Biolinguistics and Platonism: Contradictory or Consilient?

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It has been argued that language is a Platonic object, and therefore that a biolinguistic ontology is incoherent. In particular, the notion of language as a system of discrete infinity has been argued to be inconsistent with the assumption of a physical (finite) basis for language. These arguments are flawed. Here I demonstrate that biolinguistics and mathematical Platonism are not mutually exclusive and contradictory, but in fact mutually reinforcing and consilient in a coherent and compelling philosophy of language. This consilience is effected by Turing's proof of the coherency of a finitary procedure generative of infinite sets.

Keywords: biolinguistics; discrete infinity; ontology; Platonism; Turing machine

1 Introduction

In "The Incoherence of Chomsky's 'biolinguistic' Ontology" (Postal 2009), Postal attacks biolinguistics as "junk linguistics" (p. 121) with an "awful" (p. 114) ontology expounded in "gibberish" (p. 118), the "persuasive force of [which] has been achieved only via a mixture of intellectual and scholarly corruption" (p. 104), whereas writings espousing Postal's ontology "manifest substance and quality of argument at an incomparably higher intellectual level than [Chomsky's]" (p. 105). As a proponent of biolinguistics, I am tempted to reply in kind to such invective, but to do so would be bad form and bad science. A fallacy free and dispassionate — if disputatious — rebuttal is necessary and proper.

For Postal, language is a Platonic object, and therefore he concludes that the biolinguistic assumption of a physical basis for language is "*absurd*" (p. 104). To the contrary, I shall show Postal's conclusion to be a *non sequitur*.

By engaging in this argument, I fully expect Postal to accuse me of having "chosen to defend something [i.e., biolinguistics] its own author [i.e., Chomsky] is unwilling to" (p. 105), from which two conclusions necessarily follow *in Postal's mind*: (i) I am a living testament to Chomsky's "intellectual and scholarly corruption" of the youth; and (ii) "By exercising his undeniable right of silence here, Chomsky leaves unimpeded the inference that he has not attempted a refutation because he cannot" (p. 105). It goes without saying that I reject these conclusions and the premise from which they do *not* follow. (Incidentally, (i) corrupting the

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young has noble precedents (e.g., a case from 399 BCE comes to mind) and (ii) the argumentum a silentio is a classic(al) fallacy.)

This is not an apologia for Chomsky. Biolinguistics has no single author: It is a research program pursued by numerous individually-thinking scientists subordinate to no individual however foundational, august, and influential. Moreover, the theoretical and empirical contributions of the diverse subprograms in which these scientists work are so numerous and important that none can be "dominant" (Postal 2009: 104): for example, in the intersection of cognitive science, linguistics, and the formal sciences, the formal properties and functional architecture of linguistic cognition are being specified; evolutionary biology is investigating possible homologues/analogues of language in nonhuman animals; genetics is discovering some of the genes active in the development and operation of the language faculty; neuroscience is mapping the physical substrate of linguistic processing; and this is but a sampling of the biolinguistics program to "reinstate the concept of the biological basis of language capacities" (Lenneberg 1967: viii).

The subprogram I work in, call it Mathematical Biolinguistics, is so theoretically and empirically eclectic that I am naturally interested in its ontology. It therefore cannot be "odd for [Postal's] opposite in the present exchange to be anyone other than Chomsky" (Postal 2009: 105).

In the next section, I very briefly and very informally define the biolinguistics Postal impugns. The third section is a rehearsal of Postal's arguments for linguistic Platonism and *ipso facto* (so he assumes) against biolinguistics; in particular, it is argued that the notion of language as a system of discrete infinity is inconsistent with an ontological commitment to language as a neurobiological (finite) system of cognitive computation. I proceed in the fourth section to analyze some of the flaws in these arguments, demonstrating that the ontologies of Platonism and biolinguistics — properly defined — are not mutually exclusive and contradictory, but in fact mutually reinforcing and consilient in a coherent and compelling philosophy of language. This consilience is effected by Turing's proof of the coherency of a finitary procedure generative of infinite sets.

