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What sort of innate structure is needed to "bootstrap" into syntax?*

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Abstract

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The paper starts from Pinker's theory of the acquisition of phrase structure; it shows that it is possible to drop all the assumptions about innate syntactic structure from this theory. These assumptions can be replaced by assumptions about the basic structure of semantic representation available at the outset of language acquisition, without penalizing the acquisition of basic phrase structure rules. Essentially, the role played by X-bar theory in Pinker's model would be played by the (presumably innate) structure of the language of thought in the revised parallel model. Bootstrapping and semantic assimilation theories are shown to be formally very similar, though making different primitive assumptions. In their primitives, semantic assimilation theories have the advantage that they can offer an account of the origin of syntactic categories instead of postulating them as primitive. Ways of improving on the semantic assimilation version of Pinker's theory are considered, including a way of deriving the NP–VP constituent division that appears to have a better fit than Pinker's to evidence on language variation.

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Introduction

There is a long-standing conflict between theoretical approaches to language acquisition that assume that the child has innate syntactic knowledge, and approaches that assume that all primitives are semantic or cognitive. I shall refer to these, respectively, as syntactic and semantic approaches and theories. The initial goal of the paper is to demonstrate that both approaches can give accounts of the acquisition of phrase structure that are really quite similar. The best-developed current theory is a syntactic theory – that of Pinker (1984). I investigate whether it is possible to reformulate this theory, dropping its innate-syntax assumptions and replacing them with cognitive primitives. Such a reformulation constructs a semantic theory that is a twin of Pinker's syntactic theory. The second goal of the paper is to show that the reformulation yields large theoretical benefits. Finally, I consider how one might improve on the reformulated theory.

The syntactic position is that a substantial set of syntactic categories and relations is innate. Thus, the child does not "acquire" syntactic categories; rather, he or she discovers instances of syntactic categories that they already possess in the input, and the first rules they acquire refer to these categories. This position has long been urged by Chomsky (e.g., Chomsky, 1965), and has since been advocated by many linguists; Pinker (1984) develops it in considerable detail. In contrast, according to the semantic approach, there are no innate syntactic categories; the child initially acquires rules that map elements of a semantic representation into positions in the surface structure (e.g., Braine, 1976, 1988a; Schlesinger, 1971, 1982, 1988).

A problem that has been alleged against the semantic approach is that, apparently, it must postulate a mysterious transition from the early semantically based system to the adult syntactically based system – how does the semantic tadpole become a syntactic frog (to use Gleitman's metaphor)? The semantic position is that the early semantic categories develop or "grow" into the syntactic ones, without any abrupt transitions (e.g., Braine, 1988a; Schlesinger, 1982). However, the only available explanation of how this growth takes place is Schlesinger's proposal of "semantic assimilation" (Schlesinger, 1982, 1988), and his account is suggestive rather than precise. For example, Schlesinger (1982) assumes that at some early point children have an agent–action sentence schema; he proposes that this schema is used to analyze novel NP–VP sequences even though these may not strictly be agent–action ones, for example sentences with experiential verbs. Thus, seeing often involves looking and thus the subject of *see* often has an agentive quality; similarly, learning and remembering are often effortful and then their subjects resemble agents. As the agent–action schema is used to parse sentences with these verbs, the agent and action categories progressively expand beyond their original semantic nucleus: actions come to include experiences and agents to include experiencers. Schlesinger refers to this broadly extended agent category as a "generalized agent," and the idea is that as

it assimilates the subjects of intransitive verbs and stative verbs as well as experiential ones, it transmutes into subject.

Schlesinger's proposal has not been developed with the precision and detail that is characteristic of Pinker's theory. Nevertheless, it is important to note that its essential learning principle embodies the idea that already-acquired rules or patterns are used to analyze new input (e.g., as happens when the known agent–action pattern is used to parse sentences with experiential verbs). I shall call this principle the old-rules-analyze-new-material principle. It turns out to be an essential component of Pinker's learning mechanism.

Obviously, the syntactic approach does not give rise to any special transition problem – the syntactic position has *that* advantage. However, it faces two other strategic problems that the semantic position does not have – the problem of the origin of syntactic categories, and the problem of how the child could initially identify instances of them in the input. I consider the first of these briefly, and then examine in detail Pinker's (1984) "bootstrapping" solution to the second.

The problem of the origin of syntactic categories

Within the syntactic theory there is clearly a difficult scientific problem about the origin of syntactic categories: how do we get from genes laid down at conception to syntactic categories manifest two-and-a-half to three years later? Merely labeling the categories as innate does not solve this problem; it just passes the problem to biology without considering how the biologist could ever solve it. The total explanatory theory of language acquisition must eventually include a developmental theory of the origin of whatever innate primitives are postulated. Thus, if syntactic categories are innate, then a developmental account must be constructed that will provide a causal theory which bridges the gap between the genes and these innate categories. Despite the fact that the syntactic approach is over a quarter of a century old, there have been no proposals – not even any serious discussion – on how this formidable task might be accomplished. (Obviously, one cannot leave this problem entirely to the biologist – most biologists hardly know what syntax is.) While it is certainly not now reasonable to demand anything like a complete theory, it *is* reasonable to expect a promissory note, and at least a sketch of an argument as to how it might eventually be redeemed.

This lack of an account of the origin of syntactic categories is a problem peculiar to the syntactic theory. A successful semantic theory *does* account for the origin of syntactic categories – it would show how and why they emerge out of semantic categories during development. Indeed, a semantic theory *is* a theory of the origin of syntactic categories. Of course, within a semantic theory some biological basis for semantic categories is needed, but *that* is needed under *all* theoretical positions, including the syntactic position. To require of biology that it account for syntactic categories is to give it an additional major burden.

Let us pause and consider what is needed from biology (or bioneuropsychology) for semantic categories. I suggest the following:

(a) An architecture for an initial learning mechanism for concepts and relations.

(b) An account of the kinds of input delivered by sensory systems to the learning mechanism. As we know from the tradition of work started by Gibson (e.g., 1966), these can be complicated, abstract, relational, and tuned to the ecology of the organism.

