Language as a natural object; Linguistics as a natural science

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<u>Abstract</u>: The Chomskyan revolution in linguistics in the 1950s in essence turned linguistics into a branch of cognitive science (and ultimately biology) by both changing the linguistic landscape and forcing a radical change in cognitive science to accommodate linguistics as many of us conceive of it today. More recently Chomsky has advanced the boldest version of his naturalistic approach to language by proposing a Minimalist Program for linguistic theory. In this paper, we wish to examine the foundations of the Minimalist Program and its antecedents and draw parallelisms with (meta-)methodological foundations in better-developed sciences such as physics. Once established, such parallelisms, we argue, help direct inquiry in linguistics and cognitive science/biology and unify both disciplines.

1.

We are among those who are persuaded, on solid grounds we think, that in the past 50 years linguistics has progressively established itself as a genuinely scientific discipline. As physics, then biology, have taught us, there is always a price to pay for that, and linguistics is no exception. Many aspects of language that capture our attention and stimulate our curiosity as laypersons have been left out of the scientific picture, for instance literary style, the social differentiation of accents and nuances, creativity in writing, and the growth of specialized jargons in different walks of life. By and large, with few notable exceptions, all that spans over and above the single sentence has been left out of the research program. This self-imposed restriction has been very productive,

as the history of the discipline amply shows, and as we are going (all too briefly) to summarize here.

By focusing on questions (I) and (II) linguists have grounded their discipline firmly in the study of the individual mind.

(I)   What is knowledge of language?

(II)   How does knowledge of language arise in the individual?

The general answer provided in Chomsky's early work (Chomsky 1955, 1965) and refined over the years is that there is a rich, innate, species-specific component of the mind dedicated to language (the faculty of language [FL]). Knowledge of language is a property of the mind of the speaker-hearer/signer (ultimately a state of his/her brain), encompassing modes of operation (computational strategies) and specific contents, at the very least ways of categorizing Phrase-Structural constituents and establishing transformational relations among lexical items in the sense of Chomsky (1955, 1957). This mental state grows naturally in the biologically normal individual on the basis of radically impoverished and limited external linguistic input. As Chomsky (1959) convincingly argued, no 'blank slate' theory relying solely on external input can account for the creative aspect of language use and the extreme subtlety of the underlying derivations. Native speakers of any language are able to produce and understand without any effort sentences of that language that they have never heard or produced before. Chomsky's rejection of any behaviorist account, which sees language as a list of behaviors acquired by some version of operant conditioning, helped shape what came to be known as the 'second cognitive revolution' – the revival of long-forgotten Cartesian

concerns related to the nature of the mind/brain (see Chomsky 1966; see also Fodor 2003).

This approach to linguistics led to an explosion of research in traditional areas of inquiry such as syntax, phonology, morphology, and semantics, as well as to the development of subfields such as psycholinguistics and language acquisition. Relentless attention has been paid to data from a variety of languages and dialects, and many crucial lessons have been derived from a novel approach to comparative linguistics, leading to successive revisions of the initial hypotheses. By now this work has revealed principles of great subtlety, abstractness, and deductive richness. Such results are due essentially to the adoption of an explicitly biological perspective on language. As Chomsky has repeated at various stages, linguistics, studied from a generative perspective, "is really theoretical biology" (Sklar 1968:217). 'Theoretical' here is meant in the sense of 'theoretical morphology' (see McGhee 1998). Those that Kauffman (1993) characterizes as 'Rationalist morphologists' such as Goethe, and St Hilaire, had already recognized that extant organismal forms are only a subset of the range of theoretically possible morphologies. The primary question of Theoretical Morphology, quoted in (III) parallels the one within Generative Grammar outlined in detail in Chomsky (1965:chap. 1).

(III)   *The goal is to explore the possible range of morphologic variability that nature could produce by constructing n-dimensional geometric hyperspaces (termed "theoretical morphospaces"), which can be produced by systematically varying the parameter values of a geometric model of form. […] Once constructed, the range of existent variability in form may be examined in this hypothetical morphospace, both to quantify the range of*

existent form and to reveal nonexistent organic form. That is, to reveal

morphologies that theoretically could exist (...) but that never have been

produced in the process of organic evolution on the planet Earth. <u>The ultimate</u>

<u>*goal of this area of research is to understand why existent form actually exists*</u>

<u>*and why nonexistent form does not*</u>. (McGhee 1998:2; emphasis ours)

An answer to the linguistic equivalent of (III) was part of the abstract requirements

(IV), stated by Chomsky in (1965:31) to characterize explanatory adequacy.