I must add that my work and the ontology it assumes are not representative of all biolinguistic research. Many would accept my thesis that, just as engineers have encoded abstract software into concrete hardware, evolution has encoded into the neurobiology of *Homo sapiens sapiens* a formal system (computable functions) generative of an infinite set of linguistic expressions, modulo my understanding of the (un-encoded) formal system as a Platonic object. Nor is mine the only coherent interpretation of biolinguistics. So it must not be thought that someone with my philosophy is the only possible opposite [to Postal] in the present exchange.

2 Biolinguistics

Let the ontology of some research program be defined as 'biolinguistic' if it assumes, investigates, and is informed by the biological basis of language — a definition subsuming many productive programs of research in the formal and natural sciences. But so general a definition cannot adjudicate the case with Postal. At issue here is the particular definition of biolinguistics that identifies language as *I-language* — i.e., a computational system (a function in *intension*) *internal* to the cognitive-neurobiological architecture of an *individual* of the species *Homo sapiens sapiens* — the properties of which are determined by the three factors that enter into the design of any biological system: genetics, external stimuli, and laws of nature.

That Chomsky invented the term *I-language* and has expatiated on the three factors does not render him the "author" (Postal 2009: 105) of biolinguistics — that would be a category error analogous to attributing "authorship" of evolutionary biology to Darwin given his invention of the term *natural selection* and expatiation on the factors entering into common descent with modification. Biolinguistics and evolutionary biology are research programs to investigate objects and processes of nature. Thus the only author of I-language is nature. And thus anyone is free to recognize the ontology of biolinguistics as here defined.

3 Platonist Ontology

The incoherence of the biolinguistic ontology is claimed to derive from the fact that "*there cannot be such a thing*" (Postal 2009: 105) as biolinguistics, which assumes that "a mentally represented grammar and [the language-specific genetic endowment] UG are real objects, part of the physical world, where we understand mental states and representations to be physically encoded in some manner [in the brain]. Statements about particular grammars or about UG are true or false statements about steady states attained or the initial state (assumed fixed for the species), each of which is a definite real-world object, situated in space-time and entering into causal relations" (Chomsky 1983: 156–157). To Postal, this ontology is as "*absurd*" as a "biomathematics" or a "biologic," for "[w]ere mathematics biological, brain research might resolve such questions as whether *Goldbach's Conjecture* is true. Were logic biological, one might seek grants to study the biological basis of the validity of *Modus Ponens*. The ludicrous character of such potential research is a measure of the folly of the idea that these fields study biological things" (Postal 2009: 104, 105).

By analogy, Postal argues that the objects of linguistic inquiry are not physical (*a fortiori* not biological), but rather "like numbers, propositions, etc. are abstract objects, hence things not located in space and time, indeed not located *anywhere*. They are also things which cannot be created or destroyed, which cannot cause or be caused. [Natural languages] are collections of other abstract objects normally called *sentences*, each of which is a set" (Postal 2009: 105).

In the paper under consideration, Postal does not expound this ontology; a "brief exposition of its essence" (Postal 2009: 106) suffices for his and my purposes. Essential to the ontology — a form of linguistic Platonism — are the type/token distinction and discrete infinity.

3.1 *Types/Tokens*

> ES IST DER GEIST DER SICH DEN KRPER BAUT: [S]uch is the nine word inscription on a Harvard museum. The count is nine because we count *der* both times; we are counting concrete physical objects, nine in a row. When on the other hand statistics are compiled regarding students' vocabularies, a firm line is drawn at repetitions; no cheating. Such are

> two contrasting senses in which we use the word *word*. A word in the second sense is not a physical object, not a dribble of ink or an incision in granite, but an abstract object. In the second sense of the word *word* it is not two words *der* that turn up in the inscription, but one word *der* that gets inscribed twice. Words in the first sense have come to be called tokens; words in the second sense are called types.
>
> (Quine 1987: 216–217)

