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Resurrections and Insurrections in the Neurobiology of Language

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The dominant models of how human language is neurally implemented have been slowly disintegrating for many years now, but the challenge of assembling a more modern take on this ancient question can only be feasibly undertaken by someone willing to wade through an increasingly dense literature. This someone should ideally also be involved in contemporary experimental neurolinguistics and psycholinguistics. It is with a unique sense of historical context, and contemporary clinical urgency, that Gregory Hickok assumes this task of proposing an updated view of human language processing. His book *Wired for Words* surveys the field of the neurobiology of language and offers a unique model.

The book is primarily focused on the *architecture* of the brain's language network. In slight contrast in emphasis to his early collaborator David Poeppel, Hickok agrees that "localization ≠ explanation", but he makes the important point that it is, nevertheless, useful information to have (indeed, it is difficult to think of any researcher who actually thinks localization *is* explanation). For example, if neural effects of syntax are robustly localized not just to left-hemispheric frontotemporal sites, but to right-hemispheric dorsal parietal sites, that is hugely important information to have. And this surely *will* inform mechanistic accounts, just as much as hippocampal localization of navigation and spatial memory informs mechanistic models in other domains. Different brain regions commonly host distinct cell types, and exhibit different intrinsic rhythmic properties and resting-state profiles, and connectivity profiles, both structural and dynamical in their inter-areal signatures—and all of this can contribute to narrowing down mechanistic can-

didates. This is not even to mention the rather more obvious clinical and neurosurgical issues concerning the importance of localization for treatment. Hickok's logic is clear here when he argues that due to "the tendency to minimize distance in neural wiring patterns", "knowing where phonological and semantic networks live in the brain will potentially constrain our models of where the in-between morphosyntactic networks live" (p. 168). Localization may not "equal" explanation, but it can certainly constrain it.

What follows here are some select quotations and comments, which do little justice to the intricacies of Hickok's text but which I hope offer some useful reflections and summaries. Note that some of the topics I pick up on are not central to Hickok's main theses, but are discussed enough in the book to allow for concrete responses and reflections. I will survey some of Hickok's most interesting arguments, push back against some of his claims about the nature of language and thought, present some novel hypotheses of my own, and offer some more global context concerning the place of Hickok's thought in relation to the evolving field of the cognitive neuroscience of language.

Syndromes and a Century: Language and Its Asymmetries

The book's early chapters review a number of interesting neurological case studies involving types of echolalia, Tourette's syndrome, visual form agnosia, optic ataxia, amongst many others, and which serve to set the stage for the neural organization of speech. The conscious and automatic self are discussed, with Hickok noting how many motoric acts are purely reflexive, and discussing some consequences for models of speech. Hickok reviews the computational and anatomical nature of the 'what' and 'how' streams for various functions. The complexity of linguistic behavior, however, prevents any simplistic mapping here. Dual stream models are important, "but one should not try to pigeonhole all linguistic or visuomotor function into such a framework" (Hickok, 2025, p. 37; note that all subsequent citations to the book will only provide page numbers). Hickok critiques "the language-equals-left-hemisphere dogma" (p. 47), reviewing the modern history of the field that assumed the right hemisphere cannot interpret language—but only because the tests were measured by verbal responses. When non-verbal assessments of language comprehension are used, the picture becomes more complicated. Unilateral cases of word deafness can occur, but likely only in cases of people with strong left-hemispheric language-dominance, and Hickok notes how "the empirical record never supported the widespread view that speech perception is strongly left dominant" (p. 55).

These ideas segue into later chapters, in which Hickok critiques "the overblown popular view of two entirely different minds, abilities, and ways of thinking" (p. 62). (Although he does not mention him as a target of critique, I am reminded here very much of Iain McGilchrist (McGilchrist, 2021), who can deftly conjure up quotations from

classic European literature to defend an oversimplified view of the brain's naughty left hemisphere and sagely right hemisphere and their relationship to "the divine" through his version of panentheism). Many differences between the hemispheres, as Hickok reviews extensively, are a matter of degree rather than kind. Often very subtle differences, with small effect sizes, between hemispheres have been interpreted categorically in support of functional asymmetries. In contrast, Hickok believes "we need to reset our theory of the left-right organization of the brain and return to something closer to Broca's *symmetry with modification*" (p. 71), a conclusion surely intensified by the finding that "speaking involves all of the brain's language network" (p. 231).

Hickok devotes multiple chapters to emphasizing that modern researchers should aim to resurrect many of the classical insights of the field's founding fathers. These ideas are highly relevant to models of speech perception (speech production, "converting thoughts into waves" (p. 121), does seem to be robustly left-dominant even if it calls upon widespread right-hemispheric activity). Despite McGilchrist's claims about reductionism and spiritualism and creativity, "the two sides of the brain are vastly more similar to each other than they are different", says Hickok (p. 71). Hickok notes that many cognitive neuroscientists are naturally trained to focus on apparent differences between the hemispheres, rather than evaluating more broadly their clear symmetries. (Indeed, instead of trying to ground some major functional or cognitive distinction in human nature by looking to "left-hemispheric" or "right-hemispheric" worldviews, as McGilchrist does, perhaps the real cause of these sorts of cultural and ideological shifts over the centuries lies not in splits in gross neural anatomy but rather splits inside our own selves, for which there is no singular neural boundary, and whatever drives those changes is almost certainly multi-causal and historically contingent – the problem is not that hemispheric asymmetries don't exist, but that the evidentiary base rarely licenses the sweeping cognitive and cultural conclusions drawn from them).