(IV)   ..we must require of such a linguistic theory that it provide for

[(A)]   (i)   an enumeration of the class s_1, s_2...of possible sentences

(ii)   an enumeration of the class SD_1, SD_2...of possible structural descriptions

(iii)   an enumeration of the class $G_1, G_2,$... of possible generative grammars

(iv)   specification of a function f such that $SD_{f(i,j)}$ is the structural description assigned to sentence s_i by grammar G_j, for arbitrary i,j

(v)   specification of a function m such that $m(i)$ is an integer associated with grammar G_i as its value (with. Let us say, lower value indicated by higher number)

A device that met these requirements could utilize the linguistic input to the child to form adequate grammars. The fifth condition, the "evaluation metric" orders the biologically available grammars along an accessibility hierarchy. The language acquisition device (i.e., a dedicated component of the child's mind) chooses the most highly valued grammar (the one with the lower integral value in (v)) compatible with the

4

assignment of structural descriptions for every sentence of the input received up to that moment. Thus, the evaluation metric in combination with the input selects a grammar and this is what language acquisition amounts to (for an early synthesis, see Pinker 1979, 1984; for a general mathematical treatment of learnability issues, see Osherson, Stob and Weinstein 1986, and, for a recent overview of parametric language acquisition, see Fodor 2001).

Clearly, the empirical challenge is to specify the evaluation function in (v) and the class of possible generative grammars in (iii). Restricting the class of possible grammars proved to be quite successful. In particular, research into the properties of transformations led to the discovery that certain grammatical configurations were immune to alterations of certain sorts (see especially Chomsky 1973).

There was, however, little progress on point (v) above. Stated from a cognitive perspective the issue is this: The acquisition problem is bounded by two undisputable orders of facts. First, the radically impoverished nature of external evidence used during the acquisition process. Second, the fact that languages (and their grammars) differ across the planet. So, the problem facing the child is to choose a grammar that fits the input from the class of all humanly possible grammars. The evaluation measure orders the class of possible grammars in a descending order of desirability. The task, then, is to take the input and find the "best" (i.e. highest ranked) grammar that fits.

Although this characterization is abstractly correct, it proved to be hard to implement. In fact, arguably for the first time in the history of linguistics, the outline of a solution appeared on the horizon with the introduction of the so-called principles and parameters (P&P) model (Chomsky 1981).

According to the P&P approach, children come equipped with a set of principles of grammar construction (i.e. Universal Grammar (UG)). The principles of UG have open parameters. Specific grammars arise once values for these open parameters are specified, on the basis of the input. A language specific grammar, then, is simply a specification the values that the principles of UG leave open. This (for linguistics) highly innovative "panel of switches" model (Higginbotham 1982) conceives of the acquisition process as sensitive to the details of the environmental input (in the context of the biological maturation of the mind-brain and of the development of other cognitive capacities). In this maturational context, it is, in fact, the linguistic input itself that allows to select the parameter values unambiguously. However, the shape of the knowledge attained (the structure of the acquired grammar) is not limited to information that can be gathered from the input, since the latter exercises its influence against the backdrop of the rich principles that UG makes available.

The P&P approach led to an explosion of comparative grammatical research that exploited this combination of fixed principles and varying parametric values. In spite of hard problems, theoretical revisions and still lingering perplexities about many details, this whole novel approach showed that languages, for all their apparent surface diversity, could indeed be seen as patterns with a common fixed core. For the first time linguists had the tools to provide a general answer to why human languages are fundamentally the same, and yet so different. With the aid of parameters, languages whose grammars appear radically different are in fact structurally almost identical, differing by one, or few simply stated rules. As Baker has recently expressed (Baker 2001), the discovery of such points of variation promises to yield a linguistic equivalent to the periodic table of elements.

At the same time, the P&P approach enabled the development of a comprehensive theory of language acquisition (see Roeper and Williams 1986, Hyams 1986, and for a recent review, Guasti 2002). In particular, it helped linguists formulate a selective theory (as opposed to an instructive one) of language growth (in the well consolidated sense given to these notions in biology; see Piattelli-Palmarini 1986, 1989). More recently, the detailed theory of language acquisition elaborated in the last 20 years has been put to use in the context of language deficits such as Specific Language Impairment, leading Wexler 2002 to claim that the P&P model may well provide the basis to realize Lenneberg's dream of findings the biological foundations of language (Lenneberg, 1967).