(c) Certain Kantian-type framework categories. Kant, it will be remembered, argued that certain categories, like time and space, were "forms of thought" – these provided a framework for our thinking about events which we could not avoid because the framework was built into our thinking processes. It seems to me that a number of such framework categories may be crucial to the acquisition of language. Ontological categories are a prime candidate: for instance, the way in which one makes reference to an entity characteristically depends on what kind of entity it is; for example, on whether it is an object, place, time, event, proposition, etc. (Jackendoff, 1983, 1989, 1990). Two other framework categories are "predicate" and "argument". The term "predicate" comprises concepts (including properties) and relations; the term "argument" refers to instances of concepts or entities related by relations. That is, a relation is a predicate with two or more arguments, the entities related being the arguments; a concept is a predicate with just one argument, and to predicate a concept or property of an object (argument) is merely to say of the object that it is an instance of the concept, or that it has the property. There is good reason to think that the predicate–argument distinction must be cognitively primitive. Thus, theories of concept formation in the psychological literature have all taken the distinction between a concept and its instances for granted as already available to subjects, and just seek to account for the acquisition of specific concepts; no one has thought that the distinction itself might have to be learned. The distinction is likewise taken as primitive in logic and semantics: there is no way of deriving the distinction from more primitive logical notions, and there is no known way of doing semantics without it. I have argued for the fundamental nature of these categories elsewhere (Braine, 1988a), and have also shown how they could be crucial in the acquisition of word classes (Braine, 1987). If one accepts Fodor's (1975) arguments for a "language of thought," then predicate and argument would be syntactic categories of the language of thought, aspects of an innate format for recording information. Thus, the child's comprehension mechanism would have the distinction primitively available both in understanding input sentences and in encoding events perceived, and we may assume that the child spontaneously encodes events and scenes as presenting objects that have properties and are related to other objects; for example, for a child to perceive an

event of a dog biting a cat would be to perceive an action relation (biting) between a dog (object, argument) and a cat (object, argument).

It is quite possible – indeed very likely – that there are other categories of the language of thought, beyond ontological categories and predicate/argument, that are relevant to language acquisition. If the line of thought I develop later is correct, then, inevitably, any syntactic category of the language of thought would be a semantic category of ordinary language that is relevant to syntax acquisition.

I have singled out the framework categories for special mention under (c) above because they seem especially relevant to language acquisition. I do not mean to imply that they are separate from (a) and (b) – some may well be the product of the structure of sensory systems, and the others determined by the architecture of the learning mechanism of (a). Note that there is nothing that is seriously problematic in this list of what is needed to account for innate semantic categories. Under (a), the architecture of an initial learning mechanism has both a functional and a physiological aspect: the specification of the functional architecture is a task for psychology, and discovering its physiological realization falls squarely within neurophysiology. Item (b) is a recognized scientific topic that has been actively under investigation for generations by sensory neurophysiologists and students of perception. The framework categories under (c) presumably reflect either learning mechanism architecture or the structure of sensory systems. Thus, no potentially insoluble problems have been passed to biology.

Is bootstrapping necessary?

Let us now return to the problems of the syntactic position, and in particular to the second problem whose existence I mentioned earlier. This is that innate syntactic categories are not of any use to a learner unless he or she has a means of recognizing instances of them in the input. Innate NPs, Ns, VPs, etc., are of use only if the child knows how to identify NPs, Ns, VPs, etc., in parental speech. The famous "bootstrapping" notion, suggested originally by Grimshaw (1981), and developed in detail by Pinker (1984), is proposed to solve this problem. According to the bootstrapping proposal, the child not only has innate syntactic categories, but also has innate semantic flags for them. Thus, there is an innate default assignment of words for objects to the noun class, of actions and changes of state to the verb class, of agents to subject, etc. These assignments enable the child to recognize instances of the syntactic categories in the input before having acquired any syntactic rules of the target language.

Although the child does not know syntactic rules at the stage considered (i.e., just prior to syntax acquisition), he or she is assumed to have some vocabulary

knowledge and to be able to distinguish the words in simple spoken sentences. Pinker provides rather little discussion of this point (cf. Pinker, 1982, pp. 689–690; 1984, pp. 29–30; 1989, pp. 361–363), but he clearly assumes at least some vocabulary of concrete nouns (*dog*, *cat*, etc.) and possibly some other words or short phrases (e.g., *sleep*, *go to bed*, perhaps *bit* in the example below). This vocabulary knowledge permits some matching of elements of the spoken sentence with elements of the event representation. For instance, given the spoken sentence *The dog bit the cat*, knowledge of the words *dog* and *cat* guarantees that these words, rather than *the* and *bit*, will be matched to "dog" and "cat" in the event representation. It is also assumed that parents prefer to use words whose meanings they think their child knows, and that there is enough similarity between children and adults' cognitive and perceptual mechanisms that both tend to encode similarly the events that adults talk to children about. The assumption is widely shared that children can often infer the semantic representation of parental utterances from context and vocabulary knowledge, and that they can do so often enough to get syntax acquisition started (e.g., Anderson, 1983; Braine, 1988a; Macnamara, 1972, 1982; Schlesinger, 1982; Wexler & Culicover, 1980).[1] (Of course, if the child fails to achieve a semantic representation for an utterance, then, for Pinker's model as for several others, there is simply no input.)

In Pinker's (1984) acquisition theory there are two learning phases. In Phase 1, the child uses the innate semantic flags to parse some sentences and acquire some rules. For example, given the input sentence *The dog bit the cat*, with appropriate context, the semantic flags lead the child to classify *cat* and *dog* as Ns, and *bit* as V; they also cause the child to know that *the dog*, being agent, must be subject. This means that the child can construct the tree shown in Figure 1.

Given this tree, the child acquires the following rules by reading them off the tree:

$$S \rightarrow NP_{subj} + VP$$

$$VP \rightarrow V + NP_{obj}$$

$$NP \rightarrow Det + N$$

[1]Recently, a theory known as "syntactic bootstrapping" (as contrasted with Pinker's "semantic bootstrapping") has been advanced, with considerable empirical support, to explain acquisition of the argument structure and much of the meaning of many verbs – the child infers components of verb meaning from a verb's observed subcategorization frame (e.g., Gleitman, 1990). The theory is sometimes discussed as if it were competitive with Pinker's "semantic" bootstrapping. However, it clearly cannot be, even if only because Gleitman's syntactic bootstrapping presupposes some prior knowledge of basic phrase structure in order to identify the parts (subject, object (or agent, patient), etc.) of subcategorization frames (e.g., the subcategorization frames of English and Turkish present very different surface forms for verbs with the same semantic structure). Thus, despite the similar terminology, the theories do not deal with the same phenomena. Syntactic bootstrapping presupposes some mechanism other than itself (like Pinker's theory or some replacement) for the acquisition of phrase structure.

