Biolinguistics or Physicolinguistics? Is the Third Factor Helpful or Harmful in Explaining Language?

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Noam Chomsky (2005) proposed that a 'third factor', consisting of general principles and natural laws, may explain core properties of language in a principled manner, minimizing the need for either genetic endowment or experience. But the focus on third-factor patterns in much recent biolinguistic work is misguided for several reasons: First, 'the' third factor is a vague and disparate collection of unrelated components, useless as an analytical tool. Second, the vagueness of the third factor, together with the desire for principled explanations, too often leads to sweeping claims, such as syntax "coming for free, directly from physics", that are unwarranted without a case-by-case causal analysis. Third, attention is diverted away from a proper causal analysis of language as a biological feature. The point with biolinguistics is to acknowledge the language faculty as a biological feature. The best way forward towards an understanding of language is to take the biology connection seriously, instead of dabbling with physics.

Keywords: causal analysis; Fibonacci; natural law; physics; third factor

1.   Explaining Language — Principled and Causal Explanations

Chomsky (2005) identifies three separate factors that can jointly explain the language faculty in the human brain:

(1)   Genetic endowment, the "universal grammar" (UG).

(2)   Experience, the stimulus available to the language learners.

(3)   The 'third factor', principles not specific to the faculty of language.

But what does it mean to explain language? What kind of understanding should we aim for, and how does this three-way split help us? Generative linguists have long distinguished three levels of theoretical goals in linguistics (Chomsky 1965):

- 'observational adequacy', that a theory describes language usage.[1]
- 'descriptive adequacy', that a theory accounts for the phenomena observed in adult language competence.
- 'explanatory adequacy', that a theory accounts for how children can acquire adult language competence.

The minimalist program entails a desire to move "beyond explanatory adequacy" (Chomsky 2004), adding a new level of theoretical goals, explaining not just what language is like and how it can be acquired, but also explaining in a principled way why it is that way. Chomsky (2007b) associates 'what' questions with descriptive adequacy, 'how' with explanatory, and 'why' with going beyond explanatory. Chomsky (2007b, 2010) calls an account of language "principled" if it goes beyond explanatory adequacy, grounding features of language in general non-linguistic principles, notably principles of efficient computation, which belong to the third factor.

Fujita (2007, 2009) calls the new level "evolutionary adequacy", a requirement that a theory accounts for how our faculty of language could emerge during human evolution, and Narita (2010) uses the term "biological adequacy" in much the same sense. Also Jenkins (2006) indicates 'How does language evolve in the species?' as a question to be asked in biolinguistics, in addition to the 'what' and 'how' questions underlying descriptive and explanatory adequacy. In an evolutionary context, such a theoretical goal makes sense, and Jenkins (2000) draws an explicit analogy between a theory of language acquisition providing an explanatorily adequate account of language competence, and a theory of language evolution providing an explanatorily adequate account of language acquisition.

'Evolutionary adequacy' also fits in well with the general distinction in biology between proximate and ultimate explanations (Mayr 1961), further developed by Tinbergen (1963) in his well-known four 'why' questions (adaptation, history, proximate cause, and ontogeny), to which we will return below. Descriptive and explanatory adequacy clearly deal with proximate explanations of language, whereas the level of evolutionary adequacy would be about ultimate explanations, *sensu* Mayr.

But Chomsky's (2005, 2010) quest for a new level appears to be heading in a different direction, seeking to explain language in terms of fundamental principles, rather than in terms of either adaptation or evolutionary history. Chomsky (2007b) explicitly contrasts the question of language evolution with the 'why' question beyond explanatory adequacy. Jenkins (2006) likewise regards the 'why' of language as a question beyond just evolutionary origins. The third factor is given a key role in this quest, to the extent that a principled explanation is even defined as one that is based on the third factor (Chomsky 2008).

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[1]   Observational adequacy is included in early Chomsky (e.g., 1965), but is typically absent from more recent literature (e.g., Chomsky 2007b), where the adequacy levels start with descriptive adequacy.

2. What Is the Third Factor?

The third factor can be defined as everything that is part of the explanation of language, but is not language-specific. Looking at the examples and descriptions of the third factor in the literature, it turns out to be a rather heterogeneous collection of component factors, including several types of general theoretical principles, but also biological and human-specific factors like developmental constraints and canalization in our embryology. The components of the third factor are divided by Chomsky (2005) into two classes:

- principles of data analysis
- architectural, computational, and developmental constraints

Physical and mathematical principles ("laws of form") are also included in the third factor, according to several authors (Chomsky 2004, Carstairs-McCarthy 2007, Piattelli-Palmarini & Uriagereka 2008, Di Sciullo *et al.* 2010), though they do not fit neatly into either one of the two classes above. Furthermore, it is clear from Chomsky (2005) that the interface conditions imposed by the sensorimotor (SM) and conceptual-intentional (C-I) interfaces are regarded as part of the third factor as well.

Compiling all the various suggestions for third-factor components that I find in the literature, I end up with this list (with likely but unclear overlaps between the different points):

- principles of data processing and analysis
- economy of derivation
- interface conditions
- performance systems
- general cognitive capacities, general learning strategies
- architectural and computational constraints
- developmental constraints and canalization in embryology
- physical law
- mathematical principles, e.g., symmetry
- mathematical patterns, e.g., Fibonacci series
- laws of form (*sensu* Thompson 1917)

There is no clear consensus on what is and is not included in the third factor. Its vague, negative definition makes it difficult to exclude anything. As noted by one anonymous reviewer, even adaptation through natural selection would count as part of the third factor, as every non-linguistic principle affecting language is by definition included. But others, such as Medeiros (2008), explicitly contrast third-factor explanations with "adaptationist accounts" (2008: 188), and reject the latter.

Chomsky (2007b: 15) regards the third factor as closely (causally?) connected with the conjectured optimality and perfection in language: "Insofar as third-factor properties function, language will satisfy these [interface] conditions in an optimal way, meeting conditions of efficient computation". In Chomsky (2011), optimality and principles of efficient computation are apparently equated with natural law:

> We can regard an account of some linguistic phenomena as principled insofar as it derives them by efficient computation satisfying interface conditions. A very strong proposal, called "the strong minimalist thesis", is that all phenomena of language have a principled account in this sense, that language is a perfect solution to interface conditions, the conditions it must satisfy to some extent if it is to be usable at all. If that thesis were true, language would be something like a snowflake, taking the form it does by virtue of natural law, in which case UG would be very limited.
>
> (Chomsky 2011: 26)

But natural laws are only a small part of all the different things going into the third factor. What the various component factors that make up the third factor have in common are really just two things:

- They are not language-specific.
- They are believed to play some explanatory role behind language.

Apart from these two points, there are no obvious commonalities that unite them and motivate the bundling of them into a single factor. Even the second point above is really not a commonality at all, until it is shown that there is actually some substance behind the faith in their explanatory power.

A more useful classification of these factors might be according to their origin and epistemological status:

(A)   Some factors have an aprioristic character, notably mathematical laws and some abstract computational principles.