The distinction applies to sentences: For instance, in the classic story by Dr. Seuss, there exist (by my quick count) six tokens of the one type *I do not like green eggs and ham*. Postal defines sentence tokens and types as the objects of inquiry for biolinguistics and linguistic Platonism, respectively. For biolinguistics, *as Postal understands it*, a sentence is nothing more than a "*brain-internal token*" (Postal 2009: 107) — a mental representation. Such an object is defined by spatiotemporal (neurobiological) coordinates with causes (cognitive, chemical, etc.) and effects (e.g., in reasoning and communication). For linguistic Platonism, *as Postal understands it*, this physical object is (if anything) a token of an abstract type, with only the latter being 'really' real. Empirically, "island constraints, conditions on parasitic gaps, binding issues, negative polarity items, etc." obtain not of physical objects *per se*, but of abstractions: "Where is the French sentence *Ça signifie quoi?* — is it in France, the French Consulate in New York, President Sarkozy's brain? When did it begin, when will it end? What is it made of physically? What is its mass, its atomic structure? Is it subject to gravity? Such questions are nonsensical because they advance the false presumption that sentences are physical objects" (Postal 2009: 107). For Postal, this nonsense is nonfinite.

3.2 Discrete Infinity

"[T]he most elementary property of language — and an unusual one in the biological world — is that it is a system of discrete infinity consisting of hierarchically organized objects" (Chomsky 2008: 137). "Any such system is based on a primitive operation that takes n objects already constructed, and constructs from them a new object: in the simplest case, the set of these n objects" (Chomsky 2005: 11). "Call [the operation] *Merge*. Operating without bounds, Merge yields a discrete infinity of structured expressions" (Chomsky 2007: 5). Postal invokes the type/token distinction in his critique of this biolinguistic conception of discrete infinity. He assumes that any object constructed by a physical system must be physical: "Consider a liver and its production of bile, a heart and its production of pulses of blood; all physical and obviously finite. And so it must be with any cerebral physical production" (Postal 2009: 109). Thus if language is a physical (neurobiological) system, then its productions (sentences) must be physical (neurobiological tokens). But physical objects are by definition bounded by the finiteness of spatiotemporal and operational resources: "There is for Chomsky thus no coherent interpretation of the collection of brain-based expressions being infinite, since each would take time and energy to construct, [...] store, process, or whatever[...]; they have to be some kind of *tokens*" (Postal 2009: 109, 111).

More abstractly, a discretely (denumerably) infinite set is one with expressions (members) that can be related one-to-one with the expressions of one of its subsets (and with the natural numbers). But if language is a neurobiological system, hence finite, then obviously it cannot contain or construct a set that can be related to the (countable) infinity of natural numbers: "[E]very physical production takes time, energy, etc. and an infinite number of them requires that the physical universe be infinite and, internal to Chomsky's assumptions, that the brain be" (Postal 2009: 111). *Reductio ad absurdum*, supposedly.

If biolinguistics implies that expressions are bounded by the spatiotemporal and operational resources of neurobiology, then the (infinite) majority of expressions contained in the discrete infinity are generable only in principle: there exist infinitely many more possible sentences than can ever be generated in the physical universe. So for the biolinguistic system to be defined as discretely infinite, it must be defined as an idealization: a system abstracted away from the spatiotemporal and operational resources of neurobiology. In other words, the biolinguistic system is discretely infinite only if abstracted from biology. And this, Postal concludes, is the fundamental fallacy:

> [If] the biological [Merge function] 'ideally' generates an infinite collection, most of the 'expressions' in the collection cannot be physical objects, not even ones in some future, and the [natural language] cannot be one either. [A]lmost all sentences are too complex and too numerous [...] to be given a physical interpretation[...]. In effect, a distinction is made between real sentences and merely 'possible' ones, although this 'possibility' is unactualizable *ever* in the physical universe. According to the biological view, [...] the supposedly 'possible' sentences are, absurdly, actually biologically impossible. Thus internal to this 'defense' of Chomsky's biolinguistic view, the overwhelming majority of sentences *cannot be assigned any reality whatever internal to the supposed governing ontology*. This means the ontology can only claim [natural language] is infinite because, incoherently, it is counting things the ontology cannot recognize as real. (Postal 2009: 111)