Hickok's assessment is that "clinical observations of severe word comprehension problems following unilateral left-hemisphere lesions, even acute ones, are not representative of the lateralization of speech perception in the population as a whole" (p. 76). He provides a comprehensive history of the development of the dual stream model of speech, including a number of interesting scholarly and personal elements of this story. He reviews some previously settled scores with the motor theory of speech perception. The majority of claims that the motor system is critical or helpful under certain conditions "are either wrong or overstated" (p. 97). The motor system "adds about 1–2 decibels of assistance under noisy listening conditions and only using nonecologically valid tasks that are known to implicate the motor system", and Hickok estimates that the contribution of the motor system to speech perception in real-world communication is "essentially zero" (Ibid).

The book covers a range of other interesting territory, relevant for neurobiologists of language but also a broader range of cognitive scientists and philosophically-minded

readers. We learn how "the syllable, not the phoneme, is the principal unit of speech recognition" (p. 115). Some chapters contain careful dissections of how sensorimotor transformations occur across discrete areas of the broader language faculty. Hickok thinks of these "in terms of a funnel-like process" (p. 117). He contrasts what he calls a standard *funnel model* (in which "phonemes are recovered and then assembled into syllables, syllables into morphemes, and morphemes into syntactic hierarchies") with a *leaky funnel model*, which he advocates for, under which "information relevant to multiple levels of the funnel leak out from their own levels of the thought-to-sound transformation process and add to the wave pattern directly" (Ibid.). Ultimately, this means that what gets sent to articulatory systems is a multiplexed signal coming from more than one source in parallel. In other words, windows of speech perception and planning can simultaneously trigger inferences across numerous perceptual and conceptual domains (see also Casto et al., 2025, according to whom the core language network "exports" information to various distinct networks, akin to the minimalist program notion of language sending instructions to various conceptual systems).

Hickok is also cautious not to over-interpret the functional role of neural oscillations, arguing that while they may have their place ("they are a candidate mechanism for utilizing some of these [linguistic] cues" during inference (p. 139)), many questions remain. He is surely right, and recent work assessing the functional role of brain rhythms also entertains other causal-mechanistic candidates for language, like cortical cascades, pathways, and various topological non-causal structures that can add explanatory power to neurolinguistic theory (Murphy, 2025a). The literature contains a spectrum of opinion about the strong or weak functional role of oscillations in language (Benítez-Burraco et al., 2023; Ding, 2020, 2023; Martin, 2020; Meyer, 2018; Piai et al., 2014; Rossi et al., 2023; Wang et al., 2012). Even my book titled *The Oscillatory Nature of Language* (Murphy, 2020b) invokes a number of non-oscillatory explanatory structures for certain lexico-semantic and complex syntactic processes. Sceptical attitudes like Hickok's are certainly needed, and his discussion of this topic is balanced and thoughtful. Later in the book, he offers an intriguing hypothesis that "our rhythmic abilities stem from the necessity to synchronize the dorsal and ventral speech coordination systems" (p. 292) (see also Hickok et al., 2023), which may ultimately bring Hickok's thinking in closer connection with the types of issues that functional theories of brain waves are often aimed to address. In a similar connection, Hickok discusses the common claim that the left hemisphere excels at temporal processing while the right hemisphere excels at spectral processing. He pushes back here, and argues that many of these supposed asymmetries are probably "the result of top-down selection of subnetworks of the overall system" (p. 142). Under Hickok's thesis, asymmetries are not built into auditory networks but rather the (task-dependently-triggered) higher-order networks engaged by linguistic stimuli, and if these higher-order networks are even somewhat asymmetric (which they

assuredly are) then any top-down feedback to these auditory systems will *also* be asymmetric.

This is a rather ingenious and elegant explanation for decades of contentious debate over auditory processing (a)symmetries, and it deserves critical engagement from the field, not least because this type of story will immediately be testable via reference to models of neural dynamics of language. Hickok's explanation also becomes more plausible once we consider written language and sign language, which display the same asymmetries with respect to the processing of linguistic information (Samsouris et al., 2025; Trettenbrein et al., 2025).

Sentimental Value: Intuition and Communication in Models of Language

Hickok then traverses the topic of aphasia and its relation to general cognitive deficits. He notes that some studies that have shown significant correlations between aphasia and nonverbal intelligence may be "more consistent with the correlation being driven by an accidental disruption of separate systems rather than damage to a single system that supports both linguistic and nonlinguistic ability" (p. 171). Aphasia and nonverbal deficits surely co-occur, but having aphasia does not mean a nonverbal cognitive deficit is guaranteed. Hickok's empirical assessment is persuasive, but some of the trickier conceptual issues remain to be disentangled. While it is true that damage to the language system does not necessitate specific non-linguistic deficits, this does not warrant the conclusion that language itself is not to be considered a "thought system" (depending on how we decide to define 'thought'). Merge-based syntax permits a kind of information coarse-graining, re-formatting concepts and giving us new kinds of 'things' to think about (Hinzen, 2006, 2007; Jackendoff, 2012; Murphy, 2025b; Pietroski, 2018). Language evolution did not just make it easier to communicate—it also made it easier to *think*. Merge-based syntax gives us more precise coordinates in conceptual space than a cognitive architecture that can only access discrete elements with simpler combinatorial powers. Hickok argues persuasively that "language is not thought itself" (p. 175), but there are relatively few (especially outside of pre-war philosophical texts) that have argued such a stringent connection (for discussion, see Murphy, 2020a). Hinzen (2007) is a rare example of a thesis almost equating "thought" with language. A certain older, now retired linguist used to be unfairly misrepresented here (see below), especially by many scholars Hickok cites: Arguing that language is a "system of thought" is *not* the same as arguing that language is literally identical with, and fully exhausts, thinking. Language surely does not drive or constitute *all* of human thought, but I would argue it is certainly part of it. In the literature, we often read that stroke patients have substantial language deficits, but they can still 'think' (pass various cognitive tests), therefore language cannot be considered a thought system. But this is flawed logic and a category error: Inferring

