and Bloom 1990, p. 711).

However, there are several glitches with "hill-climbing", some were stressed during the debate, but others are worth stressing here[11]:

(1) The system may always be trapped into a local maximum, unable to proceed any further (see Gibson and Wexler, 1994, for an insightful analysis of this predicament in the domain of parametric language acquisition).

(2) A cognitive system must be capable of "sensing" (understanding) how high it has climbed, what constitutes a satisfactory "height" in the

interested in some of the functions of language, but never tried to develop a conception of language as an action system and never even attempted a critique of the doctrine of competence and performance (which has been used against nearly every aspect of his theory, not just his efforts to account for language). This reviewer then adds «He [Chomsky] does not consider the possibility either of interactive representation or of language as an action system or a means of operating on interactive phenomena. But there are functional constraints on language as an interaction system that limit what its operators can be like, and therefore scaffold or otherwise enable the acquisition of such operators. He has not considered any such constraints; he merely proceeds as though they are already ruled out». I will retort that Chomsky has considered and persuasively ruled out such suggestions over many years and in many publications. Researchers of language acquisition such as Lila Gleitman, Stephen Crain, Rosalind Thornton, Kenneth Wexler and Maria-Teresa Guasti (to name just a few) offer rich data and cogent arguments against the alleged impact of generic external factors in the child's maturation of language. I am reluctant to insert more citations into an already large bibliography.

[10] Pinker and Bloom wrote their 1990 paper in defense of Darwinian natural selection in the domain of language evolution, explicitly declaring that they were reacting to my 1989 paper and to Chomsky's critique of adaptationism. I wrote, for that same issue of BBS, a critique of their critique.

[11] Chomsky (in personal communication, January 2017) adds that one of the glitches is that even if tenable, it leaves us nowhere. It implies nothing about choosing structure-dependence over linear locality, the simpler computational operation by far.

process, and must be able to track how it got there (otherwise there can be sheer "luck", but no real "learning"). These abilities cannot be "given" by the hill-climbing process itself, they must be independently derived.

(3) (Most important) it is hard to conceive of any such process as devoid of the capability to monitor (again, in the cognitive domain, understand) how high it would have climbed, had it followed a different path.

(4) Therefore, the power of handling counterfactuals must be attributed to the system. It must, once again, be independently granted. It cannot possibly be the outcome of hill-climbing.

Cellérier also proposed two possible strategies, arguably complementary:

(1) Maximize the initial structure of the learning device, and minimize the complexity of the search procedure.

(2) Maximize the complexity of the search procedure, and minimize the internal, initial, structure of the learning device[12].

We will need the combined action of both these strategies, in order to understand cognition. Whence the "compromise".

Cellérier then added: Gravity is universal, but not innate. Sickle cell anemia is innate, but not universal. None of Chomsky's hypotheses has received any support from genetics, the way sickle-cell anemia has.

Chomsky's reply was: It makes no sense at all to minimize or maximize this or that. Nothing of the sort applies in physics, chemistry or biology. The task is to understand which structures are there, for real. Hill-climbing is a doubtful metaphor. Better speak of "successive maturation of a specialized hardware" (analogous to sexual maturation, in kind). The very idea that cognitive structures are vastly more complex than those of any physical organ implicitly presupposes "a metric of complexity which I [Chomsky] don't perceive or share".

In essence, Chomsky defended the autonomy of syntax and the poverty of the stimulus, theses he had cogently defended already and that he has continued defending in the many following years. What was excluded from the process of language acquisition by the child was learning (in the traditional sense) and induction.

In the prosecution of the debate, Jerry Fodor offered a more focused line of argument: concentrating on the acquisition of concepts and the meaning of concepts. Aside from Chomsky and Jacques Mehler, the other participants were not ready for Fodor's massive onslaught on learning, in

[12] For a mini-max suggestion about the status of parametric variation in syntax, different from what Cellérier proposed at Royaumont, and approved by Chomsky, see Vercelli and Piattelli Palmarini, 2009).

all of the previously proposed mechanisms. The aura of paradox of his proposal was not obfuscated and an animated discussion followed. But let's proceed in order.

## 6. Fodor's Proof of Innateness of all (basic) concepts

Speaking of a misunderstanding, this was, and still is, one of the most egregious cases I have ever encountered. (For an update see Piattelli Palmarini, 2018). In essence, Jerry Fodor wanted to show, cogently, that, if there are, in the cognitive development of the child, genuinely "more powerful" concepts, these cannot possibly be the result of learning. He squarely concluded, after his demo, there and then that there must be some notion of learning that is so incredibly different from the one we have imagined that we don't even know what it would be like, as things now stand.

This is his "demo" (or proof, if one prefers): Fodor's buster: All concepts are innate.

Based on three converging, but distinct, lines of evidence and reasoning:

(1) No induction (no learning) is possible without severe a priori constraints on the kinds of hypotheses (concepts) that the learner is going to try out.

(2) The failure of Locke's project: Derive all concepts from a Boolean combinatorial algebra of elementary sensory primitives. But you cannot even acquire concepts such as buy and sell, automobile and typewriter on the basis of Locke's schema. That has been shown.

(3) Richer (more powerful) concepts cannot be developed out of poorer ones by means of learning (in any of the models of learning that have been proposed so far).

General learning "situation": you present items to the learner and tell him/her/it (if a machine):

These are "instances" {+ + + ......}

These are not. {- - - ......}

Instances and non-instances of what?

Some property (concept, predicate) X.

On the basis of the evidence presented and partitioned into those two mutually exclusive sub-sets (is an instance, is not an instance, it's OK it's not OK, satisfies, does not satisfy, etc.), your task is to guess (discover) what X is.

These are the possibilities:

Schema 1: The learner already has a repertoire of relevant concepts (predicates, hypotheses), X1, X2, ... Xn. He/she/it tries them out in some order of decreasing plausibility, and selects the best guess compatible with all the evidence seen so far. Inductive logic will tell you (not an easy task) which hypotheses will be tried out first, second, third etc., and what constitutes "sufficient" confirmation. It's totally silent on the origins of the repertoire. This is the innatist schema. We have some understanding of how it works.

Schema 2: The learner has a repertoire of vaguely relevant, but weaker concepts (properties, predicates, hypotheses), x1, x2, ... xn. He/she/it must find the means to develop (acquire, generate, compute) a "more powerful" concept X. Thesis: The methods for learning concepts do also tell you how the more powerful concept is generated (see Piaget's theory).

Call this: Feed-back, variational re-computation, abstraction, representational re-description, whatever. Fodor shows that no such schema could possibly work. Why?

Sub-Option 1: The learner generates X by sheer luck, and X fits the available evidence by sheer luck. Otherwise he/she/it dies, along with all the descendants. In fact, most of the time, X is wrong. Only rarely do such guesses work (extreme Darwinism). No learning has taken place, just lucky blind guesses.

Special case: The target X and the guessed Y happen to be co-extensive. They mean quite different things (they are semantically distinct)[13].

Y (not X) has been "fixed" by natural selection.

This may (just may) apply to genuine triggers.

Guidance by truth.

Sub-Option 2: The learner, somehow, "tracks" the content (the meaning) of X, and why it is adequate with respect to (true of) the available evidence. The process is, somehow, guided.