(B)   Others are empirical but not biological, like physical laws.

(C)   Others are distinctly biological, and are contingencies of our evolutionary history, placing them in the same ontological category as our genetic endowment. The developmental constraints belong here. On the issue of developmental constraints, Chomsky (2007a, 2010) relies on the general developments in biology called 'evo-devo' (Carroll 2006, Benítez-Burraco & Longa 2010). The general developmental processes behind our nervous system are shared with many animals, and are thus biological but not human-specific. Computational constraints that directly relate to the neural implementation of computations may also belong here.

(D)   Yet others are human-specific. Some details of the developmental constraints in our embryology are human-specific, as are some architectural constraints. The interface conditions can be included here as well, as they depend on the SM and C-I systems, of which at least some parts can be assumed to be human-specific, as can some parts of our general cognitive capacities.

Another way to classify the third-factor components might be according to how they may influence the human language faculty, and what causal powers they have. But also in that respect, it is obvious that the various component factors are a highly disparate collection. I will return to the causal analysis in more detail in section 3 below.

As the third factor is intimately connected with Chomsky's quest for principled explanations, it is also relevant to note that only a subset of the proposed third-factor components can by any stretch of the imagination be called "principled". Quirks of primate embryology or the human vocal tract do not lend themselves to principled explanations of anything. Even in the fundamental minimalist picture of syntax as an optimal bridge between the C-I and SM interfaces (e.g., Chomsky 2008), posited as explainable in a principled way, the interfaces themselves are beyond principled explanation (Narita 2009).

Chomsky (2008) recognizes that the third factor is still unfinished, a work in progress, and that it is a matter of empirical inquiry which of its components are actually relevant to language:[2]

> It is hardly necessary to add that the conditions that enter into principled explanation […] are only partially understood: we have to learn about the conditions that set the problem in the course of trying to solve it. The research task is interactive: to clarify the nature of the interfaces and optimal computational principles through investigation of how language satisfies the conditions they impose – optimally, insofar as SMT holds. This familiar feature of empirical inquiry has long been taken for granted in the study of the sensorimotor interface (SM). Inquiry into acoustic and articulatory phonetics takes cues from what has been learned about phonological features and other such properties in I-language research and seeks SM correlates, and any discoveries then feed back to refine I-language inquiry. The same should hold, no less uncontroversially, at the semantic/conceptual-intentional interface (C-I). And it should also hold for third factor properties.   (Chomsky 2008: 135–136)

In general, Chomsky is quite careful in print[3] to note that both the SMT and the third factor as an explanation for language are mere conjectures. But some biolinguists, for example Piattelli-Palmarini (2012), are less prudent and make sweeping claims for the powers of the third factor, an issue to which I will return in section 4 below.

But even as a conjecture, how useful is the third factor? Does it make sense to talk about *the* third factor, when there is nothing uniting the components except the negative feature that they are not language-specific, and when there is not even any clear agreement on which components should be included? Such a pseudo-concept is unlikely to contribute to our understanding of language.[4] In section 4, we will look closer at the results of this lack of clarity and coherence.

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[2]   Thanks to an anonymous reviewer for drawing my attention to this statement by Chomsky.

[3]   When giving talks, Chomsky can be less circumspect at times. In print: "If that thesis [that all phenomena of language have a principled account] *were* true, language *would be* something like a snowflake, taking the form it does by virtue of natural law […]" (Chomsky 2011: 26). In his plenary talk at the 19th International Congress of Linguists in Geneva (July 2013): "Language *forms* like a snowflake, in the simplest possible way" (emphasis added in both).

[4]   One anonymous reviewer interpreted my criticism as merely an objection to the expression "the third factor", and argued: "Change 'the third factor' to 'third factor principles' and most of the argument falls apart, because people use 'the third factor' and 'third factor principles' interchangeably all the time". But I do not criticize just the expression, my point is that it is unwarranted and potentially misleading to invoke third-factor considerations in linguistic arguments as if there were a coherent third-factor concept that in itself explained anything. Using singular and plural expressions interchangeably is not a solution to this issue; instead it is a symptom of the problem.

The incoherence of 'the' third factor does not, however, imply that its components are all irrelevant for language. It is eminently possible, and in some cases even highly likely, that several third-factor components can contribute to our understanding of language. But if so, their contributions are likely to be as disparate as the components themselves. Some may act as constraints on what is possible, either in principle or in the specific case of humans. Others may form parts of the support system of language (FLB *sensu* Hauser, Chomsky, & Fitch 2002). Yet others may provide the basis for adaptive advantage. And conceivably some may provide explanations that are both causal and principled. But they contribute as separate components, not because they belong to 'the' third factor, and their contributions must be evaluated on a case-by-case basis.

3.   Causal Analysis and Explanations in Biology

In a biolinguistic perspective, language is a feature of human biology (Boeckx & Grohmann 2007), and it would appear natural to model an explanation of the causes of language on the type of causal analyses employed in the study of other biological features. In general, the explanation for any feature in an organism needs to answer the four 'why' questions of Tinbergen (1963) mentioned above.

It must be emphasized that the four questions of Tinbergen are *complementary*, not competing explanations. A full understanding of any biological feature requires answers to all of them. The answers to the different questions are typically quite distinct, both in content and conceptually, with each answer providing only a partial explanation of a feature:

(1)   *Adaptation*? The focus here is on why the feature evolved, what made it spread in the population. This is the question to which it is usually most difficult to give a stringent answer. An answer typically starts with a functional analysis of the feature, what it is *for*, and proceeds from there to an analysis of the causal chain from its function to how it could spread in the population through natural selection and/or other evolutionary processes. Demonstrating causation in evolutionary processes is a non-trivial matter, which biologists may handle with experimental (e.g., Sinervo *et al.* 1992) or statistical (e.g., Shipley 2000, Lomolino *et al.* 2012) techniques.

Example: Sickle-cell anemia is present in some human populations *because* heterozygotes are resistant to malaria, and if malaria is common this produces enough of a selective advantage to make the sickle-cell gene spread in the population up to an equilibrium level where the homozygote disadvantage balances the heterozygote advantage.

(2)   *History?* This is a matter of determining how the feature emerged over evolutionary time, what it evolved from, and what intermediate stages it went through. Answering it is largely a matter of mapping character changes onto a phylogenetic tree, with comparative anatomical, genetic, embryological and fossil evidence being used.

> Example: Sickle-cell anemia is present in some human populations *because* a point mutation occurred in the β-globin gene some thousands of years ago, in a population exposed to malaria.

(3) *Proximate cause?* This is typically the most reductionist answer, explaining a feature in terms of the underlying mechanisms.

> Example: Sickle-cell anemia is present in some human populations *because* the mutated β-globin gene codes for a valine at position 6, creating a hydrophobic patch in the protein that under low oxygen conditions causes hemoglobin S molecules to aggregate and form fibrous precipitates.

(4) *Ontogeny*? How does the feature emerge during ontogeny, from what combination of genetic, epigenetic and environmental factors?