that "language is not a thought system" because non-linguistic thought survives after damage to language areas is like saying "vision is not a sensory system" because blind people can still smell and hear.

The vast majority of our everyday use of language is not for "communication", but for organizing our thoughts, planning, strategizing, aiding directed attention, the consolidation of experience, reflecting on personal responsibilities, cognitive model updating, and more general and abstract forms of reflection (Chomsky, 2021a, 2021b). Notice that language "use" here just means whenever our brain's language system is used to arrive at some kind of inference. Hickok, in contrast, claims that "communication appears to be what language is mostly used for" (p. 336), but he does not make it clear what "use" constitutes (he seems to equate "use" with "speaking" or "listening" or externalization more generally, which I think is an obvious problem). Our online use of language impacts and updates many conceptual processes, even if many of these systems survive after the core language network is damaged. Indeed, Hickok even concedes some points from his own published work here, noting that "there *is* a statistically reliable relation between language and nonverbal ability, but it is very loose, accounting for about 11 percent of the variance" when calculating the statistical relation between the Raven's Matrices nonverbal intelligence test and various standard aphasia assessment tests (p. 173). Hickok argues convincingly that language can surely be used in "augmenting to a modest degree" (p. 175) cognition when placed under certain external demands pertaining to constraints on memory and time, and also in the case of logical reasoning. It would be unsurprising, given neural redundancy, if language damage did not automatically disable diverse non-linguistic conceptual systems.

Hickok contrasts his "augmenting" view on the language-thought relation with what he sees as Chomsky's more hardline hypothesis. Hickok writes that Chomsky argues that language is "an integral part of our species' intellectual ability" (p. 336)—but notice that this hypothesis does not necessitate the idea that 'language = (all of) thought'. This has never been Chomsky's position, at least on my reading of him. Indeed, he has always made a point (via citations to Turing and others) that "thought" is too loose a term to be of much use. I have always found the notion that language forms "an integral part of our species' intellectual ability" to be rather obviously true, and I still find it odd that scholars like Hickok place far greater emphasis on "communication" (which is actually a tertiary function of language, since communication is one of many forms of externalization, and not all forms of externalization have a strongly communicative force to them; see Asoulin, 2016; Murphy, 2020a; Wiltschko, 2022).

The more subtle point to be made here is not about the relation between language and "thought" in the sense of card sorting tasks, picture-naming tasks, and working memory tasks—it concerns how language allows us to construct certain *types* of complex thoughts that only seem accessible (or more readily accessible) via syntactic configurations. Evidentiality and certain epistemic constructs, inductive definitions, counterfactual

reasoning, multi-step logical inferences, truth-evaluable judgments and complex nested planning are all facilitated by the core computational competence of syntax-semantics. If we ignore these types of representations and *only* focus on whether stroke patients can sort cards and point to palm trees then we will inevitably be painting an impoverished picture of human cognitive competence and miss opportunities to uncover more nuanced inter-dependencies with language.

Hickok notes that language can be used to aid certain tasks through things like internal verbal rehearsal ("thinking through" steps, etc.), but notice that there are properties of linguistic *computation* beyond phonological rehearsal that intrinsically *direct* (rather than "help" or "support") thought. Consider a row of balls of different colors. Let's say the left-to-right order is *white, yellow, green, blue, green, green, orange, green.* If I say "grab the third green ball", English speakers would grab the ball immediately to the left of the orange ball, and not the ball immediately to the left of the blue ball, because they know they need to fetch the [third [green ball]] and not the third ball in the sequence that also happens to be green. There are many such ways in which natural language syntax-semantics *directs* conceptual instructions (and, in turn, seems to reify underlying components of conceptual structure), and one would not be able to explore these types of topics if we only focused on whether stroke patients can still perceive colors, count to three, and successfully identify a ball amongst other non-ball objects. For another example, consider the fascinating reports in Pietroski et al. (2009, 2011) and Knowlton et al. (2021) exploring the meaning of 'most' and how conceptualizing identical experimental stimuli as count ('dots') vs. mass ('paint') nouns impacts behavioral performance in rapid quantity estimation tasks. Impairing our brain's language system does not mean we cannot update cognitive instructions and so cannot "think"—it just means we cannot refine the kind of nuanced coordinates in conceptual space that complex syntactic structures uniquely afford.