The content of X, and some sensitivity of the process to the truth/falsehood of X, supply the required "guidance" (tracking). Nothing else could supply it. Evolution's criterion can only be truth-value. There is learning (inductive fixation/rejection) of the meaning of X, but X cannot be fixed/rejected unless it is actually available to the learner and it is exploited in the process by the learner.

A suggestion doomed to fail:

The learner "works on" the previously available, weaker (primitive)

[13] I will go back to this central predicament in what follows. The gap between co-extensionality and intensional characterization is a perennial glitch for behaviorism and for Darwinian explanations (see my book with Fodor for an extensive treatment).

concepts x1, x2, ... xn by means of combinations, re-descriptions, thematizations, whatever, and thereby generates a genuinely new concept Y.

One possibility: Y is literally a composite concept, composed out of the xs (brown cow) and what it means is that way of composing them. No less, no more. It's not "more powerful" in any interesting way. Obviously not all concepts can be composite. Some must be primitive.

Another possibility: one is acquiring genuinely "more powerful" primitive concepts. They are not decomposable (ex hypothesis). They are not "definable" out of more elementary concepts.

Genuinely more powerful concepts cannot be exhaustively "defined" in terms of less powerful ones (Fodor's notorious "plus-X" problem. See J.A. Fodor, Garrett, Walker and Parkes, 1980). Truth conditions on formulas containing more powerful concepts cannot be characterized with formulas containing genuinely less powerful concepts. Evidence, suitably labeled, can "activate" them, but not "engender" them, for all the above reasons.

In other words: The manipulation of primitive concepts can (in fact, it typically does) produce "brown cow" from "brown" and "cow", and the syntax of the composition. But no repetition of "This A is a B", and "This A is a B", and "This A is a B" ... can generate "All As are Bs", unless you have the universal quantifier ("every", "all") already in your conceptual repertoire. This point is also made very cogently by the American logician and philosopher Hilary Putnam (Putnam, 1975). You must have a record of past observations of As and Bs involving some general uniform way of representing "All As are B". Otherwise you cannot do that, no matter how many As and Bs you observe.

In other words still:

Learning a concept is learning its meaning (its unique semantic properties).

At some stage you must entertain the following formula in mentalese:

(A) For every x, P is true of x, if and only if Q(x).

Q is a concept of mentalese. The one you have (allegedly) "learned".

P is some concept you had already.

P must be coextensive with Q, if (A) is correct.

But this is not enough: P must be coextensive with Q in virtue of what P means.

Otherwise (A) is not a correct semantic formula.

So Q is synonymous with P. So you had Q already in your "language of thought", because you had P. So Q is not "learned".

Iterate this for every primitive concept, keeping in mind the failure of Locke's program.

Conclusion: All primitive concepts are innate.

And (due to the failure of Locke's program) they are not all mere constructs from sensory impressions.

It is a shocking conclusion, but it is also unavoidable. Followed a long discussion on why such "extreme" innatism is so strongly resisted.

Coda. In Fodor's reply to Putnam. What if learning a concept is not learning its meaning, but something else? (Say, its rules of use). Well, the same kind of argument applies as well. Then "rules of use" are not the result of learning either.

Fodor's conclusion: So, where do new concepts come from?

Three possibilities: 1. God whispers them to you on Tuesdays (obviously a joke); 2. You acquire them by falling on your head (another joke); 3.They are innate.

There is no other possibility.

Immediate and typical objections, reiterated over the last 40 years are.

(1) Disbelief: There must be other explanations.

(2) Re-direction: this does not apply to other components of language.

(3) Counter-examples: This is not true of other systems (Papert's perceptron, see *infra*, and later connection machines).

(4) Myopia: We must also pay attention to other forms of instructive learning, also taking place (implicit instructions).

(5) General implausibility: An innatism so strong is absurd in itself.

(6) Evolutionary implausibility: The sudden appearance of so much domain-specificity violates all we know about biological evolution.

(7) The supremacy of dynamics: One cannot limit analysis to stationary (structural) properties, but must view the whole process over time, as a genesis.

(8) Failure of imagination: You cannot see how those language properties arise from use, communication and social exchanges, but I do (Arbib, 2012).

(9) Errors of categorization: We must widen the perspective, to cover other general systems (notably animals and machines) and acknowledge precursors and reduced models.

(10) Occam's razor: The irreducible specificity of language violates the general criterion of good-science-making. We must probe deeper than that.

Each one of these objections, and the cogent counters each received, would easily occupy the space of a whole large volume. It amounts to a large literature which I cannot even begin to summarize[14]. There was, however, an interesting objection to "strong" innatism there and then, by one of the popes of artificial intelligence: Seymour Papert, who was closely

[14] The anonymous reviewer I mentioned earlier (see footnote 9) recommends that the reader be informed of work that, in his/her opinion, cogently rebuts Fodor's innatism and Fodor's whole approach to mental representations. These references have, accordingly, been added to the bibliography: Allen and Bickhard (2013); Bickhard (1991, 1998, 2009); Bickhard and Terveen (1995); Campbell and Bickhard (1986, 1987); Levine and Bickhard (1999).

collaborating with Piaget and his group. The American philosopher Hilary Putnam, in the sequel to the debate, published in the proceedings, raises a very similar critique.

It is worth, I think, to summarize it.

## 8. Papert's perceptron: connectionism before connectionism

We have built an apparatus (the perceptron: Minsky and Papert, 1972) that has a kind of artificial retina, with interconnected local mechanisms, none of which covers the whole retina. None has any "global knowledge". Weighted sums of the local decisions are reached by each sub-machine. As a result, we have emergent global decisions, not localized in any sub-part. There is a "learning function" sensitive to positive and negative feedback supplied from the outside.

What can it learn? What is "innate" (in some sense)? The answer is far, far from obvious. Only by accumulating detailed analyses, case after case, can we answer that:

It can easily learn to discriminate, say, between "triangular" and "square", by looking at local angles in the retinal image.

What about the predicate (the property, the concept) "connected"? Can it learn to decide whether the image is made up of one single connected piece, or several distinct connected pieces? The answer (far from obvious) is that it can.

Now, imagine an investigator (a Fodorian) who, therefore, concludes that "connectedness" is innate (prewired in the machine). But the wiring diagram cannot reveal anything that corresponds to "connectedness". Big surprise!

One has to be very careful. The key is a deep theorem, demonstrated by Euler, that links the total sum of external angles to connectedness, in a universal, necessary way. No piece of the machinery "possesses" (is sensitive to) the concept of connectedness, nor does it "contain" Euler's theorem. The pieces just detect angles, and measure them. And the machine as a whole then sums up all the angles.

It does not have to "know" (keep track of) whether two non-successive observations of angles are concerned or not with the same blob. As a result (not of innateness, but of the process itself), the machine is sensitive to connectedness. In exactly the right way. In virtue of Euler's Theorem, if the total algebraic sum of the angles of the tangents is 2p, then we have one connected blob. If n2p, then we have n connected blobs.