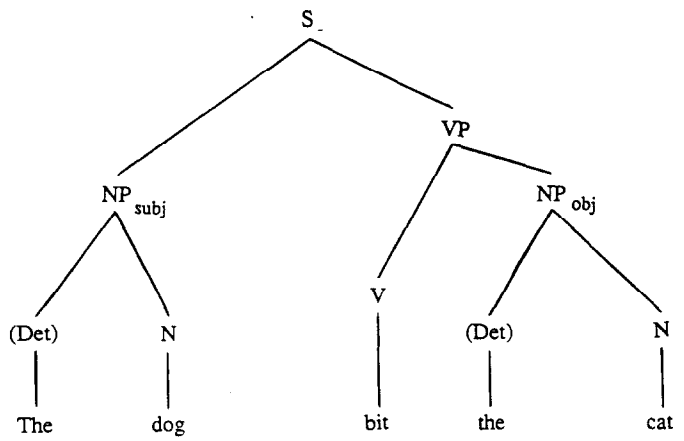

Figure 1. *Parse-tree (somewhat simplified) that a child could construct, according to Pinker's (1984) theory, given the sentence, the appropriate scene, and pre-existing vocabulary knowledge.*

I simplify a little over Pinker's presentation: Pinker has a somewhat more complicated tree and five rules rather than three, together with some lexical entries which I omit for now (Pinker, 1984, pp. 70–72). Pinker concludes from the example that on the basis of the single input event "The child has . . . induced five phrase structure rules complete with functional annotations and lexical entries for each word" (Pinker, 1984, p. 72). (I pass over, for now, the imputation of one-trial learning.)

Once the rules have been learned in Phase 1 by the procedure illustrated above, they are available in Phase 2 to analyze input sentences where semantic flags to syntactic categorization are absent. (Phase 2 is not a rigid point in time, but begins as soon as there are rules available.) Pinker's example input sentence to illustrate what happens in Phase 2 is *The situation justified the measures*. The learning principle that is operative in Phase 2 is that old rules are used to parse new input (Pinker, 1984, Procedure P1, p. 67, taken with Procedure L1, p. 68, which creates new lexical entries according to the parsing). Thus, the rule NP → Det + N causes both *situation* and *measures* to be classified as N; these words are then marked as nouns in the burgeoning lexicon. The same rule identifies the phrases *the situation* and *the measures* as NPs. The existing rules then allow the entire tree to be built, identifying *the situation* as subject and *justified* as verb.

What is interesting here – particularly noteworthy, I believe – is that the same principle, the old-rules-analyze-new-material principle, is used in both theories, that is, both Schlesinger's semantic assimilation theory and Pinker's bootstrapping theory. And in both theories it does essentially the same job: it causes new material to be assimilated into a pre-existing category, and as this happens the extension of the pre-existing category expands beyond its original semantic kernel.

Given this similarity between semantic assimilation and bootstrapping theories, let us ask a further question about Pinker's theory. What is doing the major learning work in his theory? The theory embodies two main ideas: the innate-syntax-with-semantic-flags notion, and the old-rules-analyze-new-material principle. Are both of these equally essential? It is clear that the old-analyzes-new principle is essential, because the semantic flags cannot work without it. But are the innate syntactic categories with their semantic flags necessary? One good way to answer this is to try to suppress the innateness claims, while keeping the old-analyzes-new principle and altering the rest of the theory as little as possible, and see if we can obtain a system that still learns.

In what follows, I carry out my analysis of Pinker's theory in two steps. At the first step, I drop only the assumption that "object" innately flags N, and keep all Pinker's other innate-syntax assumptions. At the second step, I drop these other assumptions.

Let us look again at our sample input sentence-event pair at Phase 1: *The dog bit the cat.* On Pinker's assumptions the child constructed the tree of Figure 1. Let us begin by dropping just the one assumption that "object" flags N – let us say that objects like cats and dogs are categorized by the child as objects, and words that refer to objects as "object-words." Then our tree becomes the one shown in Figure 2.

In this figure I attach "?" to the branches connecting the nodes NP and object-word, because there is a legitimate objection that substituting object-word for N should disrupt this connection. I ignore this objection for this paragraph and then return to it. Given the tree in Figure 2, the child can read off the rules:

$S \rightarrow NP_{subj} + VP$

$VP \rightarrow V + NP_{obj}$

NP → Det + object-word[2]

Now what happens at Phase 2 when the old-analyzes-new principle applies? Let us take Pinker's example again: *The situation justified the measures.* We apply the rule NP → Det + object-word,[2] instead of the previous NP → Det + N, and what happens is that *situation* and *measures* are both classified as object-words just as before they were classified as N. That is, *situation*, *measures*, and other non-object-words are classified in the same class as *cat*, *dog*, and other object-words,

[2]In connection with all the figures, one might raise the question how the child knows that *the* should be classified as determiner. (Pinker, 1984, p. 69, refers the reader to his chapter on inflection at this point.) I have chosen to stay as close to Pinker's analyses in form as possible, but, in fact, nothing theoretically important for this paper turns on the child initially putting a determiner node between *the* and NP. The main arguments would go through if this node were eliminated and the NP-rule were simply NP → *the* + object. Elsewhere (Braine, 1987), I discuss in some detail how a child learner might perceive the internal structure of NPs.

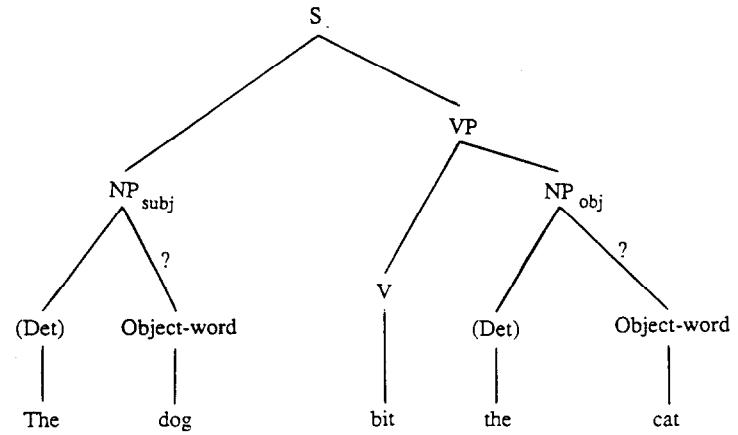

Figure 2. *Parse-tree given the assumptions of Figure 1 with the change that the child categorizes words for objects only as object-words, not as Ns.*

because of their occurrence following determiners in the same phrase – that means that they are classified in a class that has the same extension as Pinker's N. Note that, given the identity of membership, it does not matter how *we* – linguists and psycholinguists – label the class. It follows that as the child's input comes to include non-object-words in N-positions as well as object-words, the child's object-word class "grows" into the N-class, just as semantic theorists claim happens. Thus, it looks as if the innate flag may be redundant.