> Example: Sickle-cell anemia is present in some human populations *because* when the activity of the mutated β-globin gene is triggered after birth, it starts producing the mutated form of hemoglobin.

Full causal explanations, with adequate coverage of all four questions, are not very common in biology, as the analysis is very difficult and laborious for any non-trivial feature, and the historical information may simply be unavailable for features that do not fossilize. But in some simple cases, like the sickle-cell anemia used as an example above, we do understand it well enough. And even for less tractable features, including language (Jenkins 2011), Tinbergen's questions provide the appropriate framework for pushing the analysis as far as it can be done.[5] For another example of a full Tinbergen analysis, somewhat closer to language than sickle-cell anemia, see the analysis of Zeifman (2001) of infant crying.

Tinbergen proposed his questions 50 years ago, and much has happened in biology since then. We have today a much better and more sophisticated understanding of genetics, development and evolution, than we did in 1963. Tinbergen's basic analysis of the problem remains sound, but the questions need to be refined, taking into account e.g. developmental constraints as aspects of both history and ontogeny, and considering non-adaptive evolutionary processes together with adaptive explanations.

It can be noted that this kind of causal analysis does not directly involve any quest for principled explanations. Past attempts to find principled explanations for non-trivial biological features have met with very limited success, and the mainstream consensus in biology assigns a much larger role to the tinkering of Jacob (1977) than to the laws of form of Thompson (1917).[6]

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[5] One anonymous reviewer argues that such an analysis is hopeless, invoking in support a statement from Chomsky in 1980: "We can, post hoc, offer an account as to how [the] development [of an organism] might have taken place, but we cannot provide a theory to select the actual line of development, rejecting others that appear to be no less consistent with the principles that have been advanced concerning the evolution of organisms" (Chomsky 1980: 36). However, the opinion of Chomsky 33 years ago on evolution, a topic on which he is far from an expert and which has changed dramatically since 1980, carried little weight then and less weight today. See, for example, Berwick (2011) and Jenkins (2011) for recent analyses from a biolinguistic perspective that do not reject the problem as hopelessly intractable.

[6] Boeckx (2011) discusses from a favorable perspective the few biologists who disagree, while conceding that the majority agrees with my position.

3.1. *Causal Analysis in Biolinguistics*

The Poverty of the Stimulus, the insufficiency of the environmental input, is axiomatic in biolinguistics, which means that the second factor of Chomsky (2005) cannot be a major part of any explanation of language. In early versions of generative grammar, the genetic endowment was regarded as the main onto-genetic explanation for our language capacity. The language acquisition device, presumably genetically encoded, was believed to be rich and highly complex, the evolution of which would be very difficult to explain (Chomsky 2007b). The Principles and Parameters program eased this difficulty (Chomsky 2007a, Boeckx & Piattelli-Palmarini 2005); the main focus remained on the genetic endowment, but much less complexity and structure was required. In the minimalist program, however, the main explanatory burden is explicitly shifted to the third factor, with a minimal genetic endowment hypothesized (Chomsky 2005). This also entails a shift away from language-specific to non-specific explanations (Benítez-Burraco & Longa 2010, Di Sciullo *et al.* 2010), as well as a shift in explanatory level, as discussed in section 1 above. All three factors remain part of the equation,[7] but it is clear that the main thrust of recent work by Chomsky and others is in the direction of minimizing the contribution of the first two factors, with the third factor expected to do the lion's share of the causal and explanatory work.

This shift in explanatory emphasis makes it vital to understand the third factor, and how it can and cannot be used in a causal analysis of language. But as noted in the previous section, 'the' third factor is really a disparate collection of unrelated factors, the contributions of which to language are likely to be quite distinct from each other. Any causal analysis involving 'the' third factor must treat the various component factors separately, each on its own terms.

But any explicit causal analysis of language in third-factor terms is effect-ively absent from the biolinguistic literature; the causal power of 'the' third factor is too often simply taken for granted (see section 4.1), and there is rarely any systematic consideration of the different types of biological causes summarized in Tinbergen's four questions, despite the explicit appeal to these questions in the founding issue of *Biolinguistics* (Boeckx & Grohmann 2007), as well as in other biolinguistic work, from Chomsky (1976) to Jenkins (2011). Third-factor argu-ments typically skip most of the questions, leaving too much unexplained.

One may attempt to map the various components of 'the' third factor onto the Tinbergen questions. Arguments based on developmental constraints provide partial answers to the history question. Arguments based on efficiency and optimality can provide indirect answers to the adaptation question, as efficiency can sometimes explain why a certain feature has high fitness, but this needs to be made explicit. Arguments based on natural law can either likewise provide a background to the adaptation question, as with bird wings, or they can provide a proximate cause, as with cell shape (see section 4.3 below); but natural laws rarely provide both, and do not on their own explain biologically useful complexity (Mayr 2004).

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[7]   As noted by Rie Asano (p.c.), with only the non-specific third factor we could not explain the *differences* between language and, for example, music.

Epstein (2007) draws an interesting parallel between the three factors of Chomsky (2005) and the "dual causation" of Mayr (2004).[8] The first of Mayr's two causes here consists of a genetic program that may be affected by environmental input, and thus maps onto Chomsky's first two factors, whereas Mayr's second cause is natural law, making it the equivalent of a subset of Chomsky's third factor. But Mayr (2004) regards the role and effect of natural law as quite limited, in contrast with the major explanatory burden with which Chomsky (2005) endows the third factor. Mayr distinguishes *teleomatic* processes coming from natural law, which are limited and without goal, from the seemingly purposeful *teleonomic* processes typical of biological systems.

Physical laws have inescapable causal powers that can never be ignored, and can often be a proximate cause in biological systems, with the ultimate biological causes acting to set up the situation so that the physical causes do something biologically appropriate — see section 4 below. But more often physical laws function either as constraints or in shaping selective pressures. Jenkins (2000: 159) quotes Chomsky as calling it the "space of physical possibility within which selection operates", which is a nice way of catching the relationship between physics as providing constraints, and biology as operating within, and sometimes exploiting, those constraints. But the constraints themselves do not provide any biologically useful complexity for free. As Mayr (2004: 50) puts it: "[T]he very general terminal situations effected by natural laws are something entirely different from the highly specific goals coded in programs".

And even in cases where the proximate causes of biological phenomena are physical, it does not follow that the other three questions of Tinbergen (1963) can be answered by appeals to physical law, nor can they be ignored. It goes without saying that biology cannot violate physical laws — but this is a far cry from saying that physical laws *explain* biological features in any interesting sense (Mayr 2004). The burden of proof rests squarely on anybody proposing that language is an exception in this regard, a complex biological feature that physical principles *can* explain.