Suppose we did not know about Euler's theorem: we would have concluded that the perceptron had "learned" the concept of connectedness. That's wrong. It's neither innate (prewired) nor learned. It is the inevitable

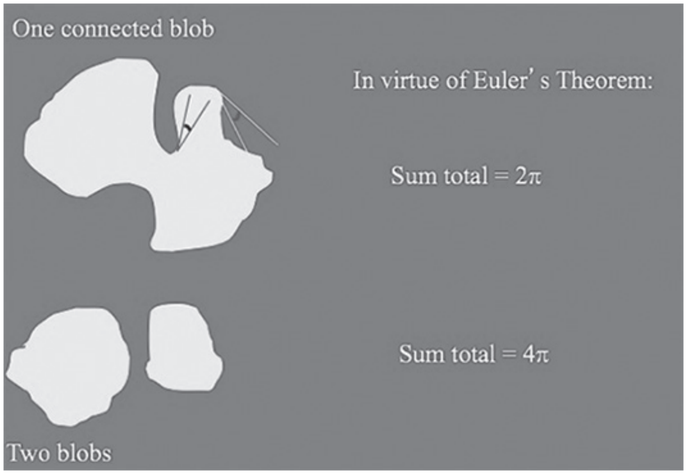


FIG. 1.

consequence of the deep property discovered by Euler. If the algebraic sum total of all the curvatures along the borders of a blob is 2p, then the blob is connected, whatever its shape. Otherwise it's not. If it is n2p. Then we have n distinct objects. It's all so precise, and deep, and surprising. Terms like "concept", "notion", "predicate" are generic and misleading. We need better ones.

The cognitive capacities of the adult may well be neither innate, nor learned. They have a developmental history. They emerge from other, different, components.

Whatever is innate will not resemble in the least what you find in the adult's mind.

The real search will have to track precursors, intermediate entities and constructions.

Without the help of mathematicians and genetic epistemologists, we will never be able to track them, and understand how they interlock, to give the full-blown "concepts" of the adult mind.

Artificial intelligence is a powerful tool in understanding these processes. It is a «long, arduous and technical path» (LL, p. 96).

Papert's Piagetian "lesson" was that, for instance, numbers are neither learned, nor innate. They are built through successive stages, by means of factorization (of a whole into sub-parts), the successor function (*à la* Peano), joint exhaustibility of sets by one-to-one pairing of their elements (*à la* Bourbaki). Different (though mathematically equivalent) definitions of numbers are more or less easy to learn, notably by the child. Most learnable is Bourbaki/Piaget, less so Russell/Whitehead, least of all Peano. All of them splendid mathematicians, but not all of them equally good "developmentalists".

Anticipating what several authors will restate in the following years – see for instance Fiona Cowie's critique of innatism (Cowie, 1999, 2000) – Chomsky's "conundrum", about the child adopting structure-dependent rules first, is solved: because she has learned to do so "outside of language". A.I. has good models of how this happens. Moreover, implicit learning and implicit teaching are very important. Any child receives masses of subliminal, implicit teaching. It's wrong to disregard this crucial component (the way Chomsky does)[15]. We have to look at the structure of mathematics as the object of a general theory of structures. Not just at the structure of language.

## 9. Chomsky and Fodor strike back

The machine has the concept "connected", since it necessarily (not by sheer luck) applies the concept correctly to all and only the connected blobs. You would not have noticed that it had this concept, and why, if you were not as clever as Euler. But it does have the concept "connected", exactly for the reasons explained by Papert, based on Euler's theorem. A cognitive system does not have only the concepts that it's easy for us, cognitivists, to ascertain that it has.

Papert's reply was that the perceptron, indeed, has the concept "connected", but it's precisely and exhaustively defined on the basis of other predicates the machine is sensitive to (local angles of curvature and their algebraic sum). So, contra Fodor's thesis of the innateness of all concepts, this global concept is genuinely constructed from strictly local ones. If you had searched the "genome" of this machine to find where "connected" was encoded, the answer would have been: Nowhere! Yet, the machine has it, as also Fodor and Chomsky admit.

Chomsky's counter was: This is totally irrelevant. The set of actually available predicates has many interconnections, and it may be hard to discover some of these interconnections (it may take an Euler to discover some of them).

Fodor's counter was: Predicates come in clusters, and we have to keep three problems separate:

(1) What's the evidence that definitively compels the experimentalist to attribute possession of a concept (of a predicate) to the device;

(2) Which predicates the device actually has;

[15] Chomsky (p.c. 2017) stresses that the proposal of paying attention to implicit learning is completely beside the point. Suppose that implicit teaching yields the concept of hierarchy. It also yields – far more simply in fact – the concept of linear locality. So we end up exactly where we were, with the original conundrum. Same logical error is made by Perfors *et al.* (2006, 2011) and others too numerous to mention.

(3) What possessing a predicate amounts to.

We have established that the concept is there, and that the device actually exploits it in carrying out its tasks. That's all is needed. The problem of the definability of that concept in terms of other concepts is a separate one. One thing we now know for sure: That Locke's program was bound to fail. There is no buildup of such concepts from basic perceptual primitives.

## 10. Towards epigenetics

I think we owe, posthumously alas, apologies to Piaget. He was, there and then, perceived to be a Lamarckian and this was anathema. Today, in the light of the burgeoning field of epigenetics, we understand that he had discovered, in the depth of the Lake of Geneva, a case of trans-generational epigenetic transmission. In fact, before he became one the most authoritative psychologists of all times, he has studied zoology and had published a compte rendu of his studies of phenotypic transformations in a family of molluscs, the *Limnaea stagnalis* (Piaget, 1929). In essence (I remember a colloquial exposé he gave on the sides of the debate, over lunch) when transporting the light-colored species, a variant typical of the shallow waters of the lake, to the depths of the lake, these creatures developed a darker color. After some generations, the dark variety could be transported back to shallow waters and it retained the dark color. The neo-Darwinians, there and then (and I was one of them) suggested that there had been a repeated selection in favor of the variants at the far end of the color distribution curve, without any need to invoke a transmission of acquired traits. Piaget was, understandably in hindsight, dubious that this could be the explanation, because the light-colored species had no individuals presenting such a darker color. He had, we now understand, discovered a case of trans-generational epigenetic transmission, very similar to the cases discovered by the British geneticist, embryologist and epi-geneticist Conrad Hal Waddington. (The interesting repercussions of these observations into his psychological theories and the relations between the ideas of Waddington and Piaget are well explained by Sara Campanella in her dissertation, 2012).

A personal anecdote is apt, I think, to illustrate the neo-Darwinian scientific dogmatism of the time. More or less in those years, I had planned to go to London and interview Waddington in relation to a report on the state of the art in biology and genetics for an Italian journal (*I Futuribili*). When I told this to Jacques Monod, he warned me (literally gave me "une mise en garde", in his own words) to be extremely cautious in reporting what Waddington was claiming, because "il est un Lamarckien notoire". Today, no general introduction to epigenetics by the most respected biologists can fail to show a picture of Waddington and of his famous "epigenetic landscapes" and "genetic assimilation" (see for instance Slack, 2002). Times have changed!

In view of what comes next, it may be of interest to disentangle epigenetics from Lamarckism, in spite of frequent claims, mostly in the popular press, that we are witnessing a "return" of Lamarckism.

## 11. Why epigenetics is not Lamarckism[16]

The inheritance of acquired traits, according to Lamarck, was supposed to be the result of sustained efforts caused by fundamental needs in the parent organism. The textbook vignette is one of the giraffe progressively developing a longer and longer neck, over many generations, by persistently straining to access fruits higher and higher up in the trees. Waddington's seminal experiments do not fit this schema.

