A Solution to the Logical Problem of Language Evolution:

Language as an Adaptation to the Human Brain

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Chomsky's (e.g. 1965, 1980) proposal that human language is underpinned by a genetically specified universal grammar (UG) is astonishingly bold. Generative grammar is seen not primarily as concerned with finding the most elegant account of the linguistic patterns observed in the world's languages, but rather as a part of biology: it is viewed as specifying the structure of a "language organ" whose development is unfolds under genetic control. Thus, according to this perspective, language acquisition should not, strictly speaking, be viewed as a process of learning at all; it should be viewed as a process of growth, analogous to the growth of the arm or the liver. But the proposal that generative grammar aims to characterize UG, interpreted as an abstract specification of a biological organ, comes at a price: that the putative language organ, like any other biological structure, must have explicable origins in the framework of natural selection.

The evolution of UG, though, appears deeply puzzling, as we shall argue below. Indeed, we present positive reasons to doubt that an evolutionary account of the origin of UG, as classically conceived, is viable. These arguments thereby cast doubt on the viability of the concept of UG, as an abstract specification of biological structure.

If UG is abandoned, what alternative theoretical synthesis is possible? How can the apparent 'fit' between languages and language learners be explained? How might universal, but often apparently arbitrary, patterns across the world's languages arise? In short, what theoretical options are available, if the concept of UG is abandoned?

In this chapter, we sketch a framework in which we hope a new synthesis can be constructed (this viewpoint is developed in more detail in Christiansen & Chater 2008). We suggest that this framework provides an alternative way of integrating insights from biology, the cognitive and brain sciences, and linguistics, and that it provides, in particular, an evolutionary plausible account of the biological basis for language acquisition.

This synthesis, as we shall see, inverts the explanatory structure underlying the postulation of UG. Instead of seeing the brain as a genetically specified system for language, which must have somehow arisen over the course of biological evolution, we view the key to language evolution to consist in evolutionary processes over language itself. Specifically, language should be viewed as an evolving system, in which the features of languages have been shaped by the process of acquisition and transmission across successive generations of language users. In particular, aspects of language that are easy to learn and process, or are communicatively effective, tend to be retained and amplified; aspects of language which are difficult to learn or process, or which hinder communication, will, if they arise at all, rapidly be stamped out. According to this perspective, the "fit" between the structure of language and the brains of language users comes about not, primarily, because the brain has somehow evolved a genetically specified UG capturing the universal principles of language, but instead because language itself is shaped by the brain.

The remainder of this chapter outlines this viewpoint in four main sections. We begin by framing what we call the *Logical problem of language evolution* that arises from a conventional UG perspective. We then, in *Language as shaped by forces of cultural transmission*, consider how language might, instead, be viewed as a cultural product, shaped by successive generations of speakers. We argue that biological and cognitive constraints cannot be left out—they are likely to be crucial in explaining the cultural evolution of language. We sketch some of these constraints in *The neural and cognitive basis of language*. The core of our account is that language evolves to fit the brain; but can the brain also adapt to deal with language? In *Problems of gene-language co-evolution* we describe circumstances under which such co-evolution can or cannot occur, suggesting that the brain may have adapted to stable "functional" aspects of languages, even though it could not have internalized the types of arbitrary linguistic constraints captured by a putative UG. Finally, we briefly sketch some *Future directions* for research.

1. The logical problem of language evolution

How might a language organ have evolved? How might the principles of UG, specifying, by assumption, highly complex and arbitrary constraints on the structure of language, become genetically encoded? As with any other putative biological structure, an evolutionary story can take one or two routes. One route is to assume that specialized brain mechanisms specific to language have evolved over long periods of natural selection (e.g. Pinker & Bloom 1990). The other route rejects the idea that UG has arisen through adaptation and proposes that UG has emerged through some non-adaptationist route (e.g. Lightfoot 2000), just as it has suggested that many biological structures are not the product of adaptation. Yet both routes run into fundamental difficulties.