If, however, tokens as physical objects can implement abstract types, then presumably a recursive rule — a finite type — could be tokenized as a procedure in the mind/brain. This Postal concedes: Although "nothing physical is a rule or recursive," because recursive rules are Platonic, a "physical structure can encode rules" (Postal 2009: 110). Presumably, therefore, Merge — the mentally-represented/neurobiologically-implemented recursive procedure posited in biolinguistics to generate discrete infinity — is a legitimate posit. Postal dissents: "[A]n interpretation of physical things as representing particular abstractions [is] something Chomsky's explicit brain ontology has no place for" (Postal 2009: 110). Furthermore, Merge generates sets, and sets are Platonic abstractions, but as "an aspect of the spatiotemporal world, [Merge] cannot 'generate' an abstract object like a set" (Postal 2009: 114). So Merge is either biological — not mathematical and hence incapable of generating a set (let alone an infinite one) — or it is mathematical — hence non-biological but capable of generating discrete infinity. In sum, language is either physical *or* it is Platonic, and only under the latter definition can it be predicated of that "most elementary property," discrete infinity — or so Postal maintains.

4 Mathematical Biolinguistic Ontology

Let me affirm at the outset my commitment to *mathematical* Platonism, which informs my biolinguistic ontology in ways to be discussed. More strongly than Chomsky, who does grant mathematical Platonism "a certain initial plausibility," I am convinced of the existence of "a Platonic heaven [of] arithmetic and [. . .] set theory," *inter alia*, that "the truths of arithmetic are what they are, independent of any facts of individual psychology, and we seem to discover these truths somewhat in the way that we discover facts about the physical world" (Chomsky 1986: 33). It follows from this position that I must be committed to *linguistic* Platonism for any linguistic objects reducible to or properly characterized as mathematical objects. And indeed in my theory of natural language, the quiddities that define a system as linguistic are ultimately mathematical in nature. (The 'essence' of language, if you will, is mathematical — a proposition I shall not defend here, assuming it to be essentially correct, for at issue in this discussion is not whether the proposition is true, but whether it is consistent with a biolinguistic ontology if true.)

4.1 Overlapping Magisteria

It has been convincingly argued (see, e.g., Hauser, Chomsky, Fitch 2002; Watumull, Hauser, Berwick 2013) that a recursive function generative of structured sets of expressions is central to natural language; this function is defined in intension as internal to the mind/brain of an individual of the species *Homo sapiens sapiens*. So conceived, I- language has mathematical *and* biological aspects.

Of course to Postal this is nonsense: The ontologies of mathematics and biology are non-overlapping *magisteria*. Assuming mathematical Platonism, I concur that a mathematical object *per se* such as a recursive function (the type) is not physical. However, even Postal (2009: 110) concedes that such an object can be physically encoded (as a token). The rules of arithmetic for instance are *multiply realizable*, from the analog abacus to the digital computer to the brain; *mutatis mutandis* for other functions, sets, etc. And *mutatis mutandis* for abstract objects definable as mathematical at the proper level of analysis, such as a computer program:

> You know that if your computer beats you at chess, it is really the *program* that has beaten you, not the silicon atoms or the computer as such. The abstract program is instantiated physically as a high-level behaviour of vast numbers of atoms, but the *explanation* of why it has beaten you cannot be expressed without also referring to the program in its own right. That program has also been instantiated, unchanged, in a long chain of different physical substrates, including neurons in the brains of the programmers and radio waves when you downloaded the program via wireless networking, and finally as states of long- and short-term memory banks in your computer. The specifics of that chain of instantiations may be relevant to explaining how the program reached you, but it is irrelevant to why it beat you: there, the content of the knowledge (in it, and in you) is the whole story. That story is an explanation that refers ineluctably to abstractions; and therefore those abstractions exist, and really do affect physical objects in the way required

> by the explanation.
>
> (Deutsch 2011: 114–115)

(Though I shall not rehearse the argument here, I am convinced by Gold (2006) that "mathematical objects may be abstract, but they're NOT [necessarily] acausal" because they can be essential to — ineliminable from — causal explanations. The potential implications of this thesis for linguistic Platonism are not uninteresting.)

I take the multiple realizability of a computer program to evidence the reality of abstractions as well as anything can (and I assume Postal would agree): Something "substrate neutral" (Dennett 1995) is held constant across multiple media. That something I submit is a Turing machine (computable function): the mathematical object representing the formal properties and functions definitional of — and hence universal to — computational systems.