However, as noted earlier, one can properly ask: what justifies attaching the node object-word under NP, once we substitute object-word for N in Figure 2? In Pinker's theory, N is attached under NP because all X-bar theory is assumed to be innately known to the child: in X-bar theory, any word class X (X = N, V, A, or P) is inherently attached under its phrase-class XP. (Of course, in X-bar theory there is a hierarchy of nodes, X, X′, X″, and in most versions X‴ also, where X′, X″, X‴ are phrasal. Pinker assumes three levels – X, X′, X″; I have further simplified by only considering two – N, NP, V, VP – in the above examples.) But, obviously, X-bar theory would not allow us to attach object-word under NP. Also, in any case, the present goal is to investigate the possibility of dropping strong assumptions of innateness of syntax, such as the assumption that all X-bar theory is innately known. So I shall now proceed to my second step in analyzing Pinker's theory and try to drop this assumption.

It turns out, fortunately, that there is a good semantic rationale for attaching object-word into a tree structure that is similar in form to Figure 2. In the input sentence *The dog bit the cat*, *the dog* and *the cat* are arguments of the predicate *bit*. This fact is clearly recorded in the f-structure that Pinker assumes for this sentence (Pinker, 1984, p. 69). (In the parlance of lexical–functional grammar (LFG), f-structure refers to aspects of semantic structure that may obtain

syntactic expression. Pinker assumes that the child is able to deduce the f-structure from the situational context sufficiently often, and that the child begins learning syntax from sentences whose f-structure has been worked out from context.) The f-structure also marks *the dog* as the agent argument. In addition, *the dog* and *the cat* are not just arguments – they are arguments of a particular kind, namely object arguments (unlike arguments like *in the garage*, in *George put the car in the garage*, which are place arguments – see Jackendoff, 1983, Chs. 3 and 4).

In connection with Figure 2 we assume that the child classifies words that indicate object kinds as object-words; let us now extend this assumption to posit that the child initially classifies words and phrases according to the ontological category of the entity they refer to. Depending on the assumptions made about semantic structure and trees, the semantic structure described for this sentence would allow various trees to be constructed for the sentence. One such tree, with a simple branching structure that makes minimal assumptions, is shown in Figure 3. From this tree a child could acquire the following rules by reading them off the tree:

$S \rightarrow$ object-argument-P_{agent} + predicate + object-argument-P

object-argument-P $\rightarrow$ Det + object-word

Another tree is possible if we follow the assumption of Pinker's theory that agent arguments are specially privileged tree-structurally in having a major branch allotted to them. Because *the dog* is marked as agent in the f-structure, that assumption would lead to a tree like the one shown in Figure 4. One may note

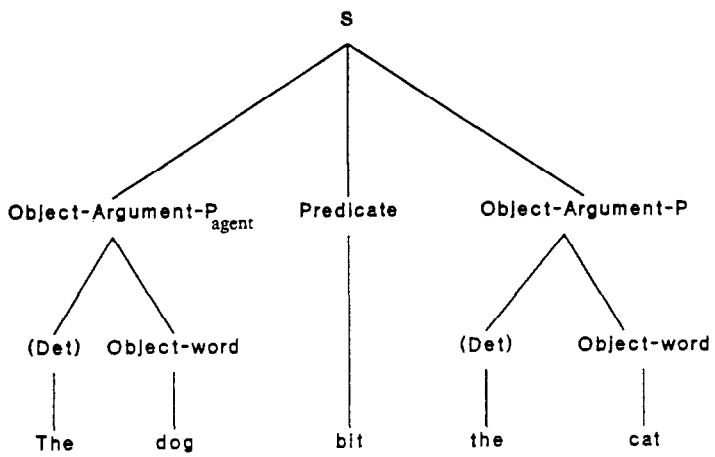

Figure 3. *Parse-tree that might be constructed by a child categorizing words and phrases according to ontological category and predicate/argument status.*

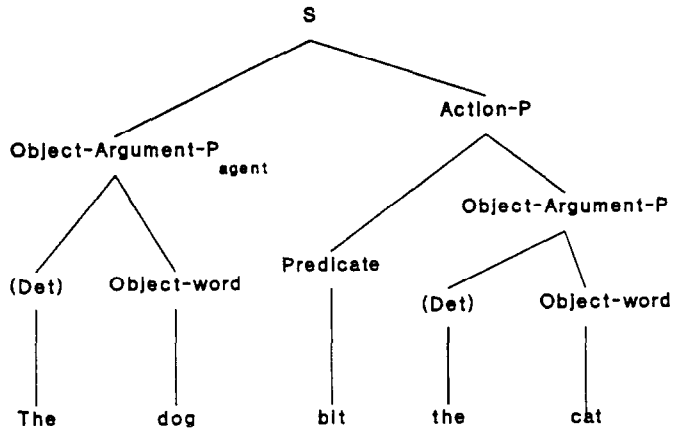

Figure 4. *An alternative parse-tree to Figure 3, which privileges agents.*

that the tree of Figure 4 differs from that of Figure 1 only in the fact that the nodes have semantic rather than syntactic labels. I use the term "action phrase" for the node that is complementary to the agent-argument node. From this tree the child could read off the rules:

$S \rightarrow$ object-argument-P_{agent} + action-P

action-P $\rightarrow$ predicate + object-argument-P

object-argument-P $\rightarrow$ Det + object-word

Now let us see what happens when we take the rules learned in Phase 1 and apply them, in Phase 2, to Pinker's next sentence *The situation justified the measures*, under the principle that old rules analyze new material. Assuming the configuration of Figure 4 and Pinker's learning procedures (as before, Procedures P1 and L1 (Pinker, 1984, pp. 67–68)), the rules force the assignment of the tree structure shown in Figure 5. This causes *situation* and *measures* to be categorized as object-words, and *the situation* and *the measures* as object-argument-phrases. Note that if we had assumed the tree structure of Figure 3 instead of Figure 4 we would still have found that *situation* and *measures* were categorized as object-words, and *the situation* and *the measures* as object-argument-phrases. That happens regardless of which tree is assumed. Thus, assuming that the child has experience with a range of English sentences and given the principle that old rules analyze new material, it is apparent that object-argument-Ps will eventually become co-extensive with NPs and the object-word category with N.