Significantly, the P&P view found rather direct parallels in biology. As Chomsky (1980:67) already noted, the P&P approach was "rather similar" to the problem of biological speciation, as discussed by molecular biologist Francois Jacob (1977). Focusing on the remarkable constancy of biochemical building-blocks throughout the living world, and on their combinatorial powers, Jacob had written that

It was not biochemical innovation that caused diversification of organisms ... What accounts for the difference between a butterfly and a lion, a chicken and a fly, or a worm and a whale is not their chemical components, but varying distributions of these components… specialization and diversification called only for regulatory circuits, which either unleash or restrain the various biochemical activities of the organism, that the genetic program is implemented. [In related organisms, mammals for example], the diversification and specialization ... are the result of mutations which altered the organism's regulatory circuits more than

its chemical structures. The minor modification of redistributing the structures in time and space is enough to profoundly change the shape, performance, and behavior of the final product (quoted in Chomsky 1980:67)

On his way toward developing the P&P framework in linguistics, and stressing a close parallel with biology, Chomsky observed that

In a system that is sufficiently intricate in structure, small changes at particular points can lead to substantial differences in outcome. In the case of growth of organs, mental organs in our case, small changes in parameters left open in the general schematism can lead to what appear to be very different systems. (Chomsky 1980: 67)

The explanatory model based on a fixed and rather limited repertoire of constituent blocks, susceptible of being multiply recombined and integrated into larger functional units, under precise constraints, has been extended from the biochemical constituents all the way up to the assembly of whole genomes. In the last several years, in fact, the discovery of regulatory "master" genes and the remarkable conservation of their sequences and modes of operation across the living world give new substance to, and specify remarkable details for, the very idea that minute parametric variations in the developmental plan of the organism lead to dramatic differences in the terminal phenotypes (for an earlier entry-level summary, see McGinnis and Kuziora 1994) Even more recently, the epigenetic modulation of traits encoded in identical genomes opens up a further dimension of biological variability whose bounds and consequences are still being debated as we write (For an early insight, see Changeux 1980; for a recent entry-level summary Gibbs, 2003; for the very idea of a "histone code", see Grewal and

Moazed 2003; Jaenisch and Bird 2003). For several years now selective (as opposed to instructive) theories have been known to operate in other biological systems besides language. Niels Jerne's Nobel awarded work, for instance, introduced a selective theory of antibody formation, whereby antigens select antibodies that already exist in an individual's immune system.[1] Tonegawa's later work, also rewarded with a Nobel prize, unraveled the details of the genetic recombinations that give rise to the awe-inspiring immune repertoire generated anew in each individual – see his 1987 Nobel Lecture (Tonegawa 1993)). The abandonment of the traditional associative models of instructive, general-purpose learning in animal psychology in general, with a radical reinterpretation of the data on classical conditioning, and a strong plea for the switch to neurally specialized learning modules, subject to selection, is expressed by Gallistel (Gallistel 2000). He presently also recommends a reconceptualization of the whole notion of associative learning, a shift away from single physical stimuli toward irreducibly abstract invariants in the informational content (in Shannon's sense) of whole flows of events (Gallistel 2002).

Such parallelisms between biology and cognitive science, and between biology and linguistic in particular, reinforced the position of linguistics as a branch of biology, a position characterized as making "eminent sense" already several years ago by Luria (1973:141) (see also Monod 1974:129; Jacob 1976:322; and Jerne 1985:1059).

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[1] For discussions of the impact of these ideas in linguistics and cognitive science, see Chomsky 1980, esp. pp. 136-7, where a parallel is made with Peircean abduction; see also Piattelli-Palmarini 1986 on selective theories in biology and their relevance for linguistics.

2.

In light of the success of the P&P model[2] the central questions of the generative enterprise led quite naturally to further refinements, to elegant deeper simplifications and ended up being, in a sense, transcended in a novel, bolder move: an attempt to go "beyond explanatory adequacy" (Chomsky 2004). Chomsky returned to an early concern of his, stated in *Aspects* but which had so far resisted genuine breakthroughs: Why is Language the way it is?

Chomsky (1965:6) had noted that

There is surely no reason today for taking seriously a position that attributes a complex human achievement [language in this case] entirely to months (or at most years) of experience, rather than to millions of years of evolution or to principles of neural organization that may be even more deeply grounded in physical law.

Let's notice the appeal to physical (or, equivalently, to formally necessary and universal) explanations, over and beyond the biologically contingent ones. In recent years, this theme has been addressed under the rubric of the minimalist program.

