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Natural language and natural selection

Steven Pinker[a] and Paul Bloom[b]
[a]Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139 and [b]Department of Psychology, University of Arizona, Tucson, AZ 85721
Electronic mail: *[a]steve@psyche.mit.edu and [b]bloom@rvax.ccit.arizona.edu*

Abstract: Many people have argued that the evolution of the human language faculty cannot be explained by Darwinian natural selection. Chomsky and Gould have suggested that language may have evolved as the by-product of selection for other abilities or as a consequence of as-yet unknown laws of growth and form. Others have argued that a biological specialization for grammar is incompatible with every tenet of Darwinian theory – that it shows no genetic variation, could not exist in any intermediate forms, confers no selective advantage, and would require more evolutionary time and genomic space than is available. We examine these arguments and show that they depend on inaccurate assumptions about biology or language or both. Evolutionary theory offers clear criteria for when a trait should be attributed to natural selection: complex design for some function, and the absence of alternative processes capable of explaining such complexity. Human language meets these criteria: Grammar is a complex mechanism tailored to the transmission of propositional structures through a serial interface. Autonomous and arbitrary grammatical phenomena have been offered as counterexamples to the position that language is an adaptation, but this reasoning is unsound: Communication protocols depend on arbitrary conventions that are adaptive as long as they are shared. Consequently, language acquisition in the child should systematically differ from language evolution in the species, and attempts to analogize them are misleading. Reviewing other arguments and data, we conclude that there is every reason to believe that a specialization for grammar evolved by a conventional neo-Darwinian process.

Open Peer Commentary

Natural selection or shareability?

Jennifer J. Freyd
Department of Psychology, University of Oregon, Eugene, OR 97403
Electronic mail: *jjf@dynamic.psych.oregon.edu*

To what extent is external language structurally isomorphic with internal brain mechanisms? Pinker and Bloom (P&B) implicitly suggest that this isomorphism is wide and deep. If they are right, natural selection may have considerable explanatory power for natural language. I suggest instead that P&B fail to distinguish adequately *language* – the public, shared system multiple humans create over time – from the human *language faculty* – the mental mechanisms that support the ability to acquire and use language.

Natural selection can only operate on innate mechanisms; it cannot operate on overt behavior (Cosmides & Tooby 1987) or on its external products. Those external products of human behavior may themselves "evolve" over time; however, that evolution does not operate via sexual reproduction of genetic material.

A crucial empirical question, therefore, concerns just how isomorphic external language structure is with internal language faculties. P&B follow Chomsky (1965) and others in assuming that universals – language characteristics seen across different languages – are direct evidence of an isomorphism between external language and internal language faculties. At least four nonmystical hypotheses (see Table 1) can be invoked to explain an observed universal, however. These hypotheses are not

Table 1 (Freyd). *Four ways to relate observed universals in external language with internal brain mechanisms*

1. Environmental reflections	Universals may reflect "truths" (such as, perhaps, ontological distinctions) on earth, much as the "language" of mathematics is often thought to reflect a reality outside the brain. Language could be fairly arbitrarily related to brain mechanisms.
2. Monogenesis	Universals may reflect a single common historical language. Language may be fairly arbitrarily related to brain mechanisms and even fairly arbitrarily related to the world, as clothing fashions are.
3. Biological determinism	External language is structurally isomorphic to brain mechanisms supporting language use. 3A: The brain mechanisms are language-specific; 3B: The brain mechanisms are not language-specific.
4. Shareability	External language has universal properties that predictably emerge when minds share information. The relationship between external language and brain mechanisms is thus not arbitrary; but neither is that relationship characterized by a simple isomorphism.

necessarily exclusive. I will not discuss monogenesis (see Greenberg 1966a) or environmental reflections any further except to say that these are possibilities that should be kept in mind when evaluating the implications of observed universals.

To the extent that biological determinism accounts for language universals, I agree with P&B that natural selection for language specific abilities (see 3A on Table 1) is a likely and parsimonious explanation for many of those universals. Although physical evaluation may be *necessary*, however, it may not be *sufficient* to understand much of human behavior, including linguistic behavior.

Shared knowledge exists in a community of minds over time and space; it does not depend on any one mind specifically, yet it is influenced constantly by individual minds. Perhaps most important, shared knowledge evolves at a much faster rate than our genetic code. This relatively rapid evolution of shared knowledge suggests that shared knowledge cannot be fully predicted from our genetic code. Nor can it be fully understood through an analogy to physical evolution. Although there may be a role for "mutations" in shared knowledge, it does not evolve through sexual reproduction. We need different conceptual tools for analyzing what determines whether knowledge is shareable. We must take into account the constraints of the individual brain, but we also need to consider what happens when brains interact. The emergent properties of shared knowledge suggest the need for an appropriate level of analysis.

Thus, it is the hypothesis of shareability (Freyd 1983) in which I am interested, in particular, a comparison between shareability and biological determinism. Shareability can be expressed in two propositions:

Proposition 1: Shared knowledge structures (e.g., natural languages, shared musical systems) have the structure they have partly by virtue of the fact that the knowledge structures must be shared.

Proposition 2: Internal cognitive representations are influenced by these shared knowledge structures.