If we are willing to make the assumption about the tree-structure privilege of agents that motivates the configuration of Figure 4, we obtain an interesting result. Because of the match between Figure 4 and Figure 1, we can envisage a

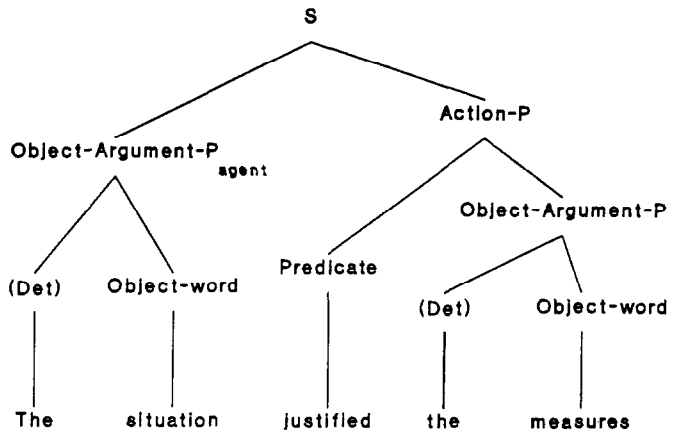

Figure 5. *Parse-tree for* The situation justified the measures, *that a child might construct after having learned the rules derivable from Figure 4.*

theory that matches Pinker's, except for the dropped innateness-of-syntax assumptions. Given a child that encounters the same set of sentences that Pinker's child encounters, that child is bound to acquire categories that are co-extensive with the categories that Pinker's child acquires at every stage of the learning; moreover, the categories would appear in phrase structure rules isomorphic to Pinker's. The same syntax would be acquired by the two model children. As noted earlier, given the identity of extension, it does not matter what linguists and psycholinguists call the categories. It follows that it is possible to drop the innateness-of-syntax assumptions of Pinker's that we have considered; and then, with suitable assumptions about the structure of the child's semantic representations, we can obtain a semantic assimilation theory that learns phrase structure as well as Pinker's theory does, and indeed in essentially the same way that his theory does.

However, the assumption of Pinker's that justifies Figures 1 and 4 – the tree-structure privilege of agents – is problematic because of the nature of some ergative languages. As Pinker himself points out (1987, p. 413), if the child innately assumed that agents are tree-structurally privileged, it would make languages where subject is not correlated with agent inherently very difficult for a child to learn – see Braine (1988b) for further discussion and Pye (1990) for detailed treatment together with some developmental evidence on morphologically ergative languages. For the special acquisition problems associated with the typically split nature of ergative systems, see Van Valin (1992). These problems are, of course, as much problems for Pinker's original theory as they are for the reformulated version.

If we adopt the configuration of Figure 3, then we still have a theory in which initial semantic categories grow into later syntactic ones. Moreover, we will have

made no assumptions that would make ergative languages difficult to learn. However, the rules acquired by a child exposed to English will not be the rules usually assumed for English. In particular, they will lack the major $NP_{subject}$–VP constituent division usually assumed for English. Something would have to be added to the model for this to be acquired. Thus, neither Figure 3 alone, nor the assumption that agents are tree-structurally privileged, provides an entirely satisfactory basis for learning. I propose a solution to this dilemma later in this paper. In the meantime, one may note that both the models associated with Figures 3 and 4 acquire syntax without Pinker's innate-syntax assumptions, one of them closely mimicking his theory.

It is important to note that in order to obtain learning without the innate-syntax assumptions, I have made some strong assumptions about the structure of semantic representation at the outset of language development. For example, I have taken it for granted that the child analyzes propositions as composed of predicates and arguments, and is sensitive to ontological category. In effect, I have assumed that a basic organization of the structure of propositions is built in (or, at least, available at the outset of syntax acquisition), and that this basic propositional structure is in many ways analogous to X-bar theory. That is, it has a tree structure like X-bar theory, and differs primarily in having semantic labels and functions for nodes, for example, object-argument-phrase in place of NP. Presumably, this basic propositional structural framework reflects (or, better, is part of) the structure of the language of thought.

The assumption that there is some basic similarity between the structure of semantic representation and the phrase structure of sentences seems well motivated, and it is certainly widely shared. Language presumably evolved as a medium to express thoughts; it is therefore expectable that there should be formal similarity between syntactic organization in the medium and the structure of the underlying thoughts; one would particularly expect such similarity when both the thoughts and the language are at their most simple, as at early stages of development. Formal parallels in the structure of syntactic and semantic representation are the norm in linguistic theories. For instance, they hold in Montague grammar (e.g., Partee, 1976). The assumption of parallel structure is implicit, within government-binding (G-B) theory, in the projection principle taken with the theta-criterion, which requires that the argument structure of a lexical item be manifest at every syntactic level, including surface structure (e.g., Sells, 1985); the assumption is reinforced in recent work on argument structure (e.g., Grimshaw, 1990; Jackendoff, 1990; Pinker, 1989) which declares it to be a projection from lexical semantic/conceptual structure. Finally, Jackendoff (1990) speaks of "X-bar semantics," arguing for strong formal similarity between semantic/conceptual representation and syntactic phrase structure.

If the assumptions about the primitive structure of semantic representation are correct, then syntactic X-bar theory is *not* innate. What is innate is a presumably

universal initial structure of the language of thought. Categories of this language of thought are mapped on to positions in surface structure to provide the child with an early set of rules of sentence formation. Then, as these rules are persistently used to analyze new material, the reflexes of the categories of the language of thought grow into the syntactic categories of the language being learned. Since the languages of the world differ from each other, the operation of the old-analyzes-new principle moulds the child's initial categories in different ways in different languages to recreate the differences among adult languages. Nevertheless, the syntactic categories of the different languages stay sufficiently close to the initial semantic nucleus that we can recognize universal syntactic categories, like NP with its root in an expression designating an object argument. That fact – the common root in a semantic category of the language of thought – accounts for the universality of syntactic categories that are universal. Indeed, research that seeks out the semantic roots of what is universal or near-universal in phrase structure (see Jackendoff, 1983, 1990, for an example) would seem to be one of the few available major routes for throwing light on the structure of the language of thought.