Another related point here. As might be clear by now, Hickok defines language in a different way from how Chomsky, Matchin, and I think of it (Chomsky, 2021a, 2021b; Matchin & Hickok, 2020; Murphy, 2025a). For Hickok, the evolutionarily early recursive compositional operator does not constitute language in itself, but rather 'language' for Hickok seems to be *externalization* and its consequences. But I see no reason why 'language' has to align with our more commonsense notion of 'stuff that is said sequentially to communicate an idea to another human being'. It may sound *unintuitive* to classify language in the way Chomsky does. But surely that is also one of the main goals of science—to show that our intuitions (about virtually everything) are wrong. Newton and later physicists showed that our intuitions about mass and motion are wrong. Mendelian genetics showed that our intuitions about much of biology are wrong. Gödel showed that our intuitions about mathematics are wrong, and of course mathematics is infamously riddled with counter-intuitive conclusions (think of Conway's surreal numbers). One of my favorite examples is the result that the infinite series 1 + 2 + 3 + 4 + …, though

divergent, is associated via analytic continuation with the value −1/12. In fact, closer to home, our intuitions about memory, navigation, and color perception are *also* wrong. So why should our intuitions about language be taken seriously as feasible means to guide scientific theories, and why should our intuitions be used as additional constraints on how we define and operationalize concepts like 'thought' and 'language'? Why is 'language' one of the only major topics in cognitive science where attitudes are so hidebound, and intuitions and biases are so unshakeable, that they guide theory-formation?

Hickok (personal communication) stresses here that "I'm open to Noam's idea [concerning the origin of language]. If it's true, then, from a biological perspective, being able to think in this more complex way must have had an adaptive advantage. Intelligence = better survival/reproduction. That makes sense. But, again, in the species that evolved this ability before externalization, was this language? I would say no." He adds that "if at some point in our evolutionary history we had merge and recursion but no way to externalize it, I would say that at that point, that species did not have language." As might be clear by now, many of the above and subsequent disagreements will hinge on how we as language scientists decide to carve out 'language' from 'thought', 'internalization', 'externalization', and other key concepts.

Some related comments on this final theme. The word 'geometry' literally translates as 'land (earth) measurement', because the first practitioners of geometry did indeed literally measure land. But the field matured sufficiently to the point that more generalizable and abstract principles could be extracted, and now modern geometry has no relation to hills and mountains. I think the same is true for 'linguistics'—the fact that our definitions of language are now quite unintuitive is a sign of progress, and should be welcomed. Same for semantics: It is certainly *intuitive* to hold the externalist notion that words 'refer' to objects in the world ('chair' refers to the set of all chairs, etc.), but as Pietroski, Strawson, Chomsky and others have nicely argued, linguistic objects do not inherently 'refer' to anything, they are just mental representations ripe for instructions to various conceptual systems. The act of 'referring' is an agentive human action, not an intrinsic abstract 'relation' between *morpheme-entity*—ditto for phonological representations and objects 'in the world'. Linguistics is riddled with numerous cases of intuitions being proven wrong. Over time, some of these harder-to-shake intuitions about language (e.g., that language is primarily a system designed and evolved for communication) may also disintegrate. It may feel odd that 'language' is at its core a recursive compositional operator, but I am sure that many of the ancient geometry scholars were also puzzled when younger generations started proposing abstract and baroque mathematical principles ("We need to return to measuring hills and mountains!"). Hickok himself is certainly not calling for such a retreat, and is fully engaged in all the relevant post-mountain-measuring apparatus, but I mention these points here to make a broader claim about the nature of intuitions and systems of explanation in science.

In brief, co-occurrence of aphasia and nonverbal deficits (discussed in Chapter 8) does not actually settle whether language is a "thought system". While Hickok's book provides an excellent empirical set-up for these conversations, these issues also require greater engagement with philosophical arguments and the formal structure of linguistic objects.

Eternal Sunshine of the Symbolic Mind: Neurobiology of Syntax

Perhaps the core argument of the book is Hickok's provocative suggestion that "aspects of our linguistic systems evolved out of nonlinguistic sensorimotor control systems", and so therefore "we can learn something about the neurocomputational architecture of language by studying visuomotor control in humans" (p. 17), and indeed many models that try and skirt over these details will be "just plain wrong" (p. 97), even while Hickok's own model "shares several features" (p. 319) with existing accounts. Precisely *how* the neural language network implements elements of "abstract knowledge systems and processes of modern linguistics" (p. 201) via this apparatus that evolved out of sensorimotor control systems remains a topic for future theoretical work. Much evidence is presented to support the claim that "the neural architecture of phonology looks a lot like sensorimotor control architectures in general" (p. 249). Hickok's long-time collaborator, William Matchin, put forward the argument to Hickok that what is surely *not* a species of sensorimotor control functions is "recursive combinatorial structure that is oriented around semantics, using atoms that are not determined by sensory-motor properties", and this property of language is "parasitic on sensory-motor systems for communication" (Matchin, post on Bluesky, November 14, 2025).

These sorts of tensions remain unresolved in much of the contemporary neurolinguistics literature. Indeed, there has been decades of skirting around these looming issues, and many researchers have been guilty of presenting a type of resolution to these puzzles that only rises to the level of rhetorically and metaphorically sophisticated devices. The elephant in the room (i.e., how our recursive-combinatorial knowledge of language is simply an entirely different mathematical object than anything else in our minds) remains ever-present. I think Hickok's conception of Merge as potentially being translatable or "reframed as a kind of sequencing" (p. 316) (via morphosyntactic sequencing) mistakenly links Merge closer to *linearization* than to *hierarchical structure-formation*. These subtle details bring with them some fairly important consequences for how we might theorize about the neural enforcement of syntactic information.