In its strongest formulation the central thesis in the Minimalist Program conjectures that the computational system ('narrow syntax') central to human language is an 'optimal'

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[2] We think that there is sense in which a parametric model of language acquisition is "logically" necessary, under the constraints of the poverty of stimulus, a selective (not instructive) acquisition process, and the morpho-lexical variability of languages. We cannot develop this idea here, but suffice it to stress the insurmountable difficulties faced by the pre-parametric (transformational) theories of language learnability and the considerable progress suddenly made possible by parametric approaches. This logical necessity holds, we think, in spite of lingering uncertainties, some of which considerable, as to a final exact characterization of all the parameters.

solution to the central task of language: relating sound and meaning. This strong thesis

will be vindicated insofar as the complexities apparent in earlier approaches are

discharged onto more peripheral components (interfaces with other cognitive

apparatuses) and, in this sense, eliminated, or else shown to be only superficial, entirely

derivable from deeper, and simpler properties.[3]

Considerable progress in this direction over the last 10 years or so constitutes, we

think, a partial vindication already. It is still uncertain, at this point, whether the strong

version of the Minimalist Program – a sort of ideal limit – can actually be reached. A

weaker, and in this sense less controversial, formulation is that the minimal program *qua*

program is fecund, and well worth pursuing.[4] There is no denying that insistence on

minimalist questions has helped reorient research concerns and directions by forcing

researchers to ask at every point of inquiry whether the technology they are using for

descriptive adequacy actually has a principled basis, and what they are calling

"explanation" is really description by ad hoc technology, or is actually principled

explanation – that notion now having a characterization in terms of interface conditions

and general principles that go beyond language, maybe beyond organisms. [5]

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[3] As Freidin and Vergnaud 2001 and Boeckx and Hornstein 2003 note, the two
approaches were clearly identified by Dirac in 1968. One method consists in removing
the inconsistencies, "pinpointing the faults in [the theory] and then tr[ying] to remove
them, (…) without destroying the very great successes of the existing theory." The other
method consists in unifying theories that were previously disjoint. Germane reflections,
and similar (or identical, in a couple of cases) quotes from the great physicists that are
relevant to the Minimalist Program are also to be found in Epstein and Seely 2002.
[4] This is arguably what Chomsky often refers to as the therapeutic value of the program.

[5] We are grateful to Noam Chomsky (personal communication) for suggesting these
clarifications in the present version of this paper.

Stated thus, the Minimalist Conjecture is no different from the emphasis in Theoretical Morphology on "model[ing] existent form with a minimum of parameters and mathematical complexity." (McGhee 1998:2). In fact, Minimalism instantiates in the domain of linguistic theory a recurrent and deep-seated urge characteristic of the mature sciences in general. As the Nobelist physicist Richard P. Feynman (1963:26) once put it:

Now in the further advancement of science, we want more than just a formula. First we have an observation, then we have numbers that we measure, then we have a law which summarizes all the numbers. But the real glory of science is that we can find a way of thinking such that the law is evident.

Or, in the words of Einstein,

[the purpose of physics is] not only to know how nature is and how her transactions are carried through, but also to reach as far as possible the Utopian and seemingly arrogant aim of knowing why nature is thus and not otherwise.
(cited in Weinberg 2001:127)

We suspect that this 'seemingly arrogant' aim of the Minimalist Program is what many have found irksome. But as Feynman's quote reveals, once observational [observation], descriptive ['numbers'], and explanatory ['law'] levels of adequacy are reached, the desire to go "beyond explanatory adequacy" (Chomsky 2004) naturally emerges, and makes sense in the context of a naturalistic approach to language (Chomsky 2000a) As Chomsky has stressed over the years (see, e.g., Chomsky 2000b:92), the Minimalist Program is just that: a "program," a mode of investigation, "not a theory." The question is not whether this new development in the field is legitimate, but rather whether it is

premature. Only time will tell, but the rewards of trying promise to be greater than those of simply waiting.

Let us focus on one telling example. The GB era devoted considerable attention to the licensing of 'traces' left by movement, and contrasted examples like (1) and (2).

(1)   What did John say that Peter bought *t*?

(2)   *What did John wonder whether Peter bought *t*?

All native speakers of English consider (1) acceptable, and most consider (2) unacceptable (whence the asterisk that precedes it). Every native speaker perceives it as sharply less well formed than (1). The general line of research (see Chomsky 1986) to explain a variety of such phenomena was that traces of movement are subject to two kinds of licensing (technically known as 'proper government'): licensing by neighboring element such as a verb ('head-government') or licensing by the moving element itself('antecedent government'). Rizzi (1990) argued that the definition of the two kinds of licensing can be made symmetric by relativizing the so-called Minimality condition on government to the type of licenser. The technical details here don't matter. What is important is that Rizzi's effort was driven toward a simplification of a technical definition. The definition itself has now fallen into disrepute, but, crucially, Chomsky and Lasnik (1993:89f.) were able to see beyond the technicalia and extracted a condition on movement that is now taken to reflect a fundamental 'minimalist' feature of language. As Chomsky and Lasnik note, "the basic and appealing intuition that lies behind the principle of Relativized Minimality [Rizzi (1990)] is not really captured by the mechanisms proposed, which list three arbitrary cases and add unexplained complexity"

(p. 89). They note further, "[t]he basic intuition is that the operation [of movement] should always try to construct "the shortest link." " (p. 89)

That is, in (2) movement of *what* crosses an element of the same type (*whether*) that occupies a position that could be occupied by *what* (cf. *John wondered what Peter bought*).