Comparison of the primitives of "assimilation" and "bootstrapping" theories

The preceding section has shown how to construct a semantic assimilation theory that is formally quite similar to Pinker's bootstrapping theory. There is such a theory (i.e., the one associated with Figure 4 above) that acquires rules that are isomorphic to those of his theory and acquires them in essentially the same way. An immediate conclusion to be drawn is that semantic assimilation and semantic bootstrapping theories are much more similar to each other than discussions in the literature would suggest. It seems that the two kinds of theories can be almost notational variants. Thus, in principle, there can be no empirical evidence that discriminates between the two classes of theories. However, despite the formal similarities between bootstrapping and semantic assimilation theories, there is a very significant difference in primitives.

In my reformulation of Pinker's theory, the developmental primatives are:

(1) a learning mechanism that uses the old-rules-analyze-new-material principle;
(2) semantic categories such as "argument" and "predicate," including ontological categories, for example "object," "place," "action," "event;"
(3a) a tendency to classify words and phrases, not already classified by (1), as referring to instances of the categories in (2).

While Pinker's original account shares (1) and (2) as primitives, it does not have

(3a); instead, it has (3b) the natural language syntactic categories themselves (N, NP, V, VP, etc.), as primitives, with each category earmarked (4) as having particular semantic categories as canonical members.

Thus, Pinker's account posits that the natural language syntactic categories exist from the outset of language acquisition as innate categories having some biological or psychological reality separate from their canonical members. On his account the mental origin of these syntactic categories is left quite mysterious and a theory of origins is needed. In contrast, in my reformulation there are initially no natural language syntactic categories, and words referring to objects, predicates, and arguments do not innately "flag" other categories as they do in Pinker's theory. In my version, syntactic categories emerge under the joint operation of (1) and (3a). Thus, the reformulated theory provides an account of the origin of natural language syntactic categories instead of postulating them as primitives. That is a very significant theoretical benefit of the reformulation.

In claiming that the reformulated theory provides an account of the developmental origin of syntactic categories, I do not mean that it leaves nothing whose developmental origin remains to be explicated. Rather, I mean that it explains syntactic categories in terms of the operation of primitives that are not themselves syntactic; that is, natural language syntax plays no role in the explanation. Incidentally, it seems to me that it speaks greatly to the value and hidden resources of Pinker's theory that with only a little tinkering it has been possible to formulate it to provide an account of the origin of syntactic categories.

While the reformulated theory eliminates innate syntactic structure as a necessary primitive for the acquisition of phrase structure, it might be argued that such categories would be needed for the acquisition of more complex phenomena. That is possible but remains to be seen. I shall not now argue against the possibility, but would note that complex syntax (e.g., control relations, long-distance binding) is acquired after basic phrase structure and thus at a time when, on anybody's theory, there is in place a substantial scaffolding of syntactic categories and rules together with syntactically annotated lexical entries. Within the G-B framework, acquisition would be affected by principles (e.g., the projection principle, the theta-criterion, subjacency, the case filter) assumed to be innate; to the extent that such principles operate on syntactic categories, the categories would themselves presumably have to be innate. However, it is also possible that relevant universal principles will turn out to be themselves rooted in semantic structure (like, it is claimed, X-bar theory), or to have a pragmatic basis (see, for example, the discussion of subjacency by Van Valin, 1991).

In sum, given the theoretical benefit and the greater economy of the semantic assimilation over the bootstrapping formulation, the former is to be preferred. I propose that, in future, the term "bootstrapping" be taken to include the semantic-assimilation formulation, and that the language that speaks of "flags" to categories be dropped as superfluous and misleading.

A range of possible theories

While I deliberately sketched a theory that was the same as Pinker's, except for the dropped innate syntax assumptions, I did so in order to make transparent the close relation between bootstrapping and semantic assimilation theories, not in order to promote a particular theory. Many different theories would be possible that share the primitives and manner of operation of the reformulated Pinker theory developed above. Below I mention two ways in which I believe both Pinker's theory and the reformulated theory could be improved, and then discuss alternative semantic bases for two important acquisitions.

First, an acquisition theory needs a mechanism that allows for gradual learning and for forgetting. While Pinker proposes a strengthening mechanism for rules and features, he largely ignores it and usually discusses his theory as if it posited one-trial learning (cf. the quotation cited earlier from Pinker, 1984). As Pinker recognizes in principle, one-trial learning is a most implausible assumption. In Braine (1988a) I propose a mechanism in which rules increase in strength when they are used to parse an input utterance, and weaken with disuse. In reviewing Pinker's theory (Braine, 1988b), I show how such a mechanism could be exploited to solve neatly several problems of a kind that Pinker's theory labors over.

Second, Pinker's model and my sketched reformulation both concentrate unduly on speech acts that are assertions of declarative propositions, which is surely not the most common kind of speech act in verbal interactions with young children. Semantic analyses more appropriate to requests and other speech acts need to be incorporated into the model. Also, to accommodate many utterances, particularly among children's first word combinations, a model should allow for the child analyzing and composing utterances that reflect parts of trees, that is, subpropositional constituents occurring in the context of various kinds of speech acts. Such constituents represent a level of complexity intermediate between single-word vocabulary and multi-word sentences. As noted earlier, both bootstrapping and semantic assimilation theories require that the child match elements of a spoken utterance to elements of the event representation. It is easy to see that mastery of short subpropositional constituents would facilitate this matching for multi-word sentences; it is worth noting, therefore, that there is plenty of evidence for their existence in children's early word combinations (e.g., Braine, 1976).

There are a number of places in the theory where different semantic analyses are possible, or different assumptions about the relations between semantic structures and trees. For instance, Macnamara (1986) suggests that distinctions within the logic of kinds are ancestral to various noun classes (see also McPherson, 1991, on the count–mass distinction). I now discuss two central issues of this sort. The first is the source of the English NP–VP constituent division; the second concerns what the child takes as the semantic basis of the NP category. Ultimate-

ly, all these suggestions involve or imply proposals about the language of thought.

The NP–VP constituent split in English and many languages

The earlier discussion concerning Figures 3 and 4 concluded that the multi-constituent division exemplified in Figure 3 does not provide a satisfactory basis for acquiring the NP–VP structure of English, and that the assumption that agents *qua* subjects are universally tree-structurally privileged (Pinker's method of justifying the constituent division of Figures 1 and 4) is also problematic. What seems to be needed is a theory in which a child would be obliged to make an analysis like that of Figure 4 only when exposed to a suitable language environment (like English). We can obtain such a theory by adopting the following two assumptions:

(1) A multi-constituent analysis like that of Figure 3 is always available to children. (By "analysis like that of Figure 3," I mean an analysis in which the main predicate and its arguments each has a main branch (or are sisters in the tree structure).[3] I assume that the branching is unordered in the language of thought, and that the child assigns the order or marking found in the language being learned.)