Hickok (personal communication) highlights a further point here, that is worth presenting: "Just because you can find things that don't follow a sensorimotor architecture doesn't mean that sensorimotor architectures aren't part of language. Moreover, I'm

talking about architectures, not computations. Merge, for example, may very well be something that is computed within a sensorimotor architecture."

Despite these qualms, Hickok stresses that when he claims that phonology and morphosyntax are organized neurally in terms of a sensorimotor control architecture, "I do not mean that phonology or morphosyntactic principles [...] reduces to generic sensorimotor systems that control, say, grasping" (256). Rather, the claim is an evolutionary one based on the principles of homology. Later chapters outline Hickok's sensorimotor control theory for speech, and he elaborates on his main claim that "the architecture of language processing is *homologous* to the architecture of nonlinguistic sensorimotor systems such as visuomotor control", and that the language system "employs homologous computations such as feedback control" (304). Hickok offers an interesting idea that feedback control may be crucial to aligning hierarchical structure formation with morphosyntactic linearization. Once we transition into the more formal computational nature of the language faculty, the importance of moving beyond neuroanatomical maps becomes clear.

In brief, Hickok's reflections on higher-order properties of language are valuable and timely, but they also risk under-specifying the formal/computational uniqueness of syntax and over-centering speech at the expense of amodal 'I-language' in the generative grammar sense (Chomsky, 1986) (i.e., an internal, intensional, and individual perspective on the faculty of language, in contrast to a more socially-inflected conception of, e.g., 'English').

What about semantics? The conceptual systems in the brain have arguably proven much more difficult to isolate than sensorimotor representation. So too for processes tied to linguistic structure (morphosyntax, or the system that interfaces meaning and phonology), which have been "hard to pin down" (p. 165). Hickok highlights the posterior middle temporal gyrus as being a likely candidate for morphosyntactic and structural processing—as well as "a linguistic gateway to the semantic network" (183), being in "an ideal location for connecting" (p. 190) with entity semantic networks anterior to it (anterior temporal cortex) and event semantic networks posterior to it (angular gyrus), given "principles of economy in cortical wiring" (p. 218). Under Hickok's framework, morphosyntax sits right at the nexus of phonology, entity semantics, and event semantics. This idea is also supported by intracranial EEG work (Murphy et al., 2022, 2024; Thye et al., 2021) and non-invasive recordings (Zhang et al., 2024).

In Chapter 9, Hickok cautions against "obsessing" (p. 214) over Broca's area when discussing syntax, pushing back against the "1980s vintage syntactic theories" (p. 216). He reviews a range of lesion studies suggesting that damage to posterior temporal sites deliver the most severe syntactic deficits, in cases of perception and production. The arguments presented here are aligned with current literature and have major implications for theories of language implementation: (i) agrammatic comprehension is not exclusive to Broca's aphasia; (ii) Broca's aphasia is not caused by damage restricted

to Broca's area; (iii) grammatical ability is present in people with agrammatism; (iv) expressive agrammatism can occur without receptive agrammatism. A major finding from the past decade that Hickok highlights is that "sentence comprehension deficits, involving a range of sentence types, are caused by damage to posterior temporal regions" (p. 213). In contrast, Broca's area has not been consistently implicated in sentence-level comprehension deficits.

All of this leads to the suggestion that some of the classical assumptions in the literature were on the right track—but they lacked the relevant computational and formal tools to capture language as a system of (i) form (*auditory, visual, tactile*), (ii) meaning (*conceptual instructions*) and (iii) structure (*configuration, constituency*). Hickok therefore argues that what is needed is "not the abandonment of the classical model […] but its *integration* with linguistics" (p. 217). Hickok reviews how expressive syntactic deficits are linked to inferior frontal cortex damage, whereas *both* expressive and receptive syntactic deficits are linked to posterior temporal damage (pp. 218–223).

Some room is also left for the role of the inferior parietal cortex. In particular, Hickok notes that evidence over the past few years has persuaded him that the supramarginal gyrus houses both sublexical *and* morphosyntactic frontotemporal interface systems, rather than only sublexical auditory-motor interface. Area 'Spt' (which Hickok was "obsessed" with early in his career (p. 241)), on the other hand, remains a phonological interface. These ideas lead Hickok to offer an interesting hypothesis concerning the foundations of paragrammatism: it could be that damage to either the core morpho-syntactic system (in posterior middle temporal cortex, impacting comprehension and production) or the morphosyntactic interface system (in the posterior supramarginal gyrus, likely impacting production more than comprehension) leads to paragrammatism of (presumably) slightly distinct flavors.