Chomsky and Lasnik go on to elevate Relativized Minimality to a "general principle of economy of derivation." (p. 90) Since then, considerations of economy have been the major focus of research in syntactic theory. Chomsky and Lasnik's perspective on Relativized Minimality has allowed numerous cases that originally did not fall within the definition of trace licensing to be incorporated into the general guideline of economy, thereby strengthening the central minimalist thesis that syntactic computation is optimal. If true, the minimalist conjecture, which, it is worth stressing, is deeply seated within the generative approach,[6] invites us to revisit the position of linguistics within the biological sciences. This is clearly expressed in Chomsky (1995:introduction; to appear). If the minimalist conjecture about the optimal character of the language organ turns out to be tenable, one will be able to draw "conclusions of some significance, not only for the study of language itself" (Chomsky 2004: 25), but for the biological world at large. It was in effect anticipated in Chomsky (1991:6), where the following question is raised: "How can we integrate answers to [the central] questions [of linguistic theory] within the existing natural sciences, perhaps by modifying them?"

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[6] Freidin and Vergnaud (2001) highlight the presence of economy and simplicity considerations, now central to the Minimalist Program, in Chomsky's earliest writings (Chomsky 1951, 1955).

3.

It is clear what the challenge posed to biology by the minimalist program is. The minimalist program has a particularly strong commitment to the Galilean vision of natural phenomena and theory construction, the belief, held by all major proponents of modern science, from Kepler to Einstein, that nature is the realization of the simplest conceivable mathematical ideas, and the idea that a theory should be more highly valued if "from a logical standpoint, it is not the result of an arbitrary choice among theories which, among themselves, are of equal value and analogously constructed." (Einstein 1949:23), a theory "which give[s] us a sense that nothing could be changed. (…) a sense of uniqueness, (…) a sense that when we understand the final answer, we will see that it could not have been any other way," (Weinberg 2001:39) a search for principles that "give theories a sense of rigidity" (Weinberg 1993:147), "of inevitability" (Weinberg 1987:64).

This minimalist/Galilean view on language and linguistic theory is at odds with the general beliefs held by mainstream biologists until very recently, and by the majority of them to this day.

As Fox Keller (2002:1) insightfully notes, whereas physicists "seek to expand the boundaries of knowledge until nothing (…) in the physical universe is left unexplained", "the ambitions of biologists are manifestly less grandiose." They don't "seem to share [the same] concept of theory", of "what counts as an explanation" (p. 3). Throughout her book, Fox-Keller emphasizes the cultural divide between physicists and biologists, and notes the marginal role played within biology by figures like D'Arcy Thompson and Alan

Turing, who devoted their energy to carry out a Galilean program for biology. Thompson (1942) was quite clear that attention should be drawn to "simple, or simplified, cases of phenomena which in their actual and concrete manifestations are usually too complex for mathematical analysis" (p. 643) – a good example of the idealizing method typical of Galileo (see Dijksterhuis 1986). Thompson was at pain to emphasize the need of "a principle of negligibility", to "learn from the mathematician to eliminate and discard; to keep the type in mind and leave the single case, with all its accidents, alone." Without this method, "there would have been no Kepler, no Newton." (p. 1029)

This is clearly parallel to Chomsky's oft-made assertion that idealization is a misnomer, as it brings us closer to the truth.[7]

As Fox-Keller notes, biologists are not sympathetic to idealization, seeing it as a "weakness", a lack of "satisfying explanation" (p. 74), always requiring "more measurement and less theory" (p. 87).

Not surprisingly, 'opponents'[8] to the minimalist program have taken issue with the Galilean method, claiming that the pursuit of the minimalist program only served to "dissociate linguistics from biology" (Jackendoff 2002:94).