Principles of efficient computation and the like, in contrast with physics, do not have causal powers *per se*, and do not drive even teleomatic processes on their own. They necessarily need to work through regular biological pathways. One may argue that our neural wiring, or faculty of language, is the way it is *because* that way is optimal in some sense. But the word 'because' here does not describe any direct causation by principles of optimality; it should be taken as shorthand for a long causal chain, going through all four of Tinbergen's questions:

In order for a neural system to be, say, computationally efficient, we need (1) a mechanism that can be the proximate cause making nerves connect in a way that provides computational efficiency; we need (2) a developmental system that provides an ontogeny in which the proximate cause can do its work; we need (3) an evolutionary history which can lead up to the appropriate mechanism and ontogeny; and we need (4) a selective environment in which efficient compu-

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[8]   Note that this is quite different from Mayr's (1961) distinction between proximate and ultimate causes.

tation is favored in a way that makes it spread in the population. This does not mean that we need the path of every nerve to be genetically specified; there are certainly much cleverer ways to do things in the interplay between genetic and epigenetic processes. But the point is that principles of efficiency *per se* do not cause anything, and do not explain anything, except in roundabout ways mediated through normal biological processes.

It is sometimes suggested by Chomsky and others (e.g., Chomsky 2008, 2010, Berwick & Chomsky 2011) that language emerged saltationally, as the result of a single mutation that made everything fall into place: "The simplest assumption […] is that the generative procedure emerged suddenly as the result of a minor mutation" (Berwick & Chomsky 2011: 29). Having a single large-effect mutation lead to something that is viable and perhaps even useful is not common, but does happen occasionally, due to robust developmental constraints and modular architecture. But having it lead to something that is optimal or perfect in any reasonable sense is unlikely in the extreme. Positing a saltational origin for language effectively amounts to positing sheer dumb luck as an explanation; I would hesitate to call such an explanation principled.

Hinzen & Uriagereka (2006) apparently have a perspective on what constitutes an explanation in biology that is fundamentally different from mine: "In the case of phyllotaxis, the Fibonacci arrangement originates as a mathematically (provably) best solution to a dynamic system of opposing forces in a compact space. That solution arguably has an adaptive effect for which it may have been selected, *but this is not its explanation*" (p. 89, emphasis added).[9] Instead they locate the explanation in "this universe's very topology" (p. 89). But there are several problems with having the universe's topology explain most biological features.[10] For one thing, as noted by Mayr (2004), quoted above, this kind of "explanation" is too general, not explaining the specifics of the biological situation. There is also a hidden normative in the explanation of Hinzen & Uriagereka (2006): "*best* solution". But the normativity here comes from biological considerations, the solution is "best" only with respect to the particular combination of adaptive desiderata and developmental constraints in the growth of plants. It is not "best" in any universal sense, which means that their argument falls apart if biological considerations are excluded.

In a biolinguistic analysis of language that takes the biological nature of the language faculty seriously, a causal analysis modeled on the style of analysis that has been fruitful in other parts of biology would appear to be the most natural way to proceed. This is no guarantee of success — it is an enormously challenging task — but going the opposite route, attempting to take an illegitimate shortcut with appeals to a uselessly vague third factor virtually guarantees failure. A critical review of a few such misguided "explanations" is the topic of the next section.

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[9]   See section 4.1 below for more on Fibonacci.
[10]   The situation is somewhat different in physics; e.g., the inverse-square laws that are ubiquitous in Newtonian physics do follow from the (not quite accurate) Newtonian assumption that the universe's topology is a three-dimensional Euclidean space.

4.   "For Free, Directly from Physics"

Some biological features are postulated to come "for free, directly from physics" (Cherniak 2005: 103), caused by third-factor principles with no need for either genetic specification or environmental input (Benítez-Burraco & Longa 2010, Narita & Fujita 2010, Cherniak 2011), and thus no need for adaptive evolution either (Carstairs-McCarthy 2007). This reliance on physics as a basis for language goes back to Chomsky (1965: 59): "principles of neural organization that may be even more deeply grounded in physical law" (though Chomsky prudently conjoined this statement with "millions of years of evolution", as pointed out by an anonymous reviewer), and is reiterated both in Chomsky (1988) and in more recent work, for example Chomsky (2007b).

Effectively equating the third factor with physical law like this neglects the fact that physical law is only a small part of the complex of disjoint components that make up 'the' third factor, as discussed in section 2 above. But let us leave that aside for the moment, and see whether the physical component of the third factor has been shown to do any biologically useful explanatory work.

4.1.   Do Aspects of Language Come for Free, Directly from Physics?

The actual workings of third-factor principles in language are not well understood, though Chomsky (2007b: 20) believes that "there has been considerable progress in moving towards principled explanation in terms of third-factor considerations". Unfortunately, I have yet to see such "considerable progress" in print. The few publications I could find that actually tried to do anything specific with third-factor principles (Walkden 2009, Carnie *et al*. 2005, Piattelli-Palmarini & Uriagereka 2008, Medeiros 2008, Soschen 2008, Kuroda 2008, Hinzen & Uriagereka 2006, Uriagereka 2008, Boeckx 2011)[11] did not provide results that warranted any conclusions about the causal efficacy of third-factor principles.

Walkden (2009) shows that the final-over-final constraint in syntax is consistent with being derived from computational principles. This is interesting, but does not show that such principles actually play any causal role behind the constraint, either in ontogeny or phylogeny.

Carnie *et al*. (2005), Soschen (2008), Medeiros (2008) and Piattelli-Palmarini & Uriagereka (2008) all focus on apparent Fibonacci patterns[12] in different aspects of language. The Fibonacci series is commonly seen in nature in the growth patterns of many organisms, for example leaves around a stem on a plant, and also in some inorganic systems (Douady & Couder 1992). It typically turns up in systems where a number of units are added one after the other to an area, and the units repel each other or otherwise try to keep as far apart as possible, but are prevented by opposing forces from moving around freely. This can either be a purely physical repulsive force as in the system studied by Douady and Couder

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[11]   Thanks to an anonymous reviewer for providing additional examples.
[12]   The Fibonacci series of numbers is a sequence where each number is the sum of the two preceding numbers (e.g., 1, 1, 2, 3, 5, 8, 13, …). The series is named for Leonardo Pisano Bigollo (c. 1170 – c. 1250), nicknamed 'Fibonacci'. The ratio between two successive numbers in the series converges towards the 'golden ratio' 1.61803….

(1992), or a biological system where natural selection provides the repulsive 'force', or a biological system that has evolved to exploit physical forces to achieve a biologically desirable configuration. As noted by Piattelli-Palmarini & Uriagereka (2008), the forces involved in the formation of a Fibonacci pattern could act either over evolutionary time (becoming genetically encoded), over ontogenetic time (channeling development), or dynamically in real time throughout an organism's life. But regardless of the time scale, something force-like is required; Fibonacci is just an emergent mathematical pattern, without causal or even explanatory force of its own.

Under certain theoretical assumptions, Carnie *et al.* (2005) find Fibonacci-like patterns in syntactic trees. The patterns are not necessarily found in actual trees, though, but in maximal trees where all branching possibilities in the chosen theory of syntax are utilized down to a given depth in the tree. They connect the occurrence of these patterns with certain properties of Merge. Somehow, their argument proceeds from the observation that Fibonacci-like patterns do occur, to the claim that there is pressure for Fibonacci-like patterns to occur, and that these pressures have a causal role in shaping syntax: "Syntactic structure, […], strives towards the particular mathematical symmetry found in the Fibonacci sequence" (Carnie *et al.* 2005: 8), though they admit that this is speculative. It is not clear to me how striving follows from the arguments given.