4.2 The Linguistic Turing Machine

Within mathematical biolinguistics, it has been argued that I-language is a form of Turing machine (see Watumull 2012; Watumull, *et al.* 2013), even by those Postal diagnoses as allergic to such abstractions:

> [E]ven though we have a finite brain, that brain is really more like the control unit for an infinite computer. That is, a finite automaton is limited strictly to its own memory capacity, and we are not. We are like a Turing machine in the sense that although we have a finite control unit for a brain, nevertheless we can use indefinite amounts of memory that are given to us externally[, say on a "tape,"] to perform more and more complex computations[. . .]. We do not have to learn anything new to extend our capacities in this way.
>
> (Chomsky 2004: 41–42)

As Postal would observe, this "involves an interpretation of physical things as representing particular abstractions," which he concedes is coherent in general because "physical structure can encode rules" and other abstract objects (e.g., recursive functions) (Postal 2009: 110) — computer programs, I should say, are a case in point. However he does not accept the interpretation in this particular case.

4.3 Idealization

Postal (2012: 18) has dismissed discussion of a linguistic Turing machine as "confus[ing] an ideal machine[. . .], an abstract object, with a machine, the human brain, every aspect of which is physical." I-language qua Turing machine is obviously an idealization, with its unbounded running "time" (i.e., number of steps) and access to unbounded memory, enabling unbounded computation. And obviously "[unboundedness] denotes something physically counterfactual as far as brains and computers are concerned. Similarly, the claim 'we can go on indefinitely' [. . .] is subordinated to the counterfactual 'if we just have more and more time.' Alas, we do not, so we can't go on indefinitely" (Postal 2012: 18). Alas, it is Postal who is confused.

4.3.1 Indefinite Computation

Postal's first confusion is particular to the idealization of indefinite computation. Consider arithmetic. My brain (and presumably Postal's) and my computer can encode a program (call it ADD) that determines functions of the form $f_{\text{ADD}}(X+Y) = Z$ (but not W) over an infinite range. Analogously, my brain (and Postal's) but not (yet) my computer encodes a program (call it MERGE) that determines functions of the form $f_{\text{MERGE}}(\alpha, \beta) = \{\alpha, \beta\}$ — with the syntactic structure $\{\alpha, \beta\}$ assigned determinate conceptual-intentional and sensory-motor representations — over an infinite range. These programs are of course limited in performance by spatiotemporal and operational resources, but the programs themselves — the functions in intension — retain their deterministic form even as physical constraints vary (e.g., ADD determines that $2 + 2 = 4$ independent of performance resources).

Assuming a mathematical biolinguistic ontology, I-language is a cognitive-neurobiological token of an abstract type; it "generates" sets in the way axioms "generate" theorems. As the mathematician Gregory Chaitin observes, "theorems are *compressed* into the axioms" so that "I think of axioms as a computer program for generating all theorems" (Chaitin 2005: 65). Consider how a computer program explicitly representing the Euclidean axioms encodes only a finite number of bits; it does not — indeed cannot — encode the infinite number of bits that could be derived from the postulates, but it would be obtuse to deny that such an infinity is implicit (compressed) in the explicit axioms. Likewise, $z_{n+1} = z_n^2 + c$ defines the Mandelbrot set (as I-language defines the set of linguistic expressions) so that the infinite complexity of the latter really is implicitly represented in the explicitly finite simplicity of the former.

So while it is true that physically we cannot perform indefinite computation, we are endowed physically with a competence that *does* generate a set that *could* be produced by indefinite computation. (A subtle spin on the notion of competence perhaps more acceptable to Postal defines it as "the ability to handle arbitrary new cases when they arise" such that "infinite knowledge" defines an "open-ended response capability" (Tabor 2009: 162).) Postal must concede the mathematical truth that linguistic competence, formalized as a function in intension, *does* indeed generate an infinite set. However, he could contest my *could* as introducing a hypothetical that guts biolinguistics of any biological substance, but that would be unwise.

Language is a complex phenomenon: we can investigate its computational (mathematical) properties independent of its biological aspects just as legitimately as we can investigate its biological properties independent of its social aspects (with no pretense to be carving language at its ontological joints). In each domain, laws — or, at minimum, robust generalizations — license counterfactuals (as is well understood in the philosophy of science). In discussing indefinite computation, counterfactuals are licensed by the laws expounded in computability theory:

> [T]he question whether a function is effectively computable hinges solely on the behavior of that function in neighborhoods of infinity[...]. The class of effectively computable functions is obtained in the ideal case where all of the practical restrictions on running time and memory space are removed. Thus the class is a theoretical upper bound on what can ever in any century be considered computable.