Emergent shareability properties need not be directly internalized (although to some extent they may be), so long as they predictably emerge in the creation of shared knowledge structures. The individual brains may have been shaped through physical evolution specifically so that those properties emerge, much as the social structure of an ant colony predictably emerges from groups of individual ants.

The possibility most different from biological determinism is that for at least some properties shareability constraints have predictably shaped external language(s) over human history, above and beyond adaptations at the level of the internal language faculties. To see how shareability might behave this way, consider a very general language universal such as the fact that "many linguistic rules are categorical, all-or-none operations on symbols" (sect. 5.2.2). P&B note that this aspect of language is ideal for communicative systems, implying that it is probably a property with which the language faculty has been endowed through natural selection.

Shareability suggests that the communicative pressures on discreetness are, on the contrary, strong enough to render it unnecessary for internal brain mechanisms to be as fully categorical. Because of sharing constraints, minds in interaction will create shared knowledge structures that have the effect of categorizing concepts into discrete chunks along dimensions (Freyd 1983). As long as there is good reason for brain mechanisms to reflect the continuity of reality, however (especially the temporal continuity of reality [Freyd 1987]), it seems likely that a strong physical evolutionary pull would be toward computations emphasizing gradation, not categorization.

An interesting empirical test case for shareability is American sign language (ASL), a linguistic medium potentially supporting gradations, because of the spatial medium. As Newport (1981) and others have noted, however, ASL exhibits the same sort of discrete structure that spoken languages do, such that middle values between discrete morphemes are not allowed. What is particularly fascinating is that the discreteness of sign languages seems to increase with the age of the systems: "Early, newly evolved communication systems display this analytic character to a lesser degree than older, more successively learned communication systems" (Newport 1981, p. 118). Shareability predicts this: Suppose that each individual's representation of concepts is fuzzy in structure, supporting lots of gradations along continuous categories. If a group of individuals attempts to share information within a particular domain, there will initially be enormous potential for information distortion because of the graded nature of the internal representations. However, across time and given different individuals, certain modal values will emerge as anchors within the shared structure. For example, new terms will be introduced through explicit or implicit comparison with old terms. The sharing process will act like a discrete filter that is relatively stable across time and space, despite inherent fuzziness and individual variance. None of this is to say that some of the communicative pressure for discreteness has not been physically internalized (indeed, phonemic computations may be such an example); instead, there is no evidence or logical necessity that all of the discreteness we see in external languages reflects internal categorization.

Shareability can be applied to syntactic regularities as well as semantic ones. The fact that grammars can be described by generative transformational rules may reflect language evolution and may have relatively little to do with physical evolution. We need only assume that language innovations will be more or less likely to survive given their shareability, and, in particular, their memorability and learnability given preexisting structures. Consider an analogy to the transformational structure of English orthography. Chomsky and Halle (1968) showed that a set of transformational rules can be used to relate English orthography to pronunciation. Miraculously, the "deep structure" resembles Middle English, and the transformations resemble phonemic shifts that have occurred since English spelling was frozen (see Crothers & Shibatani 1975). I doubt that many would want to say there is a psychological reality to this transformational structure for English orthography. Syntactic relationships may have much the same sort of historical significance. A new grammatical construction must be rooted in established constructions; one way for this to occur would be a learnable generative rule that specifies paraphrases from the old construction to the new. Similarly, a syntactic change that involved a replacement of one form with the other would be vastly more shareable if it applied generatively, as opposed to requiring the memorization of exceptions. (The very lack of shareability may be deliberately exploited for social reasons, as in argot that defines in-group members. Widespread and long-term language change, however, should move toward shareable innovations making for a regular, generative, change.)

I have argued that shareability is a plausible alternative to biological determinism for some aspects of external language. But how does one weigh the relative plausibility of these two explanations for particular language universals? One might consider other shared knowledge systems for which there is little evidence of any specific genetic adaptation. Writing systems, for instance, surely evolved at the level of shared information; given their modernity, their evolution has probably not been mirrored in changes at the genetic level. Although there is some diversity in writing systems, there are also some remarkable similarities. Mature writing systems have visual cues for individual words, as opposed to whole phrases or sentences. Production rules for handwritten symbols optimize both ease of production (reducing the number of strokes and the difficulty of making connections between strokes) and legibility (maximizing differences between individual symbols). Like natural language changes, changes in writing systems improve shareability, but unlike natural language systems, there is little chance that the properties are isomorphic with physically evolved mental structures.

In summary: The brain faculties supporting language acquisition and language use (whether language-specific or more general cognitive mechanisms) must have evolved through natural selection. P&B have shown convincingly that the complexity of language itself does not rule out natural selection any more than the complexity of the eye rules out natural selection. Language, however, is not an eye. Language is likely to be a product of "evolution" occurring at the level of shared information. Evolution of shared knowledge has emergent properties requiring appropriate conceptual analysis, much as the theory of natural selection highlights properties that emerge from the physical and chemical building blocks of living organisms.

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Correspondence may be addressed to J. Freyd, Department of Psychology, University of Oregon, Eugene, OR 97403 (jjf@dynamic.psych.uoregon.edu).