Piattelli-Palmarini & Uriagereka (2008) extend the tree work of Carnie *et al.* (2005), connecting it with syntactic phases, and also identify Fibonacci-like patterns in syllable structures. They do not make any causal claims for Fibonacci in their 2008 paper, merely concluding that the Fibonacci patterns are real but their causes are not well understood, but in a later conference abstract presenting the same work, Piattelli-Palmarini (2012) does claim that "core properties of syntax come 'for free, from physics'" (p. 1).

Soschen (2008) extends the Fibonacci work in a somewhat different direction, trying to connect the apparent Fibonacci patterns in syntax with other apparent Fibonacci patterns in microtubules at the intracellular level inside neurons. Connecting syntax with neural processes could charitably be seen as an attempt to answer Tinbergen's "mechanism" question. But in any plausible model of neurolinguistics, there are multiple intervening levels of neural organization between syntax and microtubules, and Soschen (2008) does not provide any kind of coherent argument for how the Fibonacci pattern at one level is connected with the Fibonacci pattern at another level, quite distant from the first. Soschen (2008), like Carnie *et al.* (2005) and Piattelli-Palmarini (2012), also appears to have faith in the causal powers of Fibonacci: "Natural Law (N-Law), a physical phenomenon exemplified as the Fibonacci patterns […], can be observed in language, […]" (2008: 197) and "[t]his suggests a strong possibility that N-Law or general physical laws that ensure efficient growth apply to the universal principles that govern linguistic representations as well" (2008: 198). Again, it is not made clear precisely how a mathematical pattern acquires causal powers. Soschen (2008) also appears to share with Piattelli-Palmarini (2012) a curious conflation of mathematics with physics — Fibonacci is a mathematical pattern, and somehow the appearance of this *mathematical* pattern is equated with *physical* law.

Medeiros (2008) likewise proceeds from the same observations of Fibonacci patterns, but with more restraint and sophistication. There is much less of the sweeping, grandiose claims for the magical powers of Fibonacci; instead, Medeiros (2008) provides a mainly thoughtful and nuanced discussion of the implications of Fibonacci patterns in syntax. He still concludes that "laws of form" are at work, without actually having shown this in a causal analysis, but his work is nevertheless much more prudent and careful than the other Fibonacci-related papers discussed above.

The logic of much Fibonacci work appears to follow something like this chain of inferences:

(i)   Apparent mathematical patterns are observed in some aspect of language.
(ii)   → This pattern is taken as evidence of the third factor at work.
(iii)   → The third factor causes language to be this way.
(iv)   → This aspect of language is now explained.
(v)   → This aspect of language comes "for free, directly from physics".

It is clear that every step in this chain is a *non sequitur*. The various authors cited above differ in how far down the chain of dubious inferences they proceed. But at least Piattelli-Palmarini (2012) appears to go all the way to the bottom, starting with "…Fibonacci growth patterns and principles of optimization are apparent in the structure of human language" and ending with "[t]his is a plausible instance of 'third factor' (Chomsky 2005) explanation; core properties of syntax come 'for free, from physics'" (p. 1).

The work of Kuroda (2008) is both mathematically and conceptually more sophisticated than the Fibonacci work discussed above, but part of it is similar in spirit.[13] Instead of the Fibonacci series, Kuroda identifies another mathematical pattern in a theoretical description of language: ζ functions.[14] Different ζ functions, it is argued, can represent different phrase structure languages. But Kuroda does not jump to conclusions right away — instead he makes the accurate assessment: "Speculative fantasies like this are easy to come by, but we are not in a position to tell if they might possibly have any linguistic significance" (2008: 35).

The other strand in Kuroda (2008) consists of an analogy between the structure of language and the structure of mathematics, and an argument for an ontology of language that parallels the Platonic-like mathematical realism favored by Kuroda, with both the logical structures of language and mathematics having some kind of real existence as objects in the natural world, and mathematics also existing in a Platonic world. He regards structural and processing perspectives on language as two complementary aspect that both exist at the

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[13]   As my knowledge of Japanese is limited, my discussion of Kuroda (2008) is mainly based on the English summary at the end of the paper. Thanks to Rie Asano for double-checking against the main Japanese text and clearing up some issues. Any remaining misunderstandings are my own.

[14]   A ζ function is a function of a real number s that is defined as the infinite sum of some indexed function f_i with each term in the sum raised to the power s. It turns up in many different places in mathematics and also has some applications in physics.

same time, and he identifies an 'invisible' level of reality where mathematics and linguistics have strong parallels. Mathematical and linguistic abstract concepts both have a real existence at this invisible level, and are ontologically similar in Kuroda's view. To understand the visible parts of language, one must also understand the invisible. Kuroda (2008) calls his metaphysics "naturalistic realism". But, unless one endorses Kuroda's metaphysics, the structural analogies carry little explanatory weight.

Hinzen & Uriagereka (2006), like Kuroda (2008), draw parallels between mathematics and language, both structurally and metaphysically. Hinzen and Uriagereka also regard our mathematical abilities as both biologically and metaphysically closely connected with the language faculty. As with Kuroda (2008), the metaphysical aspects of their work has no explanatory force for anyone not accepting their unorthodox ontology of language.

More interesting in this context, however, is the claim of Hinzen & Uriagereka (2006) that one aspect of language — implicational hierarchies — comes for free if syntax uses the right mathematical tools. This does carry some explanatory force, but not because it belongs to 'the' third factor, which is wisely not mentioned in the paper. The careful linguistic/mathematical analysis done by Hinzen & Uriagereka (2006) is not an example of a third-factor explanation, despite being suggested as such by one anonymous reviewer. It is better regarded as an example of good Popperian hypothetico-deductive science. They take a hypothesis about the mathematical structure of syntax, and test it by deriving a surprising consequence of the hypothesis, which is then empirically validated.

Uriagereka (2008), also invoked by an anonymous reviewer as impressive third-factor work (cf. Narita 2009), appears to be at the core an attempt to extend minimalism beyond the traditional location of the C-I interface, integrating semantics with syntax (or, on a more radical alternative, syntax *constructing* semantics). A central concept is the co-linearity thesis (CLT), according to which it is postulated that "syntax and semantics turn out to be narrowly matched, perhaps trivially so" (p. xvii), together with a reinterpretation of the Chomsky Hierarchy. This is an ambitious work, making a bold and interesting conjecture about the nature of semantics and what goes on around and beyond the C-I interface. But it remains both conjectural and quite abstract, far from the level of empirical substantiation where it can reasonably be called an explanation for language.[15] Furthermore, Uriagereka (2008) does not, as far as I can find, even mention the term 'third factor' in the book, though the review by Narita (2009) hails it as important third-factor work. Instead of wading into the misty 'third factor' swamp, Uriagereka (2008) is quite properly being specific and clear about what principles and considerations he is using in building his model. Much of it certainly belongs somewhere among all the different things people include in the third factor, but labelling it as such would in no way strengthen Uriagereka's case, rather the opposite.