(Enderton 1977: 530)

A theory of linguistic competence establishes an "upper bound," or rather delineates the boundary conditions, on what can ever be considered a linguistic pattern (e.g., a grammatical sentence). Some of those patterns extend into "neighborhoods of infinity" by the iteration of the recursive Merge function. Tautologically, those neighborhoods are physically inaccessible, but that is irrelevant. What is important is *the mathematical induction from finite to infinite*: Merge applies to any two objects to form a set containing those two objects such that its application can be bounded only by stipulation. In fact a recursive function such as Merge characterizes the "iterative conception of a set," with sets of discrete objects "recursively generated at each stage," such that "the way sets are inductively generated" is formally equivalent to "the way the natural numbers [. . .] are inductively generated" (Boolos 1971: 223).

The natural numbers are subsumed in the computable numbers, "the real numbers whose expressions as a decimal are calculable by finite means" (Turing 1936: 230). (The phrase "finite means" should strike a chord with many language scientists.) It was by defining the computable numbers as those determinable by his mathematical machine that *Turing proved the coherency of a finitary procedure generative of an infinite set*.

> For instance, there would be a machine to calculate the decimal expansion of π[. . .]. π being an infinite decimal, the work of the machine would never end, and it would need an unlimited amount of working space on its 'tape'. But it would arrive at every decimal place in *some* finite time, having used only a finite quantity of tape. And everything about the process could be defined by a finite table[. . .]. This meant that [Turing] had a way of representing a number like π, an infinite decimal, by a *finite* table. The same would be true of the square root of three, or the logarithm of seven — or any other number defined by some rule.
>
> (Hodges 1983: 100)

Though they have not been sufficiently explicitly acknowledged as such, Turing's concepts are foundational to the biolinguistic program. I-language is "a way of representing [an infinite set] by a finite table" (a function). With the set of linguistic expressions being infinite, "the work of the machine would never end," but Postal must concede that nevertheless I-language "would arrive at every [sentence] in some finite time, having used only a finite quantity of tape. And everything about the process could be defined by a finite table," and thereby programmable into a physical mechanism. (This gives a rigorous sense to the rationalist-romantic intuition of language as the "infinite use of finite means.")

5 Generation and Explanation

But for all the foregoing, the finitude/infinitude distinction is not so fundamental given the fact that "[a] formal system can simply be defined to be any mechanical procedure for producing formulas" (Gödel 1934: 370). The infinitude of the set of expressions generated is not as fundamental as the finitude of I-language (the generative function) for the following reason: it is only because the function is finite that it can enumerate the elements of the set (infinite or not); and such a compact function could be — and *ex hypothesi* is — neurobiologically encoded. Even assuming Postal's ontology, in which "[natural languages] are collections of [...] abstract objects" (Postal 2009: 105), membership in these collections is granted (and thereby constrained) by the finitary procedure, for not just any (abstract) object qualifies. In order for an object to be classified as linguistic, it must be generated by I-language; in other words, to be a linguistic object is to be generated by I-language. And thus I-language *explains* why a given natural language contains as members the expressions it does.

This notion of *I-language as explanation* generalizes to the notion of *formal system as scientific theory*:

> I think of a scientific theory as a binary computer program for calculating observations, which are also written in binary. And you have a law of nature if there is compression, if the experimental data is compressed into a computer program that has a smaller number of bits than are in the data that it explains. The greater the degree of compression, the better the law, the more you understand the data. But if the experimental data cannot be compressed, if the smallest program for calculating it is just as large as it is [...], then the data is lawless, unstructured, patternless, not amenable to scientific study, incomprehensible. In a word, random, irreducible.
>
> (Chaitin 2005: 64)

This notion is particularly important, as Turing (1954: 592) observed, "[w]hen the number is infinite, or in some way not yet completed [...]," as with the discrete infinity (unboundedness) of language, "a list of answers will not suffice. Some kind of rule or systematic procedure must be given." Otherwise the list is arbitrary and unconstrained. So for linguistics, in reply to the question "Why does the infinite natural language **L** contain the expressions it does?" we answer "Because it is generated by the finite I- language f." Thus I-language can be conceived of as the theory explicative of linguistic data because it is the mechanism (Turing machine) generative thereof.