This point is made particularly clear in Culicover and Jackendoff (2004:2-3), who note that "our general vision of language conforms not to the majestic Galilean perspective, but rather to a view, attributed to Francois Jacob, of biology as a "tinkerer"." Likewise, Jackendoff (1997:20) notes that "it is characteristic of evolution to invent or

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[7] For additional remarks on the Galilean methods, see Chomsky's interviews with Belletti and Rizzi (Chomsky 2002a) and with Fukui (Chomsky 2002b).

[8] We put 'opponents' in quote, as it is unclear to us what it means to oppose a program understood in the sense above. Surely, one should welcome an attempt to enhance explanatory adequacy (the 'therapeutic' aspect of minimalism).

discover "gadgets." (…) The result is not "perfection." " Jackendoff goes on to say that he would "expect the design of language to involve a lot of Good Tricks (…) that make language more or less good enough. (…) But nonredundant perfection? I doubt it." He also adds,

> *This is not to say that we shouldn't aim for rigor and elegance in linguistic analysis. Admitting that language isn't "perfect" is not license to give up attempts at explanation. In particular, we still have to satisfy the demands of learnability [explanatory adequacy in Chomsky's 1965 sense]. It is just that we may have to reorient our sense of what "feels like a right answer" away from Chomsky's sense of "perfection" toward something more psychologically and biologically realistic. It may then turn out that what looked like "imperfections" in language (…) are not reason to look for more "perfect" abstract analyses, as Chomsky and his colleagues often have done; rather, they are just about what one should expect.* (p. 20)

To paraphrase, since Jackendoff (and others) assumes that language is the product of adaptive pressures, language is expected to consist of a hodgepodge of loosely interacting computational tricks. If that is the case, the search for arestricted core of deep abstract principles would be doomed from the start.

Jackendoff is quite correct on one historical point. Perfection is not what we expect from biological systems, at least when it comes to their use, and to the extent that they have arisen through the pressures of natural selection. But, as Noam Chomsky points out (personal communication), Jacob is not pronouncing a dogma when resorting to his notion of tinkering. He is merely noting that to the extent that something evolves through

a long and intricate process of natural selection, with path-dependent effects on later steps, accidents, etc., then we expect tinkering. But we certainly don't expect tinkering for cell division into spheres, or for what Gould and Lewontin 1979 have called 'spandrels,' for example. In such cases, Jacob's reasoning just doesn't apply.

Unless there is some reason to dismiss the exaptation hypothesis, Jackendoff's remarks don't weigh much.

Furthermore, Jackendoff's appeal to learnability strikes us as a serious misunderstanding of the P&P approach. As noted above (see also Boeckx and Hornstein 2003 and Chomsky to appear), its primary contribution, in the present connection, was to divorce questions of learning entirely from the question of the "format for grammar", and thus to make it possible, for the first time, to address seriously what had always been understood to be the basic problems of biology of language: what is specific to the language faculty and what follows from laws of physical organization.

To reiterate our point: Although this picture is being reevaluated in biology, the prevailing trend for quite some time, and clearly expressed by Janckendoff, has been in favor of explanations based on tinkering and satisficing, rather than optimization and economy.[9] But the point of the minimalist program is to invite us to think that use aside, language as a biological system shows the kind of perfection investigated by physicists in other domains. Moreover, it's worth pausing a moment to see how the perspective in biology itself, at least in the novel orientation of some of its exponents, is slowly

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[9] It is in this historical perspective that we should understand Chomsky's repeated cautionary remarks to the effect,that the minimalist program "may still be premature" (2001:1), or even "might not be appropriate at the current level of understanding" (2000b:93). He has clearly stated that it would be "strange and surprising" (2000b:96) if the minimalist theses were true.

changing. Jacob's tinkering is an undeniable and pervasive fact, but an excessive insistence on tinkering alone may have obscured deeper organizing principles. Jacob has insisted on the fivefold independent evolutionary invention of the eye as a paradigm of tinkering. But the recent discovery of the master gene Pax6 (one of the homeodomain transcription factors, a patterning gene) reveals a quite different picture (Diez del Corral and Storey 2001). The activation of Pax6, wherever it takes place, organizes the surrounding tissue into an eye. The morphology that emerges can be quite different, from the hundreds of ommatides in an insect eye to the smooth globular structure of a mammalian eye. The pathways of development are remarkably conserved, while the differences reside almost literally in a parametric switch. The transduction of insect master genes into mammals shows that they are still active as morphogenetic initiators in spite of millions of years of evolution separating these phyla. The idea that the eye was invented by evolution five different times in five totally different ways is not tenable any more. Rather, it seems to be the case that a deeper organizational motif is common to all these instantiations of the eye. Minute developmental switches account for large differences in the final adult morphology. More generally, recent developmental genetic analyses are uncovering the existence of genes that are structurally and functionally homologous, with comparable and interchangeable function in the development of the brain in insects and vertebrates (Sprecher and Reichert 2003). The key patterning genes involved in embryonic brain development in insects and vertebrates support the hypothesis of a common, monophyletic overall Bauplan, in spite of striking differences in the adults.