In Drosophila, by exposing the developing embryo to high temperature, the resulting phenotype shows bigger eyes. This phenotype eventually stabilizes in the progeny, after several generations of crossings, even when no temperature shock is administered. By exposing the embryo to fumes of ether, an additional pair of wings sprouts from what are in the wild type extremely reduced appendages (the halteres). This famous variant, the so called bi-thorax, is eventually also stabilized by epigenetic trans-generational transmission.

More recent experiments in the mouse (Jirtle and Skinner, 2007) show that by feeding the pregnant mother with methyl-donor supplementation of folic acid, vitamin $B_{12}$, choline and betaine, the coat color distribution of the offspring shifts towards the brown pseudo-agouti phenotype. Correlated epigenetically inheritable phenotypes are also obesity and susceptibility to disease later in life. In all these cases, there is no plausible functional correlation between the external shock administered and the resulting phenotype. Temperature does not adaptively "correlate" with bigger eyes, fumes of ether do not adaptively "correlate" with extra wings, methyl-donors do not adaptively correlate with coat color. All in all, the patterns of epigenetically inheritable traits do not match the Lamarckian schema of deep needs.

A second kind of divergence between epigenetic inheritance and Lamarckism resides in the strict complementarity between genetic and epigenetic transmission. The DNA is epigenetically altered (methylated) not everywhere along its sequence, but specifically in what are called the "CpG islands". The progeny inherits these DNA mini-sequences in a

[16] I am grateful to Giorgio Graffi for recent interesting exchanges on this topic.

perfectly standard genetic transmission. These DNA sequences, and these sequences only, are the target of the epigenetic DNA modification. The additional epigenetic chemical modifications of the histones (the protein complexes around which DNA is wrapped), that is methylation, phosphorylation, acetylation, ubiquitinization, present further close complementarity between genetics and epigenetics.

Finally, the signature of a genuine trans-generational epigenetic transmission is that it attenuates progressively over the generations. Three generations in humans, four in the mouse, no more than nine or ten in the drosophila. Therefore, the role of epigenetics in speciation is not yet clear enough and likely to be fiendishly complicated[17]. Even in organisms as relatively simple as Neurospora, the role of epigenetic DNA methylation leading to what is called Meiotic Silencing by Unpaired DNA (MSUD) in producing sub-species is suggestive, but not definitively established (Allshire and Selker, 2007).

The neo-Darwinians were wrong in assimilating epigenetics and Lamarckism, and they were wrong in considering Waddington and Piaget embarrassing outliers.

Let me now come, in closing, to an interesting and complex issue: The Baldwin effect.

## 12. The Baldwin effect

There is an interesting recurrence: a sort of "hunger" that certain neo-Darwinians have for something resembling a Lamarckian factor, some "respectable" form of an inheritance of acquired traits. In the domain of cognition this seems especially unavoidable, because of the speed of adaptations, the directionality of adaptations and the need of tracking (somehow) the reasons for past success, then improving on past success. Blind trial-and-error without any tracking seems hopeless. To the Darwinians, direct assimilation (to use a notion due to Waddington) is unacceptable. The process must be progressive, cumulative, guided by natural selection and adaptation. Some "transfer" from experience to the genes is needed. Without Lamarckism and always in a Darwinian framework. How can that be?

The Baldwin effect seems to offer precisely what is needed.

The American philosopher Daniel Dennett, a committed Darwinian, so characterizes the essence of the Baldwin effect: «[a] practice that is both

[17] On this point (in personal communications), Chomsky stresses that most developmental genotype-phenotype relations are fiendishly complicated. Longa sent me a paper by Jablonka and Raz (2009), where the about 100 known cases of transgenerational epigenetic heredity are compiled, and its theoretical implications are discussed. This point is very important, for it widens the strict neo-Darwinian view that equates heredity and "naked" genes.

learnable (with effort) and highly advantageous once learned can become more and more easily learned, can move gradually into the status of not needing to be learned at all» (Dennett, 2003, p. 69). «[I]n the long run, natural selection – redesign at the genotype level – will tend to follow the lead of, and confirm the directions taken by, the individual organisms' successful explorations – redesign at the individual or phenotype level» (Dennett, 1997, p. 63). «[The Baldwin effect] genuinely increases the power – locally – of the underlying process of natural selection wherever it operates» (p. 80).

There are, however, major glitches: as we have said, trial-and-error without any tracking of the reasons for success is hopeless. Co-extensive mental contents are indistinguishable without intensionality. Hypotheses (mental contents) are successful (if they are) for a reason, not by miracle. But the reason is not itself the result of natural selection. The subject must have access to that reason. Variations, criteria of equivalence, invariants presuppose such tracking and justified inferences also presuppose tracking. If you presuppose the capacity of tracking these reasons, then you are back to square one. You have to admit hosts of counterfactuals, unsupported by the Darwinian theory. (For details of this glitch in all Darwinian explanations see part 2 of my book with Fodor). We are also back to the problem with hill-climbing and implicit learning. It gets you nowhere. It doesn't approach structure-dependence, or digital infinity, or any of the non-trivial properties of the systems under consideration.

## 13. Let's re-examine Waddington's classic experiments

In response to ether vapor a proportion of Drosophila embryos developed a radical phenotypic change, a second pair of full wings (bithorax). Then Waddington continually selected for Drosophilae with the developmental capacity to respond to the environmental stress. After about 20 generations of selection, some Drosophilae were obtained that developed bithorax without being exposed to ether treatment. What happened, according to Waddington, is that selection favored a particular pathway that led to the production of the desired effect.

Eventually the pathway became "canalized", hence the end-state, bithorax, appeared, regardless of environmental conditions.

Ditto for exposing the Drosophila embryos to high temperature. Same procedure, same result, for a phenotype consisting in abnormally large eyes.

Let's insist on two notable things: (1) The trait so selected has no "adaptive value" that one can imagine (extra wings in fumes of ether, big eyes at high temperature). (2) Development and changes in the developmental pathways, in crucial phases, are nowadays the key of Evo-Devo, detected by Waddington long before Evo-Devo (Minelli, 2003, 2015)

Canalization. Waddington's experiments showed that hidden genetic variation pre-exists in wild populations, but it is usually masked in normal development by "buffering" – see the case of Hsp90, as evidence for an epigenetic mechanism by which a gene acts as a capacitor for morphological evolution: Reidy *et al.* (2014); Rutherford and Lindquist (1998); Sollars *et al.* (2002). This finding extends our understanding of the means by which phenotypic variation is generated and brings chromatin inheritance into the realm of multigenic traits. In essence, perturbations of chromatin-inheritance genes uncover morphological variation, and epigenetic variants can be rapidly selected. When development is perturbed, buffering cannot cope, genetic variation is revealed and becomes available for artificial selection. Over the course of repeated selection, genetic "assimilation" occurs, resulting in the altered expression of a trait. If sufficient variation is now made available, the trait becomes stably expressed even in the absence of the original perturbation (Rutherford and Henicoff, 2003). Such selection experiments showed that the phenotypic constancy of normal development in outbred strains hides cryptic alleles, influencing even invariant and canalized traits.