Second, with respect to idealization generally, for mathematical biolinguistics to have defined I-language as a Turing machine is not to have confused the physical with the abstract, but rather to have abstracted away from the contingencies of the physical, and thereby discovered the mathematical constants that (on my theory) must of necessity be implemented for any system — here biological — to be linguistic. This abstraction from the physical is part and parcel of the methodology and, more importantly, *the metaphysics* of normal science, which proceeds by the "making of abstract mathematical models of the universe to which at least the physicists give a higher degree of reality than they accord the ordinary world of sensation" (Weinberg 1976: 28). The idealization is the way things *really* are. Consider Euclidean objects (e.g., dimensionless points, breadthless lines, perfect circles, and the like). These objects do not exist in the physical world. The points, lines, and circles drawn by geometers are but imperfect approximations of abstract Forms — the objects *in themselves* — which constitute the ontology of geometry. For instance, the theorem that a tangent to a circle intersects the circle at a single point is true only of the idealized objects; in any concrete representation, the intersection of the line with the circle cannot be a point in the technical sense as "that which has no part," for there will always be some overlap. As Plato understood (*Republic* VI: 510d), physical reality is an intransparent and inconstant surface deep beneath which exist the pellucid and perfect constants of reality, formal in nature:

> [A]lthough [geometers] use visible figures and make claims about them, their thought isn't directed to them but to the originals of which these figures are images. They make their claims for the sake of the Square itself and the Diagonal itself, not the particular square and diagonal they draw; and so on in all cases. These figures that they make and draw, of which shadows and reflections in water are images, they now in turn use as images, in seeking to behold those realities — the things in themselves — that one cannot comprehend except by means of thought.

Analogously, any particular I-language (implemented in a particular mind / brain) is an imperfect representation of a form (or Form) of Turing machine. *But*, Postal would object, the linguistic Turing machine is Platonic, hence non-biological, and hence *bio*-linguistics is contradictory. *But*, I should rebut, this objection is a *non sequitur*.

I am assuming that fundamentally a system is linguistic in virtue of mathematical (non-biological) aspects. Nevertheless, in our universe the only implementations of these mathematical aspects yet discovered (or devised) are biological; indeed the existence of these mathematical systems is known to us only by their biological manifestations — *i.e., in our linguistic brains and behaviors* — which is reason enough to pursue *bio*-linguistics. To borrow some rhetorical equipment, biology is the ladder we climb to the "Platonic heaven" of linguistic Forms, though it would be scientific suicide to throw the ladder away once up it. That chance and necessity — biological evolution and mathematical Form — have converged to form I-language is an astonishing fact in need of scientific explanation. It is a fact that one biological system (i.e., the human brain) has encoded within it and/or has access to Platonic objects. (Postal must assume that our finite brains can access an infinite set of Platonic sentences. The ontological status of the latter is not obvious to me, but obviously I am committed to the existence of the encoding within the former of a finite Platonic function for unbounded computation.) Surely a research program formulated to investigate this encoding/access is not perforce incoherent.

I do, however, deny any implication here that such complex cognition, "in some most mysterious manner, springs *only* from the organic chemistry, or perhaps the quantum mechanics, of processes that take place in carbon-based biological brains. [I] have no patience with this parochial, bio-chauvinistic view[:] the key is not the *stuff* out of which brains are made, but the *patterns* that can come to exist inside the stuff of a brain" (Hofstadter 1999 [1979]: P-4, P-3). Thus, as with chess patterns in "stuff" of a computer, it is not by necessity that linguistic patterns spring from the stuff of the brain; but the fact remains that they can and do. And thus linguistics is just as much a biological science as it is a formal science. (Likewise, computer science is as grounded in engineering as it is in mathematics.)