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[15]   As even the otherwise favorable review by Narita (2009) concedes: "Admittedly, most of Uriagereka's proposals await much finer empirial [sic] revision and substantiation" (p. 7 in preprint version).

Relativized Minimality (Rizzi 1990) is also held up by an anonymous reviewer as impressive third-factor work, even though it was published well before Chomsky coined the concept of a third factor. Rizzi does capture some important facts about language here (though there are plenty of complications; see e.g., Boeckx 2003), but there is no reason why the third factor should get any credit for that. The reason why Relativized Minimality largely holds may be due to some economy principle at work in syntax, or it may be due to performance effects in the parser, as argued by Ortega-Santos (2011); in both cases, the explanations do belong in the general third-factor bag, but they are clearly distinct from each other, and treating them both as 'the' third factor would be unhelpful.

Boeckx (2011) seeks a principled explanation for the binary branching in syntactic trees in an analogy with the work of Bejan (2000) on the general dendritic pattern of branching flows. Bejan shows that binary branching turns up in many different contexts of constrained flow, where the binary pattern minimizes flow resistance. This is interesting as an analogy for syntax processing, but it remains to be shown whether the various assumptions that go into Bejan's analysis actually hold for syntax. Furthermore, even if it were shown that Bejan's binary pattern would be optimal also for syntax, it would still be unwarranted to conclude that "[t]his need not be coded in the genome. As soon as Merge is available […] it would follow as a matter of course that Merge will exhibit a binary branching character if the FL is optimally designed" (Boeckx 2011: 57). Boeckx erects here an unfounded opposition between genetic encoding (and presumably adaptation) versus optimality, instead of recognizing that these are complementary, not competing, explanations;[16] cf. Jenkins (2011) and section 4.3 below. Jenkins expresses it as "principles of thermodynamic self-organization act in conjunction with genetically specified principles" (Jenkins 2011: 178).

Chomsky's own work invoking the third factor (e.g., 2008) has much in common with the approach of Uriagereka (2008). But the basic assumptions are not spelled out as clearly as one might wish; Chomsky postulates that language is "optimal" or "perfect" or "efficient" because of third-factor considerations, without really spelling out what this means — optimal with respect to what desiderata, efficient by what measure, and so on — even though Chomsky does recognize that this is an open issue: "We do not know a priori, in more than general terms, what are the right ways to optimize, say, neural networks; empirical inquiry into such matters is interactive in the same ways" (2008: 135-136). Too often the main criterion of perfection appears to be Chomsky's intuition. There is even a disturbing hint of circularity in some places, e.g., when Chomsky finds manifest imperfections at the SM interface, this is taken as evidence that the locus of perfection must be at the C-I interface (2008, 2010). Much of Chomsky's work here (e.g., 2008) erects impressive theoretical constructs, but they still fall well short of actually explaining language with 'the' third factor. There is too much leeway both in the definitions of optimality and so on, and in the selection of which aspects of language are to have principled explanations and which are shunted off beyond the interfaces, and in no small part this leeway results from the vagueness of 'the' third factor.

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[16]   Possibly this misunderstanding is connected with the 'ultra-Darwinist' strawman that Boeckx (2011) erects in this context?

The general conclusion I draw from reading putative third-factor explanations of language is that their stringency and explanatory force are in inverse proportion to how much emphasis is placed on the third factor. Those that achieve anything useful are precisely those that do *not* invoke 'the third factor' as if it were a causal force, but instead remain careful and precise about just what principles and assumptions they do rely on.

4.2.   Does Neural Wiring Optimality Come for Free, from Physics?

Cherniak and associates (Cherniak *et al.* 2004, Cherniak 2005, 2011, Cherniak & Rodriquez-Esteban 2010) have investigated the optimality of neural wiring patterns, finding that the actual neural wiring in some model systems is remarkably efficient. This work, and especially the statement that this efficiency comes "for free, directly from physics" (Cherniak 2005: 103), is frequently cited in the biolinguistic literature on third-factor issues. But Cherniak and associates only show that under certain assumptions wiring patterns appear to be efficient; they do not demonstrate what causal factors lie behind such efficiency. Evidence that a certain configuration minimizes connection length, or minimizes internal wall drag (Cherniak 2011), or whatever, is not evidence that the configuration came for free, directly from physics. A causal link from principle to configuration is required.

The finding of Fornito *et al.* (2011) that there is genetic variation in the efficiency of neural wiring patterns in humans, and that efficiency differences are under strong genetic control, is relevant in this context. This result entails three pertinent conclusions:

- Neural wiring patterns, at the level studied, are under genetic control, and thus subject to all the usual biological processes. This contradicts the claim of Cherniak and others that the efficiency comes directly from physics, *without* genetic input.[17]
- Neural wiring patterns, at the level studied, are not always optimal, as some people have measurably more efficient patterns than others.[18]
- The efficiency of neural wiring is evolvable, as there is genetic variation that provides a handle for natural selection — assuming, of course, that efficiency is correlated with fitness.

As noted by both Cherniak & Rodriquez-Esteban (2010) and Fornito *et al.* (2011), there are many competing desiderata in the wiring of a neural network — connection cost, connectivity, computational speed, energy dissipation, robusticity, and so on. It is not well understood which of these is most important, and how the conflicting demands are balanced. This makes it effectively impossible to determine whether a neural network is optimal in any general

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[17]   For example, in Cherniak & Rodriguez-Esteban (2010: 52): "not via the genome but by the underlying physical and mathematical structure of the universe".

[18]   Like Cherniak and associates, Fornito *et al.* (2011) do find quite high levels of cost-efficiency. But instead of concluding that some physical principle is at work, they conclude instead that brains evolved to be efficient.

sense, without assuming which desideratum should be optimized. This is in stark contrast with the abstract optimality proposed by Piattelli-Palmarini & Uriage-reka (2008), who talk about "structures that can be characterized as optimal *irrespective of any functional correlate*" (2008: 209, emphasis in original), which is either vacuous or incoherent.

Recent empirical enquiry into actual neural network organization is reviewed by Bullmore & Sporns (2012: 347), who conclude that "the brain's connectome is not optimized either to minimize connection costs or to maximize advantageous topological properties […]. Instead, we argue that brain network organization is the result of an economical trade-off between the physical cost of the network and the adaptive value of its topology". This type of trade-off between multiple objectives, rather than optimization for any single objective (much less any abstract objective-less pseudo-optimization), is typical of biological systems (Noor & Milo 2012).

A further consideration is that neurons are rather unreliable as circuit elements, prone to misfiring and occasionally dying. This is a constraint on neural processing that has the consequence that an optimal neural circuit (assuming, plausibly, that reliability is a desideratum) needs to have enough redundancy to make it highly robust against neuron failure, rather different from what might seem optimal to an engineer used to reliable electronic components (Fitch 2009), or to a theoretician focusing on minimalistic elegance.