Lost in Translation: A Hypothesis Concerning Nodes of the Language Network

A fascinating topic for future study concerns the role of a third node in the putative syntax network discussed by Hickok, alongside the usual two nodes in inferior frontal and posterior temporal sites. Hickok reviews meta-analyses that implicate:

i. Posterior temporal cortex (pSTS, pMTG)
ii. Pars triangularis
iii. A lightly myelinated portion of posterior middle frontal gyrus, partially overlapping with area 55b

Hickok notes that Paul Broca also recognized the possible role of (iii) (in Broca's terms, writing in 1861 he noted that the second "frontal convolution", along with the third, is "perhaps" implicated in "articulate language"). Area 55b was first described in 1956 by

Adolf Hopf, but only came into more modern focus after Glasser and colleagues' multimodal approach to cortical parcellation in 2016 (Glasser et al., 2016), combining myelin maps, task fMRI (story listening, in the case of language), and functional connectivity. Across various imaging modes, area 55b stood out as a well delineated cortical zone. Hickok confesses, concerning (iii), that "I largely ignored it myself, even though I saw it repeatedly in my own data" (p. 274). Documented effects of language here are often forgotten in review papers. Hickok speaks about dorsal frontal sites mostly in relation to his dorsal precentral speech hypotheses, but he also notes later in the book that the more anterior portions of 55b overlap with parts of pMFG that repeatedly show up in meta-analyses of syntax. He concludes that this more anterior portion (which I am identifying as (iii) here) is involved in "phrasal level prosodic planning" (p. 284).

What can we make of this mysterious third node in the syntax network, and could it potentially have functions beyond "phrasal level prosodic planning"? Due to (iii) often being implicated not just in sentence-level planning and production but also in passive comprehension tasks that do not explicitly require prosodic inferences (e.g., Murphy et al., 2023), we might consider some alternatives here.

If (i) is generally implicated in the causal *generation* of structure, and (ii) in the *use* of structure for complex inferences and as a first option for a higher-order memory buffer (Hickok says (ii) plays "a working memory-related support role" (p. 220)), then one possibility we might consider is that this third node of pMFG/anterior-55b is not just recruited for prosodic planning but is also recruited as a second syntactic workspace (for comprehension) or sequencer (for production), in the vein of Rizzi (2016), whereby the language system seems to need access not just to one but *two* workspaces. The first is used to generate a structure, and then the second is used to store it whilst another is built; Adger (2017) terms these the Operating Space and the Resource Space. Without these dual workspaces, we would only be able to build word-word ([[the] [boy]]) or word-phrase ([he [saw [the boy]]]) representations; phrase-phrase representations ([the man [saw [the boy]]], with a complex specifier and complex subject) require additional memory resources.

The notion that this area is involved in some type of memory- or sequence-related computation is supported by recent single-unit recordings (Xu et al., 2025), and other intracranial work showing engagement of parts of this pMFG region in sentence-level semantic composition (Murphy et al., 2023). This hypothesis is compatible with neuroimaging research that finds pMFG/anterior-55b more commonly recruited for sentence-level parsing over word-level processing (Matchin et al., 2019; Regev et al., 2025).

It is also possible that (i) and (ii) already provide sufficient dual-workspace resources, and that (iii) serves to help with cue integration via the syntax-prosody interface, and may also simply offer additional sites to export morphosyntactic information to, helping the language network to interface with closely abutting working memory and attention hubs in dorsal frontal cortex. As Hickok reviews, (i) and (ii) seem to be connected via

posterior and anterior subsegments of the arcuate fasciculus, while (i) and (iii) appear to be connected via the superior longitudinal fasciculus (in particular, SLF II). This provides two distinct routes for the posterior temporal cortex to export morphosyntactic information to workspaces which have their own sensitivities to different statistical, phonological and prosodic cues.

Overall, this tri-nodal morphosyntax network (the Generator, the Buffer, and the Sequencer) can help explain why this 'mystery node' of pMFG/anterior-55b crops up in sentence-level comprehension tasks. pMFG/anterior-55b implements a second-stage morphosyntactic workspace that temporarily maintains partially built hierarchical objects (or their feature bundles) to better facilitate phrase-phrase composition and multi-step dependency resolution, particularly when structure-building and linearization demands are simultaneously high.

Some actionable hypotheses quickly emerge here. For example, one may object that I am simply dressing up dorsal premotor cognitive control / working memory as syntax. To test this, we might expect to see *structure-sensitive* load effects, not only capacity effects. We would predict activation during silent comprehension of high-embedding or noncanonical structures even without articulatory planning. We would also predict that pMFG/anterior-55b activity is not redundant with inferior frontal buffers, such that we would find complementary timing. Even for a basic phrasal unit, then, we may expect activity in all three syntax areas, but with the timing of sensitivity to distinct components of structure and meaning being different. While (iii) overlaps with Hickok's dorsal precentral speech area, under the hypothesis I am presenting here we would also expect (iii) to be implicated in multi-modal, multi-unit morphosyntactic inferences.

As mentioned above, Hickok ultimately argues that pMFG and its overlap with 55b serve to compute prosodic planning (p. 305). We might extend Hickok's hypothesis by noting its clear compatibility with the extended tri-nodal syntax network I am proposing here. For instance, the syntax-prosody interface is by and large the central means by which hierarchical syntactic structures connect with sensorimotor instructions (Degano et al., 2024; Elfner, 2018). The relevance of prosody in cuing punctuated moments of syntactic processing becomes mostly relevant at the multi-phrasal ('sentence') level, and not the basic minimal phrase level. Again, this speaks to the relevance of the dorsal-frontal language site in the syntax-prosody interface and the multi-workspace model of Rizzi (2016) and others.