To reiterate, at present there exists no procedure other than human intuition to *decide* the set of linguistic patterns. The neurobiology cannot answer the question whether some pattern is linguistic (e.g., whether some sentence is grammatical), but it encodes the procedure that enables the human to intuit the answer to such a question. Analogously, neurobiological research would not establish the truth of Goldbach's conjecture or the validity of reasoning by modus ponens, but rather would be unified with research in cognitive science to establish (discover) the rules and representations encoded neurobiologically that enable cognitive conjecture and reasoning.

Moreover, the biological/linguistic distinction is arguably ill-formed if we assume as it is reasonable to do that some linguistic theories *just are* biological theories. Examples abound:

> [Sapir] was looking at the phonetic data from a certain American Indian language and was able to show that, if he assumed a certain abstract phonological structure with rules of various kinds, he could account for properties of these data. He could explain some of the facts of the language. That investigation in itself was an investigation of psychological reality in the only meaningful sense of the term. That is, he was showing that if we take his phonological theory to be a theory about the mind — that is, if we adopt the standard 'realist' assumptions of the natural sciences — then we conclude that in proposing this phonological theory he was saying something about the mental organization of the speakers of the language, namely that their knowledge and use of their language involved certain types of mental representations and not others — ultimately, certain physical structures and processes and not others differently characterized. (Chomsky 1983b: 44)

Postal believes that an "explicit brain ontology" as assumed in biolinguistics "has no place for" the encoding of an abstract object such as a Turing machine in a physical system such as the brain — but I see *no grounds whatsoever* for this belief. Not only is this belief contradicted by Chomsky's (2004: 41–42) Turing machine analogy, but Postal himself quotes Chomsky discussing how in biolinguistics "we understand mental states and representations to be physically encoded in some manner" (1983: 156–157); and to physically encode something presumes a non-physical something to be so encoded. For this reason "it is the mentalistic studies that will ultimately be of greatest value for the investigation of neurophysiological mechanisms, since they alone are concerned with determining abstractly the properties that such mechanisms must exhibit and the functions they must perform" (Chomsky 1965: 193).

It is in this sense of neurobiology encoding mathematical properties and functions that, "astonishingly" (Postal 2012: 23), we observe the most trivially obvious of facts:

> We don't have sets in our heads. So you have to know that when we develop a theory about our thinking, about our computation, internal processing and so on in terms of sets, that it's going to have to be translated

> into some terms that are neurologically realizable. [Y]ou talk about a generative grammar as being based on an operation of Merge that forms sets, and so on and so forth. That's something metaphorical, and the metaphor has to be spelled out someday.
>
> (Chomsky 2012: 91)

In other words, while the formal aspects of a Turing machine (e.g., Merge, sets, etc.) are, *ex hypothesi*, realized neurologically, it would be absurd ("astonishing") to expect physical representation of our arbitrary notations (e.g., $f_{\text{MERGE}}(X, Y) = \{X, Y\}$). As Turing observed, in researching the similarities of minds and machines, "we should look [...] for mathematical analogies of function" (1950: 439) — similarities in software, not hardware.

Of course an ontological commitment to abstract properties and functions is not necessarily a commitment to Platonism (as Aristotle demonstrated and many in the biolinguistics program would argue), yet it is certainly the default setting. So it can be argued that I-language is just like Deutsch's chess program: a multiply realizable computable function (or system of computable functions). Indeed given my understanding of a Turing machine as a mathematical object, *I-language qua Turing machine is necessarily and properly defined as a physically (neurobiologically) encoded Platonic object.*

6 Conclusion

I have argued that mathematical biolinguistics is based on the *perfectly coherent* concept of computation — as formulated by Turing — unifying mathematical Platonism and biolinguistics: Evolution has encoded within the neurobiology of *Homo sapiens sapiens* a formal system (computable function(s)) generative of an infinite set of linguistic expressions (just as engineers have encoded within the hardware of computers finite functions generative of infinite output). This thesis, I submit, is or would be accepted by the majority of researchers in biolinguistics, perhaps modulo the Platonism, for indeed it is not necessary to accept the reality of mathematical objects to accept the reality of physical computation. However, I am a mathematical Platonist, and thus do recognize the reality of mathematical objects, and thus do argue I-language to be a concretization (an 'embodiment' in the technical sense) of a mathematical abstraction (a Turing machine), which to my mind best explains the design of language.

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