The independent evolutionary origin of the two brain types, traditionally taken for a fact, is actually being questioned. Other authors have recently reported that the principles of surface distribution in the spatial layout of the cerebral cortex minimize total connection costs to an extent previously unsuspected, revealing a remarkable level of "neuro-optimality" (sic), down to best-in-a-billion, and beating even the best results obtained in artificial micro-circuit design optimization. These natural optimization models have predictive power in the reconstruction of the structure of sensory areas in the cat and the macaque cerebral cortices (Cherniak, Mokhtarzada, Rodriguez-Esteban & Changizi, 2004).

All in all, powerful unifying mechanisms and deeper optimization criteria are emerging also in biology [10]. As D'Arcy Thomson and Turing had insightfully anticipated, we are witnessing the slow, but steady, emergence of impassable outer boundaries for the vagaries of tinkering and natural selection. Jacques Monod always had it very clear that the role of chance in determining the manifold structures of living beings could be properly understood only within the boundaries of physico-chemical (and today we may

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[10] It is worth stressing that these different orders of factors in biological evolution, and in the explanation of extant biological structures and functions, are complementary, rather than antagonistic (see Gould 2002 for an emphatic defense of this point of view). Jacob's insistence on tinkering is to be complemented with his classic work (with Monod) on gene regulation, whereby, for the first time, the digital (switch-like, in their own terminology) modular (in more recent terminology) and universal nature of the activation and repression of single genes was introduced in the "logic" of biological thinking. These inner, more abstract, constraints on biological evolution will surely not deny the role of natural selection, though a radical reappraisal of its power and patterns of action may be expected. Without such a suitable re-contextualization, the role of standard Darwinian adaptationism in explaining the evolution of language will continue to be minor. (For a novel tentative reconstruction of the sudden appearance of language, the role of recursiveness-Merge and the possible selective role of bilingualism in the human diaspora as a determinant of the differentiation among languages, see Piattelli-Palmarini and Uriagereka, in press).

add computational and algorithmic) necessity (see his 1965 Nobel Lecture (Monod 1972)). It was the "necessity" half of his unified conception of life as "chance and necessity."

The past decade has witnessed an explosion of publications touching on the 'evolution'[11] of language (see Christiansen and Kirby 2003 for a comprehensive overview). Most of it has taken place either outside the horizons of generative grammar (Rizzolatti and Arbib 1998; Deacon 1997), or clearly as a global antidote to it (see, for instance, Lieberman 2000). Other authors have taken generative grammar into careful consideration, suggesting alternatives and radical revisions (Bickerton 1990). More recently, Ray Jackendoff, a former protagonist in this line of inquiry, has been recommending a cautionary attitude of dissociation from minimalism, largely on speculative evolutionary grounds (see Jackendoff 2002; Pinker and Jackendoff, submitted) .

This is hardly surprising in light of the success of the Parameters model. Once the basic architecture of language is clear, one of the why-questions that immediately arise will touch on evolution. As Berwick (1998) notes, the parsimonious inventory of basic elements in the minimalist program makes it realistic to pose the question of why syntax has the architecture is has and not some other architecture, a question that touches on the hard problem of the evolution of language. But although most researchers in the domain of evolution of language have pursued Pinker and Bloom's (1990) program based on natural selection, several authors have conjectured that language may be an exaptation (see Piattelli-Palmarini 1989, Uriagereka 1998, Longa 2001, Lorenzo and Longa

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[11] Note that 'evolution' is a misnomer if language emerged as the result of exaptation.

2003a,b). In the GB era, in fact, generative grammar invited this conjecture, by focusing on the specificities of the language organ, making it very unlikely (to put it mildly) that central linguistic posits such as c-command, government, empty categories and cyclicity, just to name a few, may have found analogs or precursors in motor control, vision or action. It was inconceivable that adaptive pressures, generically rewarding better communication and planning, might have given rise to such peculiar linguistic structures and computations. As we said above, the real breakthrough came with the advent of P&P, still central to Minimalism. Thanks to the P&P model, language learnability could be purged from any residual inductive component, the search space could be narrowed down to a finite and discrete repertoire of possible options, making the acquisition process fully selective, mostly consisting of single-trial learning based on "triggers" (Gibson and Wexler 1994, Berwick and Niyogi 1996, Fodor, 1998), "signatures" (Yang, 2002), or "cue" (Dresher 1998, Lightfoot 1999) in the context of maturational processes (Borer and Wexler 1987; Wexler and Borer 1986). With hindsight, it is quite clear that the adoption of the P&P model ultimately dispensed UG from having a highly specific, finely articulated format.