Problems for the adaptationist account

The idea of linguistically-driven biological adaptation as the origin of a genetically specified UG faces a fundamental problem. UG is intended to characterize a set of universal grammatical principles (e.g., governing phrase structure, case marking, and agreement) that hold across all languages., It is a central assumption, as we have noted, that these principles are arbitrary in the sense that they are not determined by functional considerations, such as constraints on learning, memory, cognitive abilities, or communicative effectiveness (e.g., Chomsky, 1980). Indeed, the highly abstract principles of UG have even been suggested to hinder communication (Chomsky, 2005). This arbitrariness implies that any combination of arbitrary principles will be equally adaptive—as long as speakers adopt the *same* arbitrary principles. Pinker and Bloom (1990) draw an analogy with inter-computer communication: it does not matter what specific settings (principles) are adopted as long as everyone adopts the same set of settings. Yet the claim that a particular 'protocol' can become genetically embedded through adaptation faces three fundamental difficulties relating to the dispersion of human populations, language change, and the question of what is genetically encoded.

The first problem stems from the fact that, according to a broad range of different scenarios concerning language evolution and human migration (e.g. Hawks, Hunley, Lee & Wolpoff 2000), divergent populations of language users would have arisen. Each of these different groups would have adapted to its own linguistic environment, rather than developing a universal language faculty. Indeed, salvaging the evolution of UG would require a very specific, scenario of gradual adaptation over a long period within a single, highly localized, population, prior to the dispersion and dominance of that population (at which point language divergence would begin); and an abrupt cessation of biological adaptation to language henceforth. The wide geographical spread of human populations, throughout last several hundred thousands years during which it is typically assumed that language arose seems to count against this viewpoint (Hawks et al. 2000). Second, the adaptationist account of UG faces the problem that even within a single population, linguistic conventions change much more rapidly than genes change, thus creating a "moving target" for natural selection. Computational simulations have shown that under conditions of relatively slow linguistic change, arbitrary principles cannot become genetically fixed—even when the genetic make-up of the learners is allowed to affect the direction of linguistic change (Chater, Reali & Christiansen 2009). Third, natural selection produces adaptations designed to fit the environment in which selection occurs. It is thus puzzling that an adaptation for UG would have resulted in the genetic underpinnings of a system capturing the highly abstract features of all possible human languages, rather than fixing the superficial, and specific, properties of the first language-like communication systems developed by early hominids. After all, hominids would have been positively selected for ability to learn and process the *specific* communication system they actually employed, not for the hypothetical ability to learn any of a large space of languages which have never been encountered.

It remains possible, though, that the origin of language did have a substantial impact on human genetic evolution. The above arguments only preclude biological adaptations for arbitrary features of language, whereas there might be features that are universally stable across linguistic environments (such as the means of producing speech, Lieberman 1984; or the need for enhanced memory capacity, or complex pragmatic inferences, Givón & Malle 2002; Levinson 2000) that might lead to biological adaptation, as we discuss below. However, these language features are likely to be functional, to facilitate language learning and use—and thus would typically not be considered part of UG.

1.1 Problems for the non-adaptationist account

The non-adaptationist account fairs no better. The putative language organ, embodying the genetically specified UG, must capture an enormous complex and subtle set of constraints. In the Government and Binding framework (Chomsky 1981), for example, UG is presumed to contain binding principles, theta theory, and so on, in an intricately interlocking system. The non-adaptationist account boils down to the idea that some process of *chance variation* maps existing biological structures on to UG. Yet the probability of randomly building a fully functioning, and completely novel, biological function by chance is infinitesimally small (Christiansen & Chater 2008). To be sure, modern genetics shows how small genetic changes can lead, via a cascade of genetic ramifications, to dramatic phylogenetic consequences (e.g. additional pairs of legs, instead of antennae, Carroll 2005). But such mechanisms go no way towards explaining how a completely new and functioning system can arise de novo (Finlay 2007).

1.2 Is minimalism a solution?

The formulation of the meta-theory concerning the biological basis of UG formed the basis of "mid-period" Chomskyan generative grammar. It might be suggested that recent developments in syntax, and in particular, the minimalist program (Chomsky 1995) may cast these theoretical issues in a different light. For example, Hauser, Chomsky and Fitch (2002) suggest that the content of UG (or what they term the "narrow faculty of language") may be extremely modest, consisting purely of the principle of recursion (see also Boeckx, this volume, Bickerton, this volume, Chomsky, 2005). This appears to signal an almost complete retreat from the original UG perspective. One rationale for UG was to explain how language acquisition is possible, given that the linguistic input to be child is noisy and incomplete, and the regularities of natural language are both arbitrary and highly complex (i.e. UG was presumed to solve the "poverty of the stimulus" argument; Chater & Vitányi 2007; Chomsky 1980; Pullum & Scholz 2002). If UG consists only of recursion, this solution collapses.

