

on L1 acquisition, I argue that the authors' elegant conceptualization and simulations of the logical problem of language evolution do not necessarily translate to the untidy developmental facts of language acquisition in the current linguistic environment. Specifically, it may be premature on C&C's part to advocate general-purpose cognitive mechanisms alone to explain child language learning and the repertoire of rule types that governs it.

As a first step, terms such as "language-specific constraints" and "general-cognitive constraints" must be regarded with caution. While domain specificity is often readily identified, domain generality is frequently a "moving target," precisely because it is definable by degree. That is, we say that a mechanism is domain-specific so long as it only does what it evolved to do, or as long as it is only used for learning within its domain. But we can only say that a mechanism is *more or less* domain-general: It is more domain-general or neutral the more it generalizes to other tasks outside its domain. In principle, this effect may not be problematic – after all, lots of phylogenetic and ontogenetic distinctions involve matters of degree. In synchronic terms, any general mechanisms of cognition do not dispense with the specific ones; instead, the existence of general machinery presupposes the existence of functionally related specific mechanisms. When dealing with the countless complexities of linguistic structure, Skinner's box cannot afford to be empty: it must at least contain a random assortment of various entities (paraphrasing Satterfield & Saleemi 2003). In other words, the basis from which L1 development commences had better be minimally equipped to supply learners with knowledge of grammatical functions, and Case systems, and so on, just in case children encounter these properties in their primary linguistic data. Second, C&C state that

if language is viewed as having been shaped by the brain, then language learning is by no means a standard problem of induction . . . instead, the task is simply to give the same answer as everybody else – because the structure of language will have adapted to conform to this most "popular" guess. (sect. 8.1, para. 2)

This view has several consequences in the developmental context that are not easy to explain. Consider the following cases: (1) Children in American English-speaking environments are widely attested to omit subject pronouns in tensed clauses (e.g., *Toys in there*; Hyams 1986). (2) They also insert an extra *wh*-expression in long-distance questions: for example, "What do you think *what* pigs eat?" (Crain & Thornton 1998). The structures in question seem to be at odds with "everybody else" – for example, with adult English, which contains no such features (although these are by no means "wild guesses," since in the former case [1], languages like Standard Spanish and Italian pattern somewhat in this way; and in the latter case [2], certain German dialects would be appropriate). However, it would be computationally "easier" to simply have a zero or deleted Complementizer in this site, rather than the *wh*-word. These tokens beg the question of why children should exhibit such tendencies at all. Perhaps the task requires children to initially exert multiple types of "biases" in order to obtain the maximal advantages of the grammar (Gawlitzek-Maiwald & Tracy 2005; Roeper 1999; Saleemi 2002; Satterfield 1999a; 1999b; Yang 1999; 2002).

On common ground with C&C, it is doubtful that a highly language (domain)-specific Universal Grammar (UG) functions as the sole machinery in the child's task of language acquisition. However, this position need not exclude the possibility that children pick which apparatuses they use, more-generalized or less-generalized tools, and to what degree, in a flexible and adaptive manner. Keeping this postulation in mind, consider the critical period in L1 acquisition. It has been successfully argued that not all aspects of language display critical period effects. Specifically, the acquisition of lexical items, the concatenation of words, and the nuts and bolts of semantically based principles of word

order seem immune to age-related "atrophy" of language acquisition (Hudson & Newport 1999; Jackendoff 2002; Sorace 2003). However, the capacity to acquire other parts of language in late language learning, such as the inflectional system or real intricacies in phrase structure, appears to be largely diminished (Lardiere 1998; 2000). These common L1 versus L2 conditions become at once isolatable by viewing language acquisition as a multi-layered construction with distinct learning mechanisms.

Ultimately, the solution to the logical problem of language acquisition may reside in the possibility of possessing several initial knowledge states in which domain-general mechanisms interact with domain-specific components designed to acquire the most arbitrary and least systematic knowledge of the target grammar. States that stabilize over several progressive stages could then emerge, with the help of additional domain-general learning mechanisms, which handle increasingly more systematic principles of the grammar. In sum, each transitional state may be shaped by the myriad effects of learning, or, more appropriately, of acquisition, which can be viewed as the combination of experience and internally determined processes such as maturation, learning mechanisms, and language-specific computations.

The brain plus the cultural transmission mechanism determine the nature of language

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Abstract: We agree that language adapts to the brain, but we note that language also has to adapt to brain-external constraints, such as those arising from properties of the cultural transmission medium. The hypothesis that Christiansen & Chater (C&C) raise in the target article not only has profound consequences for our understanding of language, but also for our understanding of the biological evolution of the language faculty.

Christiansen & Chater (C&C) provide a thought-provoking account of language as a cultural adaptation to the minds of language learners: Language evolves through repeated cultural transmission, adapting to multiple pressures impinging upon its learning, representation, and use. This strikes us as a powerful explanatory framework, and we hope the target article will stimulate more work fleshing out the precise relationship between constraints on language arising from the brain and features of linguistic structure.

In fact, we believe that there are two respects in which the target article actually understates the full implications of this hypothesis. First, C&C focus on language as an adaptation to language learners' brains – but language must also adapt to constraints external to the human mind. Second, in discussing their account's implications for understanding biological evolution, C&C point out the "moving target" problem – but there are at least two further issues with the interaction of cultural and biological evolution they do not recognize. Taken together, these completely change the viability of accounts based on the adaptive

evolution of a strongly constraining, domain-specific biological faculty for language.