The minimalist program now offers equally cogent data and arguments against adaptationism (Hauser, Chomsky, and Fitch 2002). They are, however, different from the specificity considerations mentioned above. The narrow core of the language faculty is still different from the basic principles governing vision, reasoning or motor control, at least as we now know them, but the emphasis on economy and minimality carves this specificity along different lines. The present conjecture is that a narrow syntactic component (NS) interfaces with other cognitive systems (the articulatory/perceptual

apparatus, on the one hand, and the intentional/conceptual apparatus on the other) each possibly pre-existing in some embryonic form in other species. NS is optimal, given the specifications of the interfaces in our species. Therefore, the single most radical difference between Homo sapiens and the closest related species in the domain of language may well be the result of differences at these interfaces. Even if we could imagine some hominid ancestor possessing the same sensori-motor system as modern humans, and the same conceptual-intensional apparatus, but lacking recursive Merge, it is very doubtful that such creature could be capable of thought and expression in anything remotely resembling the human sense.

The role that "virtual conceptual necessity" assumes in minimalism in restricting the hypotheses about NS reduces considerably the evolutionary load that previously fell upon exaptations and tinkering. Independently of this change in theorizing in linguistics, but in parallel, neurobiology has been moving away, as we said, from the haphazard addition-upon-addition of structures and functions, the newest allegedly added "on top" of the oldest (as made popular by Paul MacLean ever since the mid-fifties; for a revisitation and a compendium, see MacLean, 1990) with his once popular theory of the "triune brain", presently rejected in the neurosciences proper, though still enjoying some popularity in marginal quarters), towards a more integrated uniformity of deeper structures, driven by strict optimality principles. The optimal architecture of NS, if true, should appear a bit less surprising than it would have even a few years ago. A minimalist hypothesis that has been suggested is that language as we know it may be the result of a deep restructuring, started by a sudden genetic transposition, and then submitted to one of the ubiquitous computational-optimizing processes acting on the organization of the brain

(Piattelli-Palmarini and Uriagereka, in press). Whether this new component started out by allowing the articulation of an inner soliloquy (as Chomsky suggested in a recent lecture), and/or by allowing the deployment of the series of natural numbers, and/or by allowing the recursive merge of sets into sets of sets, it's hard to say at present. Social communication is, once again, out of this evolutionary picture, and NS does not seem to be at all the outcome of progressive adaptation.

In harmony with this more general picture, the minimalist program is concerned with finding (in the words of Thomas Huxley (cited in Chomsky to appear)), the "predetermined lines of modification", "the limitations of phenotypic variability", "caused by the structure, character, composition or dynamics of the developmental system" (see also Maynard-Smith et al. 1985). This is indeed, as we anticipated above, the program outlined by Turing: "The primary task of the biologist is to discover the set of forms that are likely to appear [for] only then is it worth asking which of them will be selected." (Sauders 1992:xii).

In the light of the above considerations (a drastic, and all too brief summary of a whole emerging Zeitgeist; see Leiber 2002) it seems to us that the significance of the issues the minimalist program raises for the biological sciences alone forces us to treat minimalism with respect, and legitimizes the attempt to move "beyond explanatory adequacy."

4.

Refusing to ask the minimalist question would introduce the kind of "methodological dualism" that Chomsky has forcefully argued against for 50 years (see Chomsky 2000a for a recent formulation). Since language can, indeed, be profitably studied as a natural object, the study of language should share the developmental paths, the assumptions and the explanatory style of the most successful natural sciences, epitomized by theoretical physics. One ought not to lose sight of the fact that linguistics is part of biology at a suitable level of abstraction, a caveat that is too often forgotten. This level is not frozen once and for all, but keeps advancing with the advancement of the discipline itself. Just like the emergence of generative grammar and its immediate success helped shape the landscape in cognitive science, and turn the attention back on to problems of central importance to any serious inquiry into the structure and function of the mind, so the minimalist program, if not unduly premature, could signal a return to central concerns shared with the Rationalist Morphologists in biology. Just like the new emphasis on deeper invariants is slowly changing the landscape of the biological sciences, the minimalist program is redefining and deepening the aims and scope of linguistics. This convergent shift is bringing linguistics closer to the goals and methods of the natural sciences, and enriching both linguistics and biology with intimations of a deductive power that might one day become not too dissimilar from that of physics.

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