Moreover, linguistics can no longer be viewed as a part of biology, capturing innate knowledge of language, if the language-specific element of this knowledge consists only of recursion. Current writings on minimalism by no means suggest whole-hearted acceptance of the consequences of this retreat (Boeckx 2006).

In any case, the supposed simplicity of the mechanisms of the minimalist program is achieved by sleight of hand. A single merge operation composes structures together; but this is more than balanced by a spectacular increase in the complexity of the lexicon. Moreover, sentence structure becomes surprisingly intricate—Boeckx (2006) notes approvingly that one 'discovery' of the minimalist account is that typical declarative sentences may consist of around fifty phrases, embedded inside one another (for discussion, see Chater & Christiansen 2007). Thus, it is by no means clear that minimalism plays any role in simplifying accounts either of language evolution or, indeed, language acquisition.

2. Language as shaped by cultural transmission

If we do away with the assumption that language requires a dedicated, genetically specified UG, then it is natural to view language as a cultural product—i.e. a collective construction, across individuals and across generations of language users. From this standpoint, language has the same status as other cultural products, such as styles of dress, art, music, social structure, moral codes, or patterns of religious beliefs. Language may, of course, be particularly central to culture—indeed, language is presumably the primary vehicle through which much other cultural information is transmitted, and hence may have produced a crucial catalytic role in the development of other aspects of human culture and society. Nonetheless, language should, from this perspective, be viewed as a creation of a human mind that is not specifically hard-wired for language, rather than as directly emerging from a genetically-specified UG. This is, in short, to return to a pre-Chomskyan conception of language (e.g. Bloomfield 1933).

From this standpoint, the evolution of language is not, at least primarily, the story of how human biology has become shaped to support language. Instead, language itself is viewed an evolving system, transmitted from generation to generation of language-users by processes of cultural transmission. Thus, it is natural to see language evolution as language-change write large: thus, the study of diachronic linguistics (i.e. the study of processes of change in current, or at least recent, languages) becomes a potentially crucial window on to the processes that may have led to the emergence of language (Heine & Kuteva, this volume). Moreover, the study of the creation of new linguistic systems, over one or two generations of learners, as in Nicaraguan sign language (Senghas, Kita & Özyürek 2004), and in the transition from pidgins to creoles (Hymes 1971), can be viewed as exhibiting the processes of cultural invention and transmission that underpin language evolution.

Accordingly, it seems natural to see the content words, referring to objects, properties and actions, which can be communicatively useful, even in the absence of a fully structured grammatical system, as the starting points for language (Bickerton, this volume). Such items might initially be strung together somewhat arbitrarily; over time (both within individuals and across generations); particular patterns may then come to have conventionalized significance. For example, an item of particular importance might be signaled, pragmatically, by being, e.g. clause-initial; this, or some other, pattern may gradually become a language-internal cue, and, eventually, a conventionalized syntactic property signaling default subject position (Levinson 2000; Jackendoff 2002).

Similarly, content words, which initially have a narrow linguistic function, may come to be used more and more widely to signal general syntactic properties, a process known as *grammaticalization* (Hopper & Traugott 1993). Thus, the English number *one* may be the origin of the determiner *a*(*n*). Similarly, the Latin *cantare habeo* ('I have (something) to sing') mutated into *chanterais*, *cantaré, cantarò* ('I will sing' in French, Spanish, Italian). The suffix corresponds phonologically to 'I have' in each language (respectively, *ai*, *he*, *ho*—the 'have' element has collapsed into inflectional morphology, Fleischman 1982), but comes to have a purely grammatical function—signaling future tense. Over time, such morphological forms may be eroded or modified, typically to make them easier or quicker to say, often yielding an increasingly irregular morphological system. Indeed, morphological structure can sometimes become so eroded that a new content word is co-opted to signal the grammatical distinction, and the cycle begins again (Fleischman 1982).

Some theorists see the view that language emerges through cultural processes as indicating that language is relative unconstrained by biological factors (e.g. Bybee, 2009). We argue, by contrast, that processes of cultural transmission alone do not place sufficient constraints on the patterns of viable languages to explain the specific patterns of natural language and the specific patterns of linguistic change that give rise to them. Rather, we suggest that biological and cognitive constraints should be seen as helping to determine *which* types of linguistic structure tend to be learned, processed, and hence transmitted from person to person, and from generation to generation. Thus, we see the processes of cultural transmission that have shaped the creation of natural languages as grounded in prior human neural and cognitive capacities.