(2) "Action" is an ontological category of the language of thought. (As evidence, Jackendoff, 1983, pp. 49–55, adduces that we make reference to actions and quantify over them. For instance, the expressions *do it*, *do that* always refer to actions; in *Bill did the same thing Jack did*, *Bill did something* [*everything*] *Jack did*, the thing or things are actions; similarly, the answer to *What did you do*? is an action; in all cases the action goes into English as an action verb together with its non-actor arguments.)

Note that if "action" is a universally available category, and if children tend to classify words and phrases as referring to ontological categories (as posited earlier), then phrases indicating actions would be represented as constituents if the structure of the language lends itself to that representation. The structure of the language will lend itself to that representation if the verb and its non-actor arguments habitually occur contiguously in a continuous string – then they can be, and (the proposal predicts) will be, labeled as a unit. In a language in which they do not habitually occur contiguously, then a multi-constituent analysis like that of Figure 3 is made. Thus, in a VSO (verb–subject–object) language, or a language with a very free word order, the analysis made would be that of Figure 3.

This proposal yields many of the same consequences as Pinker's for many

[3] I do not mean to exclude the possibility of higher nodes, for example, with elements concerned with time or tense as daughters.

languages (e.g., in Pinker's theory, VSO languages ultimately end up with tree structures for transitive verb sentences that have the same multi-constituent branching structure as Figure 3). However, there is a significant difference in that, according to this proposal, the NP–VP constituent division in languages like English owes nothing to any innate connection among agenthood, subjecthood, and being an argument that is a daughter of S. Thus, the proposal would not cause problems in accounting for the acquisition of languages where these are not correlated (or where there is little evidence for subject as a special argument category – cf. Comrie, 1989, Ch. 5). Similarly, since the proposal does not posit an innate tendency for subjects of adjective and locative predications to be put in the same category as agents, it is consistent with evidence that children distinguish these, not only in ergative languages, but even in English (Braine & Hardy, 1982). Moreover, unlike Pinker's theory, the proposal can accommodate the characteristically split nature of ergative systems (Van Valin, 1990, 1992): children can learn the extensions of semantic roles to grammatical relations construction by construction, as Pye (1990) argues that they do.

Other treatments of some of the language variations are conceivable, that differ both from this one and from Pinker's. For instance, one analysis of VSO languages (e.g., Sproat, 1985) holds that they do have a VP: the underlying constituent order is I–S–(V–O) (I is inflection); then the V moves to combine with I to give the surface VSO order (actually, I + V–S–O). (Such a proposal might be neutral on the question whether it is agency itself, or the unity given to the VP by its "action" status, that makes the subject into a VP-external argument.) Proponents have not yet developed the implications of this analysis for language acquisition.[4] However, in so far as it supposes that all languages underlyingly/innately have a VP constituent that excludes the subject, it would appear to have rather striking implications for acquisition that are testable. Presumably, at early stages prior to the occurrence of productive verb inflections, one should observe S–V–O order in children's utterances – or alternatively, perhaps, subjects would be systematically omitted (to leave the VO constituent). Then, when inflection appears, the observed surface word order should change to the adult one (or the absent subjects should appear in postverbal position). It will be time to take this proposal seriously when these somewhat counterintuitive predictions have been found to be fulfilled (or some different predictions derived from it). Quite recently, Woolford (1991) has argued, for at least a few VSO languages, that transitive verb subjects are generated VP-internally (i.e., that subject and object NPs are sisters of the verb); she has also shown how this analysis might be extended to at least some free-word-order ("non-configurational") languages. Such analyses are consistent with my proposal because the main predicate and its arguments are taken as sisters.

[4]No doubt the assumptions underlying this approach have application to ergative phenomena, too, but here the implications for acquisition cannot even be speculated about.

Other ways of rooting the NP category?

The theory presented earlier posited that the original semantic basis of NP is an argument that falls into the ontological category of object. That allowed construction of a theory that mimics Pinker's. It may well be correct. However, there is an important issue that warrants discussion – how far should it be argumenthood or objecthood that is taken as the initial basis of NP? The great majority of the NPs of very young children do undoubtedly represent objects; however, some NPs that represent events or actions can also appear very early, for example, utterances like *more that* or *see that* where *that* refers to some interesting event. Such utterances do not disprove the analysis – they could merely indicate that the old-rules-analyze-new-material principle operates very quickly to allow object argument expressions to refer to events. However, such utterances do raise the possibility that the use of NPs to refer to events might turn out to be as primitive as their use to refer to objects; that would not be consistent with the theory considered earlier (either in Pinker's version or the reformulation). So there is reason to consider the possibility of alternative analyses.

In Braine (1987) I presented an analysis that made little use of objecthood, and rooted the NP in the category argument. That proposal is unsatisfactory as it stands because of the obvious objection that there are other kinds of phrases that are arguments. For example, as noted earlier, some prepositional phrases denote arguments, notably locative phrases like *on the bed* in *George put the cat on the bed*. Arguments like *on the bed* designate places or paths; they are formed from a preposition and an NP, and have a function-argument form. The preposition is a function that maps an object argument (the bed) into a place argument (on the bed) (Jackendoff, 1983); the NP (*the bed*) is the argument of the function.

Although one cannot say, simply, that arguments are characteristically NPs, one might distinguish basic (i.e., underived) arguments from derived arguments (like prepositional phrases designating places). One might then claim that basic arguments are characteristically NPs. That is, characteristically, arguments of predicates are NPs, or built from functions whose ultimate arguments are NPs.[5] The NP would be catholic from the start in the ontological categories it could represent, whereas arguments built from functions would represent particular ontological categories specific to the function. The acquisition theory would continue to assume that children are sensitive to both argumenthood and ontological category, but would assign somewhat greater weight to argumenthood than the theory modeled on Pinker's that was developed earlier. According to the argument theory, the child's sensitivity to the category argument makes this the root of NP (i.e., NPs would be argument-phrases). When derived arguments are encountered (very early in the case of places), the argument of the function is

[5]One needs the qualification "characteristically" because there are some individual items (e.g., *here*, *there*) which are presumably not NPs although they may designate underived arguments.

recognized as an NP/argument-phrase, and the deriving function is identified with the ontological category of the derived argument (the child is still assumed to be sensitive to ontological category).