An explanation of neural wiring patterns, as with other biological features, needs to answer all four Tinbergen questions. Even if the patterns were shown to be optimal in some sense, an appeal to the third factor does not in itself provide such answers. Further analysis is needed. Cherniak & Rodriguez-Esteban (2010) do take a small step in this direction, reasoning in terms of proximate mechanisms in their discussion, noting that wiring fulfilling their efficiency criteria can be achieved if each nerve connection acts as a mechanical spring providing a force pulling the nerve cells together.[19] Minimizing the energy of such a spring network, which indeed is what it will spontaneously do if left to the laws of physics, also maximizes efficiency. But Cherniak & Rodriguez-Esteban (2010: 52) err in concluding that this efficiency comes "not via the genome but by the underlying physical and mathematical structure of the universe" — the genome still has to provide the coding for nerve connections to act as springs of appropriate strength, and for nerve cells to be free to move around in response to such spring forces, neither of which comes for free. Cherniak (2011) continues the argument of Cherniak & Rodriguez-Esteban (2010), considering both developmental and evolutionary time scales. He approaches, but does not quite reach, the reasonable conclusion that what we have here is not physics short-circuiting evolution, but rather the neural system evolving to take advantage of physical laws. The latter is ordinary evolutionary tinkering, genetically encoding the system to exploit physics, not getting anything for free. Nevertheless, Cherniak (2011: 116) concludes that this "constitutes a thesis of nongenomic nativism, that some innate complex biological structure is not encoded in DNA, but instead derives from basic

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[19]   A similar idea was proposed also by Van Essen (1997).

physical principles", a conclusion that does not follow either from his data or his arguments.

Most language-related neural wiring we simply do not understand well enough to tell whether it is optimal or not, and if so, optimal with respect to which desiderata. But there are a few cases that we do understand, which are clearly not optimal by any reasonable criterion. Precise control of the timing of laryngeal activities ought to be vital for speech, as parameters such as voice onset time need to be controlled with an accuracy of a few milliseconds at normal speaking speeds (Ladefoged 1971, Cho & Ladefoged 1999). The laryngeal nerve, providing motor signals to the muscles controlling the larynx, is made up of several branches. At least two aspects of the routing of this nerve are far from optimal:

- The left recurrent branch of the laryngeal nerve does not go straight to the larynx from its origin in the brainstem. Instead it goes down into the thorax, loops around the aorta, and then back up the neck to the larynx, adding many unnecessary centimeters to its length in humans, and thus adding a non-negligible propagation delay for motor signals. In animals with longer necks, such as giraffes or sauropod dinosaurs, the extra length can be measured in meters (Wedel 2012).

- The other branches of the laryngeal nerve all take different routes. The right recurrent branch only goes halfway down to the thorax, looping around the subclavian artery instead of the aorta, and the superior laryngeal nerve actually does take the direct route to the larynx without looping around anything. The difference in path length between the right and left recurrent branch in humans is 10 cm (O'Reilly & Fitzgerald 1985), adding a totally unnecessary complication in providing the left and right side of the larynx with precisely coordinated motor signals.

In some distant ancestor with anatomy quite different from ours, these roundabout routes may well have been direct paths. Today we're stuck with them, due to deeply rooted developmental constraints. No third-factor principle of efficiency has cleared the tangle of nerves and blood vessels in our neck; instead we have here developmental constraints, also supposedly part of the third factor, causing blatant inefficiency.

4.3. *Proposed Non-Linguistic Examples of Biological Features Coming for Free from Physics*

The biology and neurology of language is for the most part insufficiently understood to say much yet about causes and explanations. The biolinguistic literature on third-factor issues therefore invokes a number of better-understood examples from other areas of biology than language as examples of third-factor principles at work (e.g., Narita & Fujita 2010, Jenkins 2006). But the biology of these examples is well enough understood that we can say clearly and emphatically that they do not come "for free, directly from physics".

Bone structure is a case in point. It is quite true that bone is commonly structured in a way that achieves maximal strength with minimal material, as stated by Narita & Fujita (2010). But this does not come "directly from physics", it comes from the interplay between the laws of physics and a complex process of active remodeling in the bone. The biological material in the bone senses the strain on the bone, adding material where the strain is large, and removing material where the strain is small. The strain patterns do come from physics, but the remodeling does not. The strain-sensing adding/removing process is effected by a highly complex network of cellular and molecular systems (reviewed in Robling *et al.* 2006), genetically specified and presumably evolved through natural selection. It did not come for free. The only thing that physics provides for free here is a feedback signal; the system for sensing that signal and reacting appropriately had to evolve the hard way. Bone structure thus is *not* the pure result of third-factor principles at work; it is the result of biological processes in interaction with, and exploiting, physical laws.

Similarly, the shape of a bird's wings and feathers do come from the physical laws of aerodynamics, sort of. But they do not come for free. Birds do not automatically acquire wings with good aerodynamic properties. Instead, if good flying ability increases the fitness of a bird, then birds with wings and feathers providing better flying abilities will have more offspring and such wing shapes will spread in the population. The only role of the physical laws of aerodynamics in this process is to determine which shapes provide better flying abilities. The actual shaping has to be done through normal evolutionary and developmental processes.

Jenkins (2006) and Fujita (2007) invoke protein folding as an example of a biologically important process that comes from third-factor principles. This is a better example than bone or feathers, as a newly built protein typically does fold directly through physical processes into a configuration determined by its amino acid sequence. But biologically useful folding still does not come for free, for three reasons:

- The process is fairly reliable *in vitro* for most proteins, where no other factors interfere. But *in vivo* the folding frequently fails, and we have a fair amount of intracellular machinery dedicated to folding assistance, notably the chaperone proteins (Lee & Tsai 2005).
- There is no particular reason for the folding that comes from physics to be the biologically optimal one.
- The amino acid sequence that determines the folding is itself the product of a long evolutionary history, where appropriate and reliable folding is likely to have been a non-negligible selective pressure. Mutations that cause misfolding are common, and are a major cause of diseases such as cystic fibrosis.

Cells having spherical shape rather than, say, cubical, is another example, mentioned by Chomsky (2011) as following directly from physics without any genetic input needed. It is true that an isotropic elastic membrane will spontaneously make a spherical shape, in the absence of other forces than an

internal pressure. But many, probably most, cells are not spherical; there is a wide variety of cell shapes both among single-celled and multicellular organisms. Non-spherical shapes result either from a non-spherical distribution of forces on the cell membrane, or from non-uniformity of the membrane itself. As with protein folding, this is again a case of physics providing the mechanism doing the actual shaping, but with biological processes in control of the physical forces, setting up the situation so that the physical forces produce a biologically appropriate cell shape, which may or may not be spherical. Physics provides the proximate cause, but the ultimate cause why a certain cell has a certain shape is biological, not physical.