A famous case, analyzed by Waddington (Waddington, 1957): the ostrich's callosities. Callosities of the lower rear epidermis can be produced by prolonged rubbing, and when the ostrich sits down, it will rub two particular places on its ventral surface. These spots bear prominent callosities; however, surprisingly, they do not arise during life but are formed during embryonic development, so they are already present at the time of hatching. The question in the early years of the XX century was: Did rubbing the skin of ancestral ostriches bring about a change in their genes such that the callosities were produced spontaneously? The canalization and stabilization of this originally epigenetic trait is presently well explained (Slack, 2002).

## 14. Modern epigenetics and the Baldwin effect (Baldwin, 1896)[18]

As we have just seen, modern epigenetics makes genetic assimilation of inherited traits respectable. The Baldwin effect has been tied to these ideas and to Waddington's work. For a detailed analysis of the Baldwin effect and how it resonates in the work of Piaget, see the remarkable dis-

[18] Campanella continues, stressing Piaget's reaction to the most orthodox tenets of the neo-Darwinian "modern synthesis", citing (in English) Piaget's reply (in a 1979 interview with J.J. Vonéche) to the question: «what is exactly the precise significance of the Baldwin effect in your recent biological works?» Piaget replies: «there is a certain convergence here on the insufficiencies of neodarwinism. Waddington didn't attach much importance to Baldwin». I think that, once again, Waddington was right.

sertation of Sara Campanella (Campanella, 2012) and the rich bibliography in it. Campanella (2012, p. 35) says: «Questioning natural selection as the source of speciation and the attempt to integrate the ontogenetic and the phylogenetic points of view take on special relevance in the work of the American psychologist J.M. Baldwin, a work that has special value in the development of Piaget's thinking» (my translation, my emphasis).

I think, however, that this assimilation is unwarranted, agreeing, in this, with a lucid analysis by the Spanish bio-linguist and evolutionist Victor Longa (Longa, 2006, 2009)[19]. I have adapted the following schema of contrapositions from his 2006 article.

*Waddington* (but see also the work in modern epigenetics cited above):

Genetic predispositions are present already, but are hidden (buffering, capacitor genes).

The trait is instantly manifested, under environmental shock (the shock exceeds the buffering).

Unmasked genetic possibilities become then stabilized (no genetic "rigidification").

The mode and phase of administration are crucial. There is canalization of preexisting potentials, nothing "becomes" genetically fixed.

*Baldwin*:

Random genetic mutations are required (this is what makes it so relevant to the Darwinians).

The trait emerges progressively, one generation after the other (this too).

Initial plasticity turns into genetic rigidity (how, remains unspecified).

First learning, then genetic fixation (again, enunciated, but unspecified)

No mention of modes and stages of administration (but these are crucial).

In essence, if it can be determined that Waddington's mechanism of genetic assimilation and today's data on epigenetic canalization cannot be used as evidence in support of the Baldwin effect, then its empirical basis becomes seriously limited. This applies as well to computer simulations of the Baldwin effect and to Briscoe's and others' hypotheses on the evolution of language (Briscoe, 2003, 2002).

Implicit in the Baldwin effect is the view that learning can have an impact on the direction (and the speed) of evolutionary change, because learned behaviors acquired in the course of an organism's lifetime may

[19] Victor Longa, in a personal communication (January 2017) rightly stresses that, while in the Baldwin effect a mutation (or several, who knows!) is required, in Waddington's genetic assimilation the mutation preexisted, but was hidden, and in epigenetic transmission there is no mutation at all.

become inherited by its offspring. The evolutionary relevance of learning would thus imply that, as Richards (1987: 451) puts it, evolution would work «not as a blind mechanical process but as one governed by mind». The big question remains: Which mind?

There is relevant work by the evolutionary biologist Lauren Ancel, who questions that assumption. He formulates two simulations: in one of them, in fact, the result is the opposite: «plasticity uniformly slows evolution» (Ancel 2000: 309). In another simulation, Ancel shows that plasticity speeds evolution not in a general way, but only under restrictive conditions: «phenotypic plasticity does not universally facilitate evolution» (2000: 307). To sum up, even the idea that the Baldwin effect accelerates evolution should be taken with caution.

Ancel also notes an important point: the idea that plasticity accelerates evolution was emphasized since Hinton and Nowlan (1987), for Baldwin himself was more interested in how learning influences evolution than in whether or not evolution is accelerated by learning[20].

The other big question is: What is, exactly, selected? What becomes genetically fixated? A behavior? The propensity to that behavior? The ease of learning that behavior? A generalized ease of learning all new behaviors? Longa and I do not see how this question is answered, but it should[21].

The starting point of the Baldwin process is phenotypic-developmental plasticity. A phenotypic change arising as a consequence of an ontogenetic adaptation made possible by the organism's plasticity. However, for the Baldwin effect to apply, a second and crucial step is required: Namely the genetic assimilation of the phenotypic trait previously learned as a response to a given stimulus. This step assumes that the plastic learning mechanism for the phenotypic trait is replaced by a rigid mechanism based on heredity. Because of this, the Baldwin effect presupposes that «learning can guide evolution» (Pinker and Bloom 1990:723).

The central idea is: If the learning of a specific phenotypic trait varies within a population, the result will be that some individuals will be capable of learning that trait better than others. Natural selection will favor those who acquire the ability more easily (for example, on the basis of limited exposure to the trigger or stimulus), because those individuals will increase their level of fitness, that is, they will survive and reproduce to a greater extent than those possessing a lesser degree of plasticity. Surely, innate greater predisposition to learn a task (finding one's way in a maze) has been shown years ago in the mouse by the late Daniele Bovet and his collaborators (Bovet, Bovet Nitti, and Oliverio, 1969). Selectively breeding

[20] I am grateful to Victor Longa for these important clarifications.

[21] Chomsky (p. c. 2017) adds: Suppose, for the sake of argument, we believe that the Baldwin effect applies. Is there a conceivable path to the most elementary properties of language, like digital infinity, structure-dependence, etc.? Every proposal just waves hands at this point.

these "smart" varieties, the predisposition is fixated by perfectly standard genetic transmission. But this is not what the Baldwin effect is all about. It's the learning capacity (and better memory) that is selected for, not the way-finding trait itself! We do not witness plasticity and learning being progressively increased and, then, being drastically reduced and genetically assimilated.

The American-Australian philosopher and historian Peter Godfrey-Smith has offered a neat statement of the Baldwin effect:

> Suppose a population encounters a new environmental condition, in which its old behavioral strategies are inappropriate. If some members of the population are plastic with respect to their behavioral program, and can acquire in the course of their time-life new behavioral skills that fit their new surroundings, these plastic individuals will survive and reproduce at the expense of less flexible individuals. The population will then have the chance to produce mutations that cause organisms to exhibit the new optimal behavioral profile without the need for learning. Selection will favor these mutants, and in time the behaviors which once had to be learned will be innate. (Godfrey-Smith, 2003, p. 54)

Notice two things:

(1) Godfrey-Smith postulates: the chance to produce mutations that cause organisms to exhibit the new optimal behavior. Not really clear how that can be the case. Mutations, in that Darwinian frame, are random. No individual has any better (or worse) chance of "producing" [sic] a certain kind of favorable mutation. What he must mean is that the environmental conditions are such that there is a better chance of selecting those mutants.

(2) Godfrey-Smith makes the important point that phenotypic plasticity initially leads to natural selection, not for the behavior itself, but for the capacity to learn such a behavior (i.e. to learn whatever is required). So it's a "capacity" that is selected. Allegedly a specific capacity, not a generic one. But, once learning disappears, so all tracking disappears, there is no possibility any more of knowing what happened and why. Only cognitive "reflexes" may arise this way. It's doubtful, to say the least, that cognitive processes of some complexity can really be reflexes.