Although there are, of course, fundamental differences between the account offered by C&C and the Universal Grammar (UG) account they contrast it with, it is useful nevertheless to focus on a point of similarity: Both argue that language is how it is because the mind forces it to be so (the crucial difference being the extent to which the relevant mental components are domain-specific or domain-general, and who does the fitting to what). Both postulate a good fit between observed properties of language and properties of the human mind: if we see some linguistic property in the world, we can reasonably infer that it reflects a property of our minds.

We have previously demonstrated, however (Kirby 1999; Kirby et al. 2004), that mental properties cannot simply be read off from language universals, because the cultural process mediating between aspects of the mind and features of language distorts the underlying biases of human learners. For example, culture can amplify weak biases to give strong universal effects. This means that cultural transmission can obscure underlying differences in mental structure: for example, strong universal tendencies towards regularity can result from various levels of preference for regularity in individual learners, and (in extreme cases) the same observed distribution of languages can result from learners with widely differing strengths of preference for regularity (Kirby et al. 2007).

This suggests that, while we can probably get an idea of the general flavour of the human mind from observable linguistic properties, making specific inferences is more risky. To draw appropriate conclusions from a given distribution of languages, we must understand the rather opaque relationship between mental properties and linguistic properties resulting from cultural transmission.

Furthermore, not all pressures acting on language during its transmission are mental: language is not only well adapted to its users' brains, but also to its medium of transmission. Computational modelling work highlights the importance of the *learning bottleneck*: learners must infer the structure of an infinitely large language from a finite subset. This bottleneck introduces a pressure for generalisation to which language must adapt, for example, by becoming compositional (Kirby 2001; Smith et al. 2003a). Importantly, the bottleneck is not a property of language learners' brains, but rather of the medium through which language is transmitted, namely, a finite dataset. Linguistic properties that are eminently learnable (and therefore well adapted to the brain) may be disfavoured due to this transmission factor, or vice versa. Consequently, linguistic features represent a product of, or a compromise between, several pressures acting on language transmission, some (but not all) of which reside in the human brain.

There are therefore good practical reasons for taking cultural evolution seriously. However, cultural evolution is more than just a methodological hassle for cognitive scientists: the same arguments radically alter the plausibility of scenarios for the evolution of the language faculty. C&C point out one problem for biological evolution, which arises from cultural transmission – evolution is chasing a moving target. We raise an additional problem: Given the opaque relationship between mental and linguistic features, much of the human biological capacity for language will be *shielded* (Ackley & Littman 1992) from evolution. For example, Kirby et al. (2007) show that the strength of prior preferences for particular structures in language arising from an individual's biology may have no effect on the strength of the resulting universals. Under this scenario, selection is completely blind to the strength of the prior biases of individuals and there is no selection for nativisation, nor for stronger, "more desirable" prior preferences for certain languages (Smith & Kirby 2008).

Furthermore, cultural transmission may actually hinder the evolution of a priori functional domain-specific features of the

language faculty: Evolving biases for communicatively functional languages is problematic for culturally transmitted languages, because the biases of individual learners require a critical mass of learners and a reasonable span of cultural time to make their advantageous properties felt (Smith 2004). Indeed, based on such models, we expect that practically the only scenario under which biological evolution will favour particular language-learning predispositions is when those predispositions are domain-general, and selected for on account of their less problematic (acultural, non-linguistic) applications. While this is entirely consistent with C&C's argument, we believe it also follows naturally from taking cultural evolution seriously.

So if evolving a functional domain-specific set of language biases is problematic, how can we best understand the evolution of the human faculty for language? C&C force us to revisit the human uniqueness of language from a comparative perspective, and (we suggest) pose a fascinating, important new challenge for evolutionary biology: Which of their suggested domain-general pressures responsible for shaping language are unique to humans, and what can this tell us about the evolutionary origins of the species-unique trait of language? Are there pre-adaptations for the cultural transmission of linguistic systems (e.g., vocal learning capacity; intention-sharing ability)? If so, how much linguistic structure naturally falls out of the cultural transmission process once these pre-adaptations are in place?

Case-marking systems evolve to be easy to learn and process

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Abstract: Christiansen & Chater (C&C) suggest that language is itself an evolutionary system, and that natural languages "evolve" to be easy to learn and process. The tight economy of the world's case-marking systems lends support to this hypothesis. Only two major case systems occur, cross-linguistically, and noun phrases are seldom overtly case-marked wherever zero-marking would be functionally practical.

All languages employ some morphosyntactic means of distinguishing the core noun phrase (NP) arguments within a clause. The two basic predicate types are intransitive and transitive verbs, giving three core grammatical functions: S indicates intransitive subjects (*The girl slept*); A, "agent" of a transitive verb (*The girl saw a pig*); and P, "patient" (*The girl saw a pig*). Some languages (e.g., Chinese, English) distinguish A and P using word order: thus, we know which mammal saw which, because A always precedes the verb and P follows.

However, many languages employ case-marking to distinguish A and P, as in Latin:

- 1a. Puella venit.
girl.(NOM) come.PRES.3SG
"The girl comes."
- 1b. Puella puer-um audit.
girl.(NOM) boy-ACC hears.PRES.3SG
"The girl hears the boy."
- 1c. Puella-m puer audit.
girl-ACC boy.(NOM) hear.PRES.3SG
"The boy hears the girl."