4.4.   Is Physics Explained by Third-Factor Principles?

Shifting the explanatory burden to the third factor has a dual purpose. It is supposed to ease further the problem of accounting for the origins of the genetic endowment, but it is also an important aspect of the desire to go "beyond explanatory adequacy" (Chomsky 2004). Boeckx & Piattelli-Palmarini (2005) see deep parallels with the aims of fundamental physics, as envisioned by thinkers like Feynman or Einstein, whose work also involves going beyond just descriptive laws and explanatory theories, and arriving at a principled understanding of why nature is the way it is. As correctly noted by Boeckx & Piattelli-Palmarini (2005: 454): "The question is not whether this new development in the field is legitimate, but rather whether it is premature".

But the legitimacy of the quest for principled explanations does not obviate the need for causes that do the immediate work, the result of which may (or may not) be explained by fundamental principles. If nothing else, without working through the intermediate steps we cannot know if a putative principled explanation actually does explain anything, or if it is just a coincidental pattern resemblance, or even the result of wishful thinking in the quest for principled explanations.

In physics, the principle of least action can be regarded as the ultimate cause behind many processes in nature, providing a principled explanation behind many physical laws. One example is Snell's law of refraction, which in itself is purely descriptive, lacking any kind of explanatory adequacy. Least action provides a principled explanation of why Snell's law is the way it is. But behind Snell's law are also proximate explanations of why photons behave the way they do — see e.g., Feynman (1985). Feynman's explanation may even be generalized to a proximate explanation of why physics in general follows the principle of least action. I do not think I am alone in finding the combination of proximate cause and ultimate principle much more satisfactory than either one taken in isolation. This is related to the point made by Mayr (1961) and Tinbergen (1963), discussed above — their different levels of explanation are complementary, not exclusive, and the full complement of answers is needed for a satisfactory explanation.

Furthermore, it is not a given that every individual feature in nature does have a principled explanation. Some features do, but others are historical contingencies. This is true even within the physical sciences. For example: There

is a principled explanation why a star with the mass and composition of the sun has the temperature and luminosity that it has — but the mass and composition are matters of historical contingency, due to accidental circumstances during star formation once upon a time. Similarly for the planets of the Solar System: We do have a principled explanation for the general pattern, with small rocky inner planets and large gaseous outer planets, based on condensation processes in the original nebula — but the specific pattern of planets, with precisely four inner planets and four outer planets, and Earth and Venus having roughly the same size, is a pure historical contingency based on effectively random events during accretion. That the real world is not uniformly principled goes hand in hand with Chomsky's (e.g., 2008, quoted above) emphasis on the conjectural nature of his third-factor work, and should be kept in mind by biolinguists pursuing this conjecture.

5.   Conclusions

The third factor of Chomsky (2005) has received much attention in recent bio-linguistic work. But the attempts so far to actually use third-factor considerations as a major constituent in the explanation of language are uniformly un-convincing. The only supposedly third-factor based works that are worth taking seriously are those that do *not* invoke any blanket third factor, but instead are explicit about which specific principles their analysis is based on, e.g., Uriagereka (2008). Typical of the papers explicitly invoking the third factor, in contrast, is that no serious causal analysis is performed, and no causal connections from third-factor principles to linguistics are presented; instead the literature abounds with unsupported claims that this or that feature comes "for free, directly from physics". I regard this unfortunate state of affairs as the result of three conspiring factors:

(1)   Insufficient attention is paid in biolinguistics to the causal analysis of the human language faculty. Tinbergen's four questions are rarely considered, despite their prominent position in "The *Biolinguistics* Manifesto" (Boeckx & Grohmann 2007).

(2)   'The' third factor is a vague catch-all category, mixing entities with totally different causal and epistemological status, rendering its analytical value highly dubious.

(3)   At the same time, third-factor-based "principled" explanations are held up as a goal, especially by Chomsky (e.g., 2010).

The three points above conspire to give an undeserved air of legitimacy to sweeping, unwarranted claims of language "coming for free", as soon as something that might be the third factor is involved, tempting some biolinguists into drawing conclusions based more on their desire for principled explanations than on actual data and analysis. Instead of succumbing to this temptation, the following points should be kept firmly in mind:

- As 'the' third factor in its current form is not a coherent well-defined concept, any analysis invoking the third factor must carefully and explicitly consider just what kind of principles are being invoked.

- The observation of a putative third-factor pattern in an aspect of language does not in itself warrant the conclusion that the third factor *explains* that aspect of language. A pattern in language is a *clue* to possible explanations; it is not a principled explanation in itself, unless the causal connection is established and understood. A detailed case-by-case causal analysis is required.

- Searching for patterns can be a valuable heuristic in tackling problems that are difficult or intractable otherwise. But keep in mind that this is a heuristic only, a hypothesis-generator, not an end in itself.

- Postulating optimality or efficiency can likewise be a useful heuristic in the search for hypotheses in an evolutionary context. But this heuristic is useful only under the assumption that natural selection has optimized the feature in question[20], not otherwise, and its main value lies in providing clues to what natural selection has optimized *for* – cf. Tinbergen's first question.

- Mathematical elegance and beauty is nice, and at least in physics searching for elegance has a fair track record as a heuristic (Johansson 2006). But pursuing elegance for its own sake, beyond empirical support, can lead research badly astray (Woit 2007).

- The distinction that Dennett (1995) makes between skyhooks and cranes should also be kept in mind; third-factor arguments are too often used as skyhooks.

- While it would be nice if all aspects of language did have principled explanations, there is no guarantee that this will be the case. There is no serious quest for principled explanations for the vocabulary and quirks of individual languages; everybody agrees that such features are historical contingencies. The core features of syntax is the area where principled explanations can be hoped for and conjectured, but even there we have no guarantee. As repeatedly emphasized by Chomsky, the principled character of core syntax remains a conjecture. The goal of explaining language in a principled manner does not come closer by attempting to short-circuit the process with vacuous claims of getting something "for free, directly from physics".

I propose that a better way for biolinguistics to proceed is to return to its roots, as expressed in Boeckx & Grohmann (2007), taking seriously the biological nature of language that is supposed to be at the core of the biolinguistic enterprise. This means analyzing language in the same way as biologists analyze other biological features, basically as described in section 3 above. Many of the components of 'the' third factor likely have roles to play in that analysis — but unwarranted shortcuts do not.

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[20]   Or under the assumption that language became perfect purely by random accident —but such a pseudo-explanation is both extremely unlikely and far from principled.

Of course we should proceed with due consideration given to the extraordinary nature of language compared with other biological features, but we should at the same time scrupulously avoid the "methodological dualism" that Chomsky (1995) warns against, not treating language as different in kind from other biological features, not seeking explanations for language that are different in kind from the explanations sought for other biological features. Physical laws and efficiency considerations should have the same kind of place in the explanation of language as in the explanation of, for example, the eye or any other biological feature.

The unification of linguistics with the rest of science remains a goal that we have in common. But it is misguided to attempt the unification of linguistics with physics before biology. We are doing biolinguistics, not physicolinguistics.

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