A big glitch: If the cost of learning is reduced (and eventually there is no more learning), so is the capacity to learn from errors and to adapt to further new situations. This is a perennial glitch for behaviorism and for Darwinian explanations: the gap between extensional and intensional cognitive contents. Without a possibility of tracking the reasons for cognitive success and of formulating counterfactuals (if I had done that instead of this, the consequences would have been...) there can be no learning. Reflexes do not allow counterfactual reasoning. An intelligent creature must be able to track the differences between co-extensional, but intensionally different, mental contents. Have I learned to turn left, or to turn North, or to seek the best path? These alternatives may well be extensionally identical, but are intensionally different. This differences are crucial for an organism that can learn.

Moreover, the transitivity of degrees of fitness and monotonicity of improvement are essential in that framework, but there are serious exceptions to the transitivity of fitness, as the leading American evolutionary biologist Richard Lewontin has rightly stressed (Ariew and Lewontin, 2004; Lewontin, 1998); see also Piattelli Palmarini and Fodor (2010), Fodor and Piattelli Palmarini (2011).

## 15. Back to Baldwin

Baldwin himself had well noticed the problem of intensionality, that he calls "consciousness", and has a paragraph that it's not so easy to interpret: «I have argued [...] in detail that the assumption of determinate variations of function in ontogenesis, under the principle of neurogenetic and psychogenetic adaptation, does away with the need of appealing to the Lamarckian factor». He sees that, in the case of instincts (reflexes), «if we do not assume consciousness, then natural selection is inadequate; but if we do assume consciousness, then the inheritance of acquired characters is unnecessary» (Baldwin, 1896, p. 446; he quotes himself from Baldwin, 1896b).

I interpret him as saying that, if we do not have any kind of tracking (consciousness), then (cognitive) success comes as a punctate miracle, no relevant variation, no extrapolations, no invariants, no equivalences, no inferences, no counterfactuals. Therefore natural selection is indeed inadequate. But, if we assume some kind of tracking (consciousness), then some other kind of evolutionary process is needed, without resorting to Lamarckism. Arguably, progressive incremental selection for better and faster internal representations of the most adequate behaviors. Standard Neo-Darwinism is out of the picture anyway. «A premium is set on congenital plasticity and adaptability of function rather than on congenital fixity of function; and this adaptability reaches it highest in the intelligence».

In his article in the American Naturalist, he thus concludes: «So we may say, finally, that Organic Selection, while itself probably a congenital variation (or original endowment) works to secure new qualifications for the creature's survival; and its very working proceeds by securing a new application of the principle of natural selection to the possible modifications which the organism is capable of undergoing» (p. 552). Then he explains what Organic Selection is:

> The process of ontogenetic adaptation considered as keeping single organisms alive and so securing determinate lines of variation in subsequent generations. Organic

Selection is, therefore, a general principle of development which is a direct substitute for the Lamarckian factor in most, if not in all instances. If it is really a new factor, then it deserves a new name, however contracted its sphere of application may finally turn out to be (p. 552).

In more contemporary parlance, maybe, Baldwin is suggesting a kind of "endo-Darwinism", an internal pruning of unnecessary brain connections and a potentiation of useful connections, something that has recently been advocated by the American immunologist and neurobiologist Gerald Edelman (Edelman, 1987) and the French neurobiologist Jean-Pierre Changeux (Changeux, Courège and Danchin, 1973). Not that I am advocating this approach as an explanation for the evolution of language and cognition, but it may be a modern avatar of what Baldwin was alluding to with his terms "neurogenetic and psychogenetic adaptation" and "organic selection".

Baldwin's contemporary, the Canadian-English evolutionary biologist, physiologist and comparative animal psychologist George J. Romanes, had seen a problem in Baldwin's "new factor in evolution", namely a flavor of the pre-science of innovative adjustments. He wrote: «Does the organism learn to make new adjustments, or to modify old ones, in accordance with the results of its own individual experience? If it does so, the fact cannot be due merely to reflex action [inherited machinery], for it is impossible that heredity can have provided in advance for innovations upon, or alterations of, its machinery during the lifetime of a particular individual» (Romanes, 1882).

Much later, one of the giants of neo-Darwinism, Theodosius Dobzhansky, iconically stated: «Only a vitalist Pangloss could imagine that the genes know how and when it is good for them to mutate» (Dobzhansky, 1970, p. 92 [cited in Longa 2006 p. 310]).

Baldwin replies to Romanes defending the elaborate notion that «co-adaptations may be held to be gradually acquired; since the coordinations of a partial kind are utilized by the imitative function before they become instinctive» (Baldwin, 1896a, p. 440).

We reach a point of view which gives to organic evolution a sort of intelligent direction after all; for of all the variations tending in the direction of an instinct, but inadequate to its complete performance, only those will be supplemented and kept alive which the intelligence ratifies and uses for the animal's personal adaptations. The principle of selective value applies to the others or to some of them. So natural selection kills off the others; and the future development of instinct must at each stage of a species" development be in the directions thus ratified by intelligence (p. 441. Emphasis in the original).

The "sort of intelligent direction" and a "ratification by intelligence" proposed by Baldwin excluding Lamarckism and maintaining the role of natural selection, nebulous as they are, meet the desires of contemporary neo-Darwinians such as Dennett, Pinker and Bloom and Briscoe (just to name a few).

I endorse Longa's dissociation of the Baldwin effect from Waddington and modern epigenetics and I share his skepticism about the possibility of any explanatory power of this factor in the phylogeny of language and cognition[22].

Summing up: If the Baldwin effect cannot be linked to Waddington's canalization and to present-day epigenetics, if there is no evidence of any instance of the Baldwin effect in biology proper, and if modern versions of canalization cannot be adduced as supporting it, then its alleged explanatory power in the evolution of language and cognition vanishes.

It's interesting, though, that there is such a need for it in standard neo-Darwinian reconstructions of the evolution of language and cognition.

Although, for the reasons exposed above, the Baldwin effect is not a workable alternative to strict neo-Darwinism, Piaget had some interesting and innovative intuitions based on his reading of Baldwin and he was right in having (as Cellérier told us) a "gentleman's disagreement" with Darwin. A number of us, today, also have such disagreement[23].

## References

Allen J.W.P. and Bickhard M.H. (2013). Stepping off the pendulum: Why only an action-based approach can transcend the nativist-empiricist debate. *Cognitive Development*, 28: 96-133, doi: 10.1016/j.cogdev.2013.01.002.

Allis C.D. *et al.*, eds. (2007). *Epigenetics*. Cold Spring Harbor (NY): Cold Spring Harbor Laboratory Press.

Allshire R.C. and Selker E.U. (2007). Fungal models for epigenetic research: Schizosaccharomyces pombe and Neurospora crassa. In: Allis C.D. *et al.*, eds. *Epigenetics*. Cold Spring Harbor, New York: Cold Sprinhg Harbor Laboratory Press: 101-125.

Ancel L.W. (2000). Undermining the Baldwin Expediting Effect: Does Phenotypic Plasticity Accelerate Evolution?. *Theoretical Population Biology*, 58: 307-319, doi: 10.1006/tpbi.2000.1484.