3. The neural and cognitive basis of language

If language is a collective cultural creation, then its properties may be expected to reflect the neural and cognitive machinery of language users. In other cultural domains, this is a familiar observation. Musical patterns appear to be rooted, in part at least, in machinery of the human auditory and motor systems (Sloboda 1985); art is partially shaped by the properties of human visual perception (Gombrich 1960); tools, such as scissors or spades, are built around the constraints of the human body; aspects of religious belief may connect, among other things, with the human propensity for folk-psychological explanation (Boyer 1994). But the general observation that language may be adapted, over generations of cultural transmission, to the human brain gains bite only if specific aspects of language, particularly those typically identified as emerging from UG, can be seen as arising from particular aspects of human learning and processing capacities. To this end, Christiansen and Chater (2008) identify four overlapping sets of factors**:** thought, pragmatics, perceptuo-motor factors, and cognition, which we now briefly review in turn.

3.1 Constraints from thought

Language allows us to communicate our thoughts—and hence the nature of those thoughts must surely strongly influence the structure of language. Thus, the meaning of content words is, presumably, closely constrained, at least in concrete domains, by the objects and categories delivered by the perceptual and attentional system. Quine (1960) observed that, for a translator of a newly encountered language, hearing a cry of "gavagai!" while a rabbit races by might, in principle, lead to an infinity of hypotheses concerning its meaning, from "Lo, food"; "Let's go hunting"; "Lo, a momentary rabbit-stage"; "Lo, a detached rabbit-part." Developmental psychologists have established that a range of powerful perceptual and attentional constraints allow children to consider only a tiny fraction of possible meanings (e.g. Bloom 2000). With regard to grammar, the representational complexity of thought presumably determines that no finite inventory of messages could provide a practicable linguistic system, and instead requires that language has a compositional structure, using a finite set of lexical and grammatical resources to encode an unlimited set of possible messages (e.g. Brighton, Smith & Kirby 2005). More broadly, while there is continuing controversy concerning the Whorfian hypothesis that language influences thought, there can be little doubt that thought profoundly influences language.

3.2 Pragmatic constraints

The communicative function of language is likely to shape language structure not only in relation to the thoughts that are transmitted, but regarding the processes of pragmatic interpretation that people use to understand each other's behavior (whether linguistic or otherwise). For example, one pragmatic principle is that people typically aim to convey as much information as possible in their utterances. So, for example, *John admires himself* is specific in that *himself* can refer only to John. In *John admires him*, *him* is much less specific—it must refer to a (contextually obvious) male. But pragmatic constraints would indicate that, were this person John, then *himself* would have been used (because this would have been more specific); hence, if *him* is used, it should not refer to John. This pattern may, through repetition, then become "fossilized" in the syntax of the language: new generations of learners may never observe *him* to be used to refer "reflexively," and hence may assume that this pattern is not grammatically acceptable (rather than acceptable, but pragmatically awkward). Thus, to adapt a phrase of Givón (1979), today's syntax may be, in part at least, yesterday's pragmatics. Levinson (2000) has developed this line of argument to provide an account of a wide range of related phenomena, traditionally described by purely abstract, and apparently entirely arbitrary, syntactic principles (the "binding constraints," Chomsky, 1981).

3.3 Cognitive mechanisms of learning and processing

A further source of constraints derives from the nature of cognitive architecture, including learning, processing and memory. In particular, language processing involves generating and decoding regularities from highly complex sequential input, indicating a connection between general-purpose cognitive mechanisms for learning and processing sequential material, and the structure of natural language. For this reason, sequential learning tasks have become an important experimental paradigm for studying language acquisition and processing (in areas including 'artificial language learning' or 'statistical learning,' Gómez & Gerken 2000); and computational models of sequence learning have been used to explain patterns of language structure. For example, Christiansen and Devlin (1997) aimed to explain statistical consistency in the head-order of the world's languages using a connectionist network, the simple recurrent network (SRN, Elman 1990). They trained SRNs to predict the next lexical category in a sentence on corpora generated by 32 different grammars, differing in head-order consistency (i.e. inconsistent grammars would mix head-first and head-last phrases). Although lacking built-in linguistic biases, the SRNs' performance was nonetheless sensitive to the amount of head-order consistency found in the grammar: the more inconsistent the grammar, the harder it was to learn. Christiansen and Devlin further analyzed frequency data on the world's natural languages concerning head-order, and found that languages incorporating patterns that the networks found hard to learn tended to be less frequent.