The model of syntax that Hickok presents (from Matchin & Hickok, 2020) separates out hierarchical structure building in (i) from linearization in (ii). While this is one of the more compelling models in the literature, there are certain things that are less well captured. For example, what is the role of this third syntax area in (iii) (Hickok suggests prosodic frames), and what is the interactional profile of hierarchical structure building (i.e., which other areas (cortical and subcortical) does (i) interact with to assemble hierarchical syntactic objects?). In addition, while the Matchin and Hickok (2020) model and

Hickok's own slightly updated ideas about syntax separate out hierarchical structure building from linear morphosyntax, there is nothing clearly stated in the book about dependencies. The reader may of course internally navigate this theme by sussing out which areas are implicated in 'vertical' syntactic knowledge (hierarchical constituency structure) and 'horizontal' syntactic knowledge (linearized, sequential relations), but a more explicit syntax-semantics architecture would make some of the denser chapters later in the book easier to parse out in terms of how they map to psycholinguistic models. This is especially important given that syntactic dependencies are always horizontally realized but crucially constrained by hierarchical structure-dependent rules.

Despite some of these less resolved issues, Hickok makes an important point that instead of seeking a *seat of syntax* in the brain, we should instead be looking for a *network of morphosyntax*. Syntax does not live on its own. Composition in language is intrinsically tied up in form-meaning-structure regulations, where there is no principled one-to-one-to-one relation between these three. Hickok often invokes the concept of 'lemma', a rather innocent sounding name for something that has proven to be most inconvenient for numerous neurolinguistic theories (Krauska & Lau, 2023). As Hickok notes, things that 'look' lemma-like probably reflect the *process* of these mappings that show more regular trends, not hard-coded stored lemmas. This results in a rather intricate language network, although Hickok places more focus on the dorsal stream rather than the ventral hubs for semantic processing. This brings us to our next series of arguments.

Past Lives: Old Ideas for New Problems

While he does not ignore it entirely, one theme that is not elaborated on much in Hickok's narrative is the crucial distinction between lexico-semantic meaning and compositional meaning. There are types of conceptual structures that can only be accessed and triggered by multi-phrasal structures, like truth-evaluability in the context of complex concepts like evidentiality, causation, factivity, and so on. "Lion" or "man" cannot be true or false, and neither can a simple phrase like "proud lion" and "tall man". It is only when we assemble "the tall man hunted the proud lion" that we can begin to make higher-order inferences (i.e., with Inflectional/Tense Phrases) (Hinzen, 2007). I assume from Hickok's broader model that he would implicate inferior parietal structures and also semantic hubs here, since they are thought to encode eventive constructs, but some elaboration here would be beneficial. For instance, while Hickok writes about the theme of "where do you know what you know?" (p. 167), some clarification about the scale and format of knowledge assumed would be helpful (e.g., compare knowledge of the noun "male", the noun phrase "Tom Cruise", and the larger constituent "My top 10 Tom Cruise movies"). The meaning of a stop sign on the road is a different formal entity from the

meaning of the noun phrase "[stop [sign]]". How the brain negotiates differences in *types of knowledge* relevant to language processing is a broader question in the background.

A related point to make here comes when Hickok discusses the semantic network, and notes how knowledge of the word 'dog' would trigger "shape, size, color, texture, and sound" features (p. 183). His argument admits some further complexity in the book's Appendix, but only in relation to contexts of use of common objects, not inherent representational complexity. He discusses work arguing that angular gyrus is implicated in eventive knowledge and anterior lateral temporal cortex is implicated in entity knowledge. But again, how directly pertinent is this to the neural architecture of language? Language does not uniquely contribute "shape, size, color, texture, and sound" features—these components of meaning are all contributed by non-language representational domains. An object's 'telic' and 'agentive' components (concerning its purpose and function, and origin) are different from its 'constitutive' and 'formal' components (concerning the relation between an object and its constitutive parts and how to distinguish it amongst other objects) (Pustejovsky & Batiukova, 2019). What language and our capacity for representational thinking seems to uniquely encode with respect to the meaning of 'chair', for example, would not be its shape and color features, but its functional origin and purpose; so too for many other seemingly simple nouns like 'water', 'city' and 'house' (Chomsky, 2000).

Hickok argues that event and entity hubs in the brain likely work not through an entity-to-event stream, but rather in parallel, given that event and entity knowledge is plainly dissociable (pp. 184–187). There is more to the story here, again informed by linguistic theory. While it is true, as Hickok suggests, that entity-event hubs likely work in parallel, the formal properties of the mind contribute important constraints and directives that add certain details to this story that are otherwise missing. Features of entities and events can be separable, but all events presuppose entities, whereas entities do not presuppose events. Likewise, verb phrases contain noun phrases, and not the other way around, with constituency structure having an organizational influence that aligns with the structure of folk metaphysics: 'John ran' is an event whose participant is John—it is not a special kind of John that exhibits running features. Once more the specter of linguistic constituency structure rears its head, but the implications for the neural architecture of language (and its interfaces) is rarely discussed in the literature (see also Adger & Svenonius, 2015). Consider also how objects assemble into events, which compose into complex processes, and then states, and then these can be parts of facts, which eventually lead to full propositions—all of which incrementally 'climb' the syntactic hierarchy, with language mirroring the ontology of conceptual knowledge. Hickok includes a paragraph about argument structure when talking about event/thematic knowledge (p. 186), an important piece of the puzzle here.