I shall not develop this theory further because I know of no current evidence that would clearly favor it over the theory reviewed earlier. However, it seems important to note that, if adopted, this theory would place constraints on possible semantic analyses in linguistics, namely, that they do not contradict the generalization that, characteristically, arguments of predicates are NPs or built from functions whose ultimate arguments are NPs. For instance, predicate adjectives could not be analyzed as property arguments. Thus, a statement like *The man is rich* would have to be analyzed as "RICH (The man)" not as "BE (The man, Rich)". Similarly, VPs like *Paint the wall green* and *Make the man rich* could not be analyzed as "PAINT (The wall, Green)" and "MAKE (The man, Rich)", but would have to be analyzed as "PAINT-GREEN (The wall)" and "MAKE-RICH (The man)", with PAINT-GREEN and MAKE-RICH being predicates that are compositionally derived by a function that maps simple predicates into complex ones (e.g., MAKE mapping the one-place predicate RICH into the two-place predicate MAKE-RICH). I believe that there is plenty of independent motivation for the complex-predicate analysis (cf. Chomsky, 1975).

Why aren't semantic categories sufficient?

One might wonder why syntactic categories emerge at all, given that the child starts with semantic categories. For the child the answer is simple – syntactic categories emerge because languages have them; that is, because languages present categories whose extensions do not match those of the semantic categories which are the child's starting point. Since the language has such categories the child has no option but to acquire them: the old-rules-analyze-new-material principle provides the mechanism which adjusts the extensions of the initial categories (created by labeling expressions after semantic categories) to match the extensions of the categories presented by the language. (This adjustment is what I mean in speaking of initial semantic categories "growing" into the syntactic categories of the language being learned.)

However, one can shift the scope of the question from the child learning a language to language in general: if children start with semantic categories, then why do languages have syntactic categories whose extensions do not match those of semantic categories? While anything like a full answer to this equation is beyond the scope of this paper, a brief sketch of the general lines of a possible answer may be appropriate. A few factors may be critical.

First, plausible semantic categories of the language of thought often seem to have fuzzy boundaries; for example, the distinction between an action and an

experience is not transparent at the boundary, nor is that between an event and a state of affairs; see Schlesinger (1979) on gradation between comitative and instrumental. The consequence is that where languages require a boundary to be drawn, they are free to determine its placement, and nothing forces every language to locate it in the same place.

Second, the different kinds of categories typically communicated through grammar tend to be orthogonal to each other, and semantic relations can be similar to each other along many cross-cutting dimensions. Thus, the semantic roles of arguments and adjuncts cut across ontological categories; similarly, the pragmatic roles that are often grammaticalized – topic/comment and focus/nonfocus (or new/given)(Comrie, 1989, pp. 62–65) – cut across both the semantic roles and ontological categories. There are well-known similarities of spatial relations to temporal ones, and also to other relations like possession; spatial paths can be seen as similar to temporal and informational ones; sources and goals can be locations or have to do with agency or purpose; there are similarities among transfer relations, whether these are physical, informational, or refer to changes in possession of property (Gruber, 1965; Jackendoff, 1983). Languages may capitalize on these similarities in different ways in establishing the relations to be marked in the grammar, thus installing different mappings (including many-to-one mappings) from semantic to syntactic categories.

Third, learners are sensitive to phonological similarities among words (e.g., Brooks, Braine, Catalano, Brody, & Sudhalter, 1991; Karmiloff-Smith, 1978; Levy, 1983) – a fact that makes possible the acquisition of phonologically marked categories that are semantically arbitrary, like many noun declensions and verb conjugations (Braine, 1987; MacWhinney, 1978).

Finally, the oral–auditory nature of language means that a spoken sentence must consist of a linear string of elements occurring one after the other in time. In most languages the number of structurally distinguishable positions is quite limited. For example, excluding the verb, in English, one can distinguish subject, object, and a limited number of preposition-marked phrases. Similarly, in inflected languages the number of different noun case inflections is commonly rather few (e.g., Latin had six). Typically, then, the number of available surface-structure positions is less than the number of semantic categories that can exist in the semantic representations of sentences. In that case, a many-to-one mapping from semantic structure to surface position is forced.

One can reasonably ask why the latter situation should arise: why should not a language have as many prepositions or affixes as there are relational meanings to be expressed? The most likely reason is that limiting the number of surface cues facilitates learning and processing. For instance, two of Slobin's (1973) "operating principles" were that new meanings tend to appear first expressed by familiar forms, and that new forms tend to appear first expressing familiar meanings; note that both these principles operate to destroy rather than install one-to-one

mappings between syntax and semantics – they indicate that the ease-of-learning benefit from acquiring one new thing rather than two often outweighs the benefit of a strictly one-to-one mapping from semantics to syntax.

Other factors than these may also be operative, but these few suggest that there are a number of processes that would tend to cause natural languages to have syntactic categories whose extensions are not in perfect correspondence with initial categories of the language of thought. It follows that for the adult language – indeed for any developmental stage after the very initial stage – description of the language should be expected to require separate syntactic and semantic levels of representation. Thus, except for the initial stage, a semantic assimilation acquisition theory is quite consistent with the thesis of the autonomy of syntax, although it does not mandate it.

Conclusion

It is perfectly feasible to have an acquisition theory that starts with semantic structure and posits no innate syntactic structures. Such a theory has important advantages. First, it is at least as plausible and more economical than the syntactic theory. This follows evidently, since the theory sketched in the main section of the paper ("Is bootstrapping necessary") is essentially Pinker's theory with the structure of the language of thought substituted for X-bar theory. From the point of view of economy, that substitution is pure gain since one has to assume anyway that a basic semantic structure for propositions is present at the outset of language acquisition (and that is assumed by Pinker), and the substitution has the additional economy of eliminating the need for the innate semantic flags to syntactic categories that Pinker is forced to postulate. Another advantage is that such a theory provides an account of the developmental origin of natural language syntactic categories, instead of postulating them as primitives whose source has to be explained by a supplementary biological theory of a kind we do not know how to construct.

It follows from this conclusion that a full theory of language acquisition requires understanding of the semantic roots of syntax, including especially of X-bar theory, that is, of the semantic roots of what is universal or near-universal in phrase structure. Such investigation (exemplified, for instance, in Jackendoff, 1983, 1990) appears to be one of the few routes into the structure of the language of thought, the definition of which should surely be a central goal of cognitive science.

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