If language has adapted to pre-existing cognitive machinery, then this raises the possibility that human sequential learning abilities may be one of the key pre-adaptations that allowed human language processing to "take-off." Conway and Christiansen (2001) reviewed sequential learning in non-human primates and argued that non-human primates cannot match human performance regarding hierarchical sequential structure. This may be part of the explanation for the uniqueness of human language. Finally, note that people with acquired agrammatic aphasia, typically viewed as a language-specific impairment, also show impairment of sequential learning abilities in a non-linguistic artificial sequence learning task (Christiansen, Kelly, Shillcock & Greenfield 2008).

3.4 Perceptuo-motor factors

The perceptual and motor basis of language is also a powerful influence on language structure. For example, the serial character of vocal output forces a sequential construction of messages. Moreover, a perceptual system with a strictly limited capacity for storing sensory input, where new sensory information typically overwrites old, demands a linguistic code which can interpreted incrementally (in contrast to standard codes used in communication engineering, where information is stored in large blocks). The noisiness and variability (across contexts and speakers) of linguistic production, and of the acoustic environment, may, moreover, force a "digital" communication system, in which lexical items are encoded as sequences of a small number of basic units, phonemes, to support error-correction; these discrete units in turn appear closely related to the vocal apparatus and to "natural" perceptual boundaries (Kuhl 1987). Thus, the boundaries between phonemes are not chosen arbitrarily, but are easy to produce and perceive distinctly, given perceptual and motor equipment which pre-dates the development of language. Some theorists have argued for deeper impacts. Thus, MacNeilage (1998) argues that syllable structure may be parasitic on the jaw movements used in eating; and for some cognitive linguists, the machinery of the perceptual-motor system crucially underpins language content and structure via embodied image schemas (e.g. Hampe 2006). The depth of the influence of perceptual and motor factors on more abstract aspects of language is controversial, but such influence may be substantial.

3.5 The importance of multiple constraints and reconsidering the problem of language acquisition

We have sketched a few of the constraints that may have shaped language. In reality, we suggest that many aspects of language may be shaped by the interaction of a wide range of constraints. Thus, for example, the tendency for linguistic constraints to be local, rather than long-distance, might be shaped by restrictions on memory, the communicative pressure for incremental interpretation, and preferences for nested hierarchical structural relationships. Similarly, processes of morphological erosion (Heine & Kuteva, this volume) might be affected by ease of articulation, communicative pressure for rapid communication, aspects of perceptual discrimination, and pressures of learnability.

The more numerous and more complex these constraints, the more challenging it will be for theorists to unpick them. Yet, perhaps paradoxically, postulating a greater number of constraints simplifies the problem of language acquisition. This is because constraints on language structure will be *shared* across people. And given that the same biases regarding pragmatics, perception, motor control, thought, or learning, will be shared across the population, this drastically prunes the number of options that the language learner need consider (Chater & Christiansen in press). Crucially, a learner embodying these biases will typically make the *right* guesses, given a relatively small amount of linguistic input—precisely because the learner embodies the *same* constraints that have driven previous generations of language users to settle on particular linguistic structures.

Indeed, while there are positive results, concerning the learnability of languages from corpora of linguistic input alone with no language-specific bias (e.g. Chater & Vitányi 2007), we suggest that rapid and robust language learning is likely to be guided by powerful biases within the learner. Rather than conceiving of these biases as arising from a dedicated, genetically specified UG, the present viewpoint is that natural languages have themselves been constrained, through processes of cultural transmission and evolution, to lie within a small region of the space of logically possible communication systems—those which best fit the multiple constraints that shape the evolution of language. From this perspective, though, it seems unlikely that the world's languages will fit within a single parameterized framework (e.g. Baker 2001), and more likely that languages will provide a diverse, and somewhat unruly, set of solutions to a hugely complex problem of multiple constraint satisfaction, as appears consistent with research on language typology (Comrie 1989; Evan & Levinson in press). Thus, language universals are therefore best construed, on our account, as probabilistic tendencies—akin to Wittgenstein's (1953) notion of "family resemblances"—rather than rigid properties that hold across all languages.