The basic lesson I am hinting at here is that language is simply a radically different beast when compared to other domains of cognitive neuroscience, and so assembling

one's model of the neural architecture for language by mostly contrasting it with known models of visual processing, or motor action, or entity/event hubs, will inevitably leave aside some rather critical computational, representational (hence processing related) and formal aspects. One piece I would argue is missing in Hickok's puzzle is a discussion of these formal properties, and differences, between natural language and things like sensorimotor control and visuomotor processing. The algebraic properties of syntax seem to be unlike anything else in cognition: how the brain enforces a *free non-associative commutative unbounded digitally infinite combinatorial hierarchical recursive structure-building tree-formation category-theoretic magma operation* ('Merge', for short) remains a mystery. It is unclear in the text how Hickok's cortical network might execute this (see Murphy, 2025a). But this is hardly a unique limitation of Hickok's book (similar criticisms can be made of other neural models of language, e.g., Friederici, 2017).

Another possible limitation of the book, depending on one's interests, is its overwhelming focus on speech. 'Reading' and 'orthography' do not appear in the Index, and are not mentioned in terms of how visual processing of words relates to Hickok's model of syntax, semantics or comprehension. Sign language research is discussed in much greater detail than reading. If the book's subtitle was 'The Neural Architecture of Speech', rather than 'Language', this would not be an issue. As it stands, some discussion of how the reading literature relates to Hickok's thinking would be useful.

One Battle After Another: Post-Revolution Challenges

Research in the language sciences in the 1950s and 1960s has often been characterized as triggering a "cognitive revolution". If this post-war period heralded such a revolution, then the 2020s may be described as an era of *insurrections* in the language sciences. That is to say, no new singular upheavals have emerged, but a series of counter-insurgencies have swept the field. We have seen Large Language Models pushing against traditional theoretical linguistics (though with dubious success; Dentella et al., 2024; Fox & Katzir, 2024; Katzir, 2023; Lan et al., 2024; Moro et al., 2023; Murphy et al., 2025). We have seen neural dynamics of language pushing against traditional localizationist models (adding 'how' questions to 'where' questions). With Hickok's assistance, we have also seen a revival of expressive-receptive asymmetries pushing back against processing models that do not accommodate psycholinguistically plausible architectures. Hickok provides arguments for moving "beyond Broca" (p. 285) (conceptually and neuroanatomically) by identifying multiple distinguishable streams of speech planning (Hickok et al., 2023)—revising rather than fully replacing more traditional conceptions of the speech network.

One final topic can be noted here for possible expansion in future work. Decades of work in linguistics and cognitive neuroscience suggests that the core domain-specific

property of human language is its generative, recursive hierarchical property, not the generation of linear sequences (Adger, 2025; Chomsky, 1995; Murphy, 2015, 2020a).

Other recent neural models embracing neural dynamics have proposed how the algebraic structure of human syntax might be neurally enforced (Murphy, 2025a), permitting the mapping of hierarchical, multidimensional conceptual structures onto temporally ordered objects. As a result, it may be possible to use the formal, mathematical properties of language to help narrow the space of candidate neural mechanisms for how language is encoded (Marcolli & Berwick, 2025)—an explanatory step that simply cannot translate into models of language that are purely 'boxological' and localizationist. Thanks to research over the past decade or so, we have a much better understanding of which brain regions seem to be critical for core syntactic operations. The open question the field now has, after having successfully localized much of the morphosyntactic apparatus, concerns the causal-mechanistic basis of language. For every 100 theories of Binding and Wh-movement in the literature, there are perhaps 3 or 4 theories of which brain regions encode this type of syntactic information (Friederici, 2017; Matchin & Hickok, 2020; Pylkkänen, 2019), and an even smaller number of models that explore these 'how' questions (Ding, 2020; Murphy, 2024, 2025a).

Wake Up Dead Man: Summary and Conclusion

Hickok's book is essential reading for both novices and hardened experts in the fields of cognitive neuroscience and the neuropsychology of speech and language. It is the only academic neurolinguistics book published this year in which the author provides quotations from Keanu Reeves, *The Princess Bride*, Dumbledore, Paul Broca, the Bible, and his own papers as relevant epigraphs to different chapters. One of the most impressive aspects of the book is Hickok's complete command of the literature: instead of focusing mostly on recent cutting-edge material, or on more classic literature, he spends an equal amount of time surveying texts of all ages. It is an excellent, and entertaining book. Hickok's critical analyses are sharp, and he spares no one: Friederici, Hagoort, Broca, Wernicke and others are all cast under a rigorous analytical lens. The book revives older ideas from figures such as Broca and Wernicke about expressive-receptive asymmetries and classical conceptions of left-right functionality, whilst simultaneously challenging many current assumptions about 'Broca's area-centrism' for syntax, and incorporating modern ideas about hierarchical processing and linearization.

While I have focused here mostly on topics at the syntax-semantics interface, I look forward to seeing future authors engage with Hickok's other arguments and hypotheses. The force of his critical assessments and imaginative hypotheses have the potential to inspire a fresh array of theories, and to help sustain a research culture that resists tendencies to focus too much on contemporary talking points and models, where atten-

tion is paid only to the most vogue and current frameworks while decades-old insights become forgotten, and "whereon every past shall full fost sleep" (Joyce, 1939, p. 473).

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