Arbib M.A. (2012). *How the Brain Got Language: The Mirror System Hypothesis*. Oxford-New York: Oxford University Press.

Ariew A. and Lewontin R.C. (2004). The confusions of fitness. *Brit. J. Phil. Sci*, 55: 347-363, doi: 10.1093/bjps/55.2.347.

[22] Chomsky (p. c. 2017) adds: Still seems to me that an overwhelming objection is that it gets us nowhere – thus why does it favor the complex computation of structure-dependence over the trivial computation of linear locality? He then adds: a further point, not understood at the time, is that structure-dependence is the null hypothesis, given automatically if we assume the simplest operation that yields digital infinity. So all of the proposed alternatives would be ruled out even if they did not fail abysmally, at least by the standards of science.

[23] See Piattelli Palmarini and Fodor (2010), for several quotes from the work of distinguished geneticists and evolutionists all stating that natural selection is not the most important factor in evolution.

Baldwin J.M. (1896a). Heredity and Instinct. *Science*, 3, 64 (March 20): 438-441.
Baldwin J.M. (1896b). Heredity and Instinct (II.). *Science*, 3, 67: 558-561.
Baldwin J.M. (1896c). A new factor in evolution. *American Naturalist*, 30, 354: 441-451. Reprinted in: *Basic Baldwin: Selected Works of James Mark Baldwin*, a Mead Project website at the Department of Sociology of Brock University: 536-553.
Berwick R.C. and Chomsky N. (2016). *Why Only Us: Language and Evolution*. Cambridge (MA): MIT Press.
Berwick R.C., Chomsky N. and Piattelli Palmarini M. (2013). Poverty of the Stimulus Stands: Why Recent Challenges Fail. In: Piattelli Palmarini M. and Berwick R.C., eds. *Rich Languages from Poor Inputs*. Oxford: Oxford University Press: 19-42, doi: 10.1093/acprof:oso/9780199590339.003.0002.
Bickhard M.H. (1979). On necessary and specific capabilities in evolution and development. *Human Development*, 22: 217-224, doi: 10.1159/000272443.
Bickhard M.H. (1980). *Cognition, convention, and communication*. New York: Praeger.
Bickhard M.H. (1991). The import of Fodor's anti-constructivist argument. In: Steffe L.P., ed. *Epistemological foundations of mathematical experience*. New York: Springer-Verlag: 14-25, doi: 10.1007/978-1-4612-3178-3_2.
Bickhard M.H. and Campbell R.L. (1992). Some foundational questions concerning language studies: With a focus on categorial grammars and model theoretic possible worlds semantics. *Journal of Pragmatics*, 17, 5/6: 401-433, doi: 10.1016/0378-2166(92)90060-o.
Bickhard M.H. (1995). Intrinsic constraints on language: Grammar and hermeneutics. *Journal of Pragmatics*, 23: 541-554, doi: 10.1016/0378-2166(94)00071-l.
Bickhard M.H. (1998). Levels of representationality. *Journal of Experimental and Theoretical Artificial Intelligence*, 10, 2: 179-215, doi: 10.1080/095281398146824.
Bickhard M.H. (2004). Process and emergence: Normative function and representation. *Axiomathes – An International Journal in Ontology and Cognitive Systems*, 14: 135-169.
Bickhard M.H. (2007). Language as an interaction system. *New Ideas in Psychology*, 25, 2: 171-187, doi: 10.1016/j.newideapsych.2007.02.006.
Bickhard M.H. (2009). The interactivist model. *Synthese*, 166: 547-591, doi: 10.1007/s11229-008-9375-x.
Bickhard M.H. (2015). The social-interactive ontology of language. *Ecological Psychology*, 27, 3: 265-277, doi: 10.1080/10407413.2015.1068656.
Bickhard M.H. and Terveen L. (1995). *Foundational issues in artificial intelligence and cognitive science: Impasse and solution*. Amsterdam: North-Holland.
Bovet D., Bovet Nitti F. and Oliverio A. (1969). Genetic Aspects of Learning and Memory in Mice. *Science*, 163, 3863 (Jan. 10): 139-149.
Briscoe T. (2003). Grammatical assimilation. In: Christiansen M. and Kirby S., eds. *Language Evolution*. Oxford-New York: Oxford University Press: 295-316, doi: 10.1093/acprof:oso/9780199244843.003.0016.
Briscoe T., ed. (2002). *Linguistic Evolution through Language Acquisition*. Cambridge: Cambridge University Press.
Campanella S. (2012). *L'"Ouverture sur les nouveaux possibles' nell'epistemologia piagetiana*. Tesi di Dottorato di ricerca in Filosofia, Sapienza Università di Roma.
Campbell R.L. and Bickhard M.H. (1992). Types of constraints on development: An interactivist approach. *Developmental Review*, 12, 3: 311-338, doi: 10.1016/0273-2297(92)90012-q.
Campbell R.L. and Bickhard M.H. (1986). *Knowing Levels and Developmental Stages*. Basel: Karger.

Campbell R.L. and Bickhard M.H. (1987). A deconstruction of Fodor's anticonstructivism. *Human Development*, 30: 48-59, doi: 10.1159/000273135.

Campbell R.L. (1998). Why Chomskyan linguistics is antipsychological. In: Gernsbacher M.A. and Derry S.J., eds. *Proceedings of the Twentieth Annual Conference of the Cognitive Science Society*. Mahwah (NJ): Erlbaum: 208-213.

Changeux J.P., Courège P. and Danchin A. (1973). A Theory of the Epigenesis of Neuronal Networks by Selective Stabilization of Synapses. *Proceedings of the National Academy of Sciences USA*: 2974-2978.

Chater N., Reali F. and Christiansen M.H. (2009). Restrictions on biological adaptation in language evolution. *Proceedings of the National Academy of Sciences USA*, 106: 1015-1020.

Cowie F. (1999). *What's Within? Nativism Reconsidered*. New York-Oxford: Oxford University Press.

Cowie F. (2000). Whistling "Dixie": Response to Fodor. In: Nani M. and Marraffa M., eds. *E-Symposium on Fiona Cowie's 1999 What's Within? Nativism Reconsidered*. (Vol. Book Symposia). Roma, http://host.uniroma3.it/progetti/kant/field/booksymp.html.

Dawkins R. (1996). *Climbing Mount Improbable*. New York: W.W. Norton & Co.

Dennett D.C. (1997). *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. New York: Simon & Schuster.

Dennett D.C. (2003). The Baldwin Effect: A crane, not a skyhook. In: Weber B.H. and Depew D.J., eds. *Evolution and Learning. The Baldwin Effect Reconsidered*. Cambridge (MA): MIT Press: 69-79.

Dobzhansky T. (1970). *Genetics of the Evolutionary Process*. New York: Columbia University Press.

Edelman G.M. (1987). *Neural Darwinism: The Theory of Neuronal Group Selection*. New York: Basic Books.

Fodor J. and Piattelli Palmarini M. (2010). *What Darwin Got Wrong*. New York: Farrar, Straus & Giroux.

Fodor J. and Piattelli Palmarini M. (2011). *What Darwin Got Wrong (Paperback, with an update, and a reply to our critics)*. New York: Picador Macmillan.