4. Problems of gene-language co-evolution

We argued above that genes for arbitrary features of language, as postulated in UG, could not have co-evolved with natural language itself—and, more broadly, that UG, as standardly construed, is implausible on evolutionary grounds. In essence, the problem is that, prior to the existence of putative language genes, such arbitrary features of the language will be highly variable over time. Such linguistic change is likely to be very much faster than genetic change, so that the linguistic environment provides a 'moving target,' to which putative language genes would be unable to adapt. Moreover, the diffusion of human populations would be expected to lead to a wide diversity of languages (and, indeed, human languages diverge very rapidly—Papua New Guinea contains perhaps one quarter of the world's languages, exhibiting an extraordinary diversity of phonology and syntax, despite being settled only within the last 50,000 years, Diamond 1992). Gene-language coevolution can, of course, only adapt to the current linguistic environment. Hence, any such co-evolution would generate different selective pressures on "language-genes," as we noted above. Yet modern human populations do not seem to be selectively adapted to learn their own language groups—instead, every human appears, to a first approximation, equally ready to learn any of the world's languages (although see Dediu & Ladd 2007).

It is important to stress, however, that our arguments have been directed only against a genetic basis for putatively arbitrary aspects of language; they do not necessarily apply to *functional* aspects of the language. Functional aspects of language, perhaps including vocabulary size, the emphasis on local linguistic processes, the layered digital codes of phonological and syntactic structure, and compositional semantics (Brighton et al. 2005) may be stable aspects of the linguistic environment, precisely because of their functional role in subserving effective communication. Thus, while (prior to the emergence of putative UG) arbitrary linguistic conventions may be expected to change rapidly, functionally important constraints may be stable-- hence providing stable aspects of the linguistic environment against which biological natural selection can take place. Thus, it is possible that language has co-evolved with genes associated with, for example, particular perceptuo-motor processing machinery, specialization of the articulatory apparatus, large long-term memory, general sequential processing abilities, and so on.

Finally, note that our arguments concerning the coevolution of language and language genes are instances of a broader line of argument. For example, evolutionary biologists interested in the evolution of a species in the context of a fast-changing environment (here, the linguistic environment) typically argue that "generalist" behavioral strategies typically dominate—because specific adaptations to today's environment are typically poorly matched with the challenge encountered tomorrow (Thompson 1994). Moreover, the considerations arguing against the co-evolution of arbitrary linguistic structure and language genes apply equally to other, putatively arbitrary, cultural "universals," such as a putative universal "moral grammar" (Hauser 2006).

5. Future directions

If language has been shaped by pre-existing human neural and cognitive abilities, rather than guided by a genetically-specific UG encoding arbitrary linguistic principles, the implications for the study of language are far-reaching. Indeed, Christiansen and Chater (2008) argue that this perspective may help create a new synthesis for the interdisciplinary study of language.

Most immediately, from this viewpoint, the study of language evolution is directly connected with diachronic linguistics, the study of language change (McMahon 1994), instead of being viewed as fundamentally different (i.e. one being concerned with the evolution of the genetically-specified UG; the other being concerned with language change within the bounds set by UG). Thus, as we have argued, processes of language change, such as grammaticalization, may illustrate broader processes of language evolution, in microcosm; and processes of language transmission may be studied using formal and computational methods (e.g. Brighton et al. 2005). Moreover, language typology (Comrie 1989) can also be reconnected with the study of the neural and cognitive foundations of language—basic cognitive, perceptual, learning and communicative principles may help explain patterns in the bewildering variety observed across the world's languages (see also Evans & Levinson in press, for a similar point); and this variety is likely to prove to be a powerful tool for constraining such principles, particularly those which are initially created in the context of English, or at best a small number of European languages.

The present viewpoint, as we have noted above, cast the problem of language acquisition in a fresh light—as being tractable precisely because of the multiple constraints that are shared by language users and new language learners. Thus, understanding the constraints on language structure may potentially connect directly with empirical and theoretical work on language acquisition. One recent development which fits this pattern is the emergence of construction grammar in linguistics (e.g. Goldberg 2005), and the parallel development of usage-based accounts of language acquisition, which stress the construction-specific character of early language acquisition, and the fact that more abstract linguistic generalizations (e.g. over entire syntactic categories, rather than specific lexical items) emerge late in acquisition (Tomasello 2003).

To sum up, viewing language as shaped by the brain explains the fit between language and language users by viewing language as adapted to prior biological and cognitive biases, rather the postulating the existence of a language-specific UG. We hope that this standpoint may help synthesize an integrated study of language, incorporating descriptive and theoretical linguistics, and providing a new connection between linguistics and the brain and cognitive sciences.

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