Fodor J. *et al.* (1980). Against definitions. *Cognition*, 8: 263-367, doi: 10.1016/0010-0277(80)90008-6.

Gibson E. and Wexler K. (1994). Triggers. *Linguistic Inquiry*, 25, 3: 407-454.

Godfrey-Smith P. (2003). Between Baldwin scepticism and Baldwin boosterism. In: Weber B.H. and Depew D.J., eds. *Evolution and Learning: The Baldwin Effect Reconsidered*. Cambridge (MA): MIT Press: 53-67.

Hinton G.E. and Nowlan S.J. (1987). How learning can guide evolution. *Complex Systems*, 1: 495-502.

Jablonka E. and Raz G. (2009). Transgenerational epigenetic inheritance: prevalence, mechanisms, and implications for the study of heredity and evolution. *The Quarterly Review of Biology*, 84: 131-176, doi: 10.1086/598822.

Jirtle R.L. and Skinner M.K. (2007). Environmental epigenomics and disease susceptibility. *Nature Reviews: Genetics*, 8 (April): 253-262, doi: 10.1038/nrg2045.

Levine A. and Bickhard M.H. (1999). Concepts: Where Fodor went wrong. *Philosophical Psychology*, 12, 1: 5-23, doi: 10.1080/095150899105909.

Lewontin R.C. (1998). The evolution of cognition: Questions we will never answer. In: Scarborough D. and Sternberg S., eds. *An Invitation to Cognitive Science – Vol. 4 Methods, Models and Conceptual Issues*, Vol. 4. Cambridge (MA): MIT Press: 107-132.

Longa V.M. (2006). A misconception about the Baldwin Effect: Implications for language evolution. *Folia Linguistica*, 40, 3-4: 305-318, doi: 10.1515/flin.40.3-4.305.

Longa V.M. (2009). Everything You Wanted to Know About the Genetics of Language (and Beyond). *Biolinguistics*, 3, 4: 412-419.

Minelli A. (2003). *The Development of Animal Form: Ontogeny, Morphology, and Evolution*. Cambridge: Cambridge University Press.

Minelli A. (2015). EvoDevo and Its Significance for Animal Evolution and Phylogeny. *Evolutionary Developmental Biology of Invertebrates*, 1: 1-23, doi: 10.1007/978-3-7091-1862-7_1.

Minsky M. (1961). Steps toward Artificial Intelligence. *Proceedings of IRE*, 49: 8-30, doi: 10.1109/jrproc.1961.287775.

Minsky M. and Papert S. (1972). *Perceptrons: An Introduction to Computational Geometry*. Cambridge (MA): MIT Press.

Musso M. *et al.* (2003). Broca's area and the language instinct. *Nature Neuroscience*, 6, 7: 774-781, doi: 10.1038/nn1077.

Perfors A., Tenenbaum J.B. and Regier T. (2006). Poverty of the simulus? A rational approach. In: Sun R. and Miyaki N., eds. *Proceedings of the Twenty-Eighth Annual Conference of the Cognitive Science Society*. Mahwah (NJ): Erlbaum: 663-668.

Perfors A., Tenenbaum J.B. and Regier T. (2011). The learnability of abstract syntactic principles. *Cognition*, 118, 3: 306-338, doi: 10.1016/j.cognition.2010.11.001.

Piaget J. (1929). Les races lacustres de la Limnaea stagnalis L.: recherches sur les rapports de l'adaptation héréditaire avec le milieu. *Bulletin biologique de la France et de la Belgique*, 63, 3: 424-455.

Piaget J. (1971). *Science of education and the psychology of the child*. New York: Viking Press.

Piaget J. (1977). Foreword. In: Gruber H.E. and Vonèche J., eds. *The essential Piaget*. London: Routledge and Kegan Paul.

Piaget J. (1987) Reflections on Baldwin. An Interview conducted in March 1979 by J.J. Vonèche. In: Broughton J.M. and Freeman-Moir J., eds. *The cognitive developmental psychology of J.M. Baldwin*. Norwood: Ablex Publishing Corporation: 80-86.

Piattelli Palmarini M., ed. (1979). *Théories du langage, théories de l'apprentissage: le débat entre Jean Piaget et Noam Chomsky*. Paris: Éditions du Seuil.

Piattelli Palmarini M., ed. (LL). *Language and Learning: The Debate between Jean Piaget and Noam Chomsky*. Cambridge (MA): Harvard University Press, 1980.

Piattelli Palmarini M. (1989). Evolution, selection and cognition: from "learning" to parameter setting in biology and in the study of Language. *Cognition*, 31: 1-44, doi: 10.1016/0010-0277(89)90016-4.

Piattelli Palmarini M. (1994). Ever since language and learning: afterthoughts on the Piaget-Chomsky debate. *Cognition*, 50: 315-346, doi: 10.1016/0010-0277(94)90034-5.

Piattelli Palmarini M. e Fodor J. (2010). *Gli Errori di Darwin*. Milano: Feltrinelli.

Piattelli Palmarini M. (2018). Fodor and the innateness of all (basic) concepts. In: de Almeida R.G. and Gleitman L., eds. *Concepts, Modules, and Language: Cognitive Science at its Core*. Oxford: Oxford University Press: 211-237.

Pinker S. and Bloom P. (1990). Natural language and natural selection. *Behav Brain Sci*, 13, 4: 707-784, doi: 10.1017/s0140525x00081061.

Putnam H. (1975). Probability and Confirmation. In: *Philosophical Papers, Vol I: Mathematics, Matter and Method*. Cambridge: Cambridge University Press: 293-304.

Reali F. and Christiansen M.H. (2005). Uncovering the richness of the stimulus: structure dependence and indirect statistical evidence. *Cognitive Science*, 29: 1007-1028, doi: 10.1207/s15516709cog0000_28.

Reidy M. *et al.* (2014). Hsp40s Specify Functions of Hsp104 and Hsp90 Protein Chaperone Machines. *PLoS Genet*, 10, 10: e1004720, doi: 10.1371/journal.pgen.1004720.

Richards R.J. (1987). *Darwin and the Emergence of Evolutionary Theories of Mind and Behavior*. Chicago: University of Chicago Press.

Romanes G.J. (1882). *Animal Intelligence*. New York: D. Appleton and Company.

Rutherford S.L. and Henicoff S. (2003). Quantitative epigenetics. *Nature Genetics*, 33: 6-8, doi: 10.1038/ng0103-6.

Rutherford S.L. and Lindquist S. (1998). Hsp90 as a capacitor for morphological evolution. *Nature*, 396: 336-342, doi: 10.1038/24550.

Slack J.M.W. (2002). Conrad Hal Waddington: the last Renaissance biologist? *Nature Reviews: Genetics*, 33: 889-895, doi: 10.1038/nrg933.

Sollars V. *et al.* (2002). Evidence for an epigenetic mechanism by which Hsp90 acts as a capacitor for morphological evolution. *Nature Genetics*, 33, 1: 70-74, doi: 10.1038/ng1067.

Vercelli D. and Piattelli Palmarini M. (2009). Language in an epigenetic framework. In: Piattelli Palmarini M., Uriagereka J. and P. Salaburu, eds. *Of Minds and Language: A Dialogue with Noam Chomsky in the Basque Country*. Oxford: Oxford University Press: 97-107.

Waddington C.H. (1957). *The Strategy of the Genes*. London: Routledge.