

The Human Language Faculty as an Organ

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ABSTRACT: Developments in the study of language and cognition give increasing credibility to the view that human knowledge of natural language results from — and is made possible by — a biologically determined capacity specific both to this domain and to our species. The functional properties of this capacity develop along a regular maturational path, such that it seems more appropriate to speak of our knowledge of our language as “growing” than as “being learned.” That our learning of language results from a specific innate capacity rather than by general mechanisms of induction is supported by the extent to which we can be shown to know things that we could not have learned from observation or any plausibly available teaching. The domain-specificity of the language faculty is supported by the many dissociations that can be observed between control of language structure and other cognitive functions. Finally, the species-specificity of the human language faculty is supported by the observation that (absent severe pathology) every human child exposed in even limited ways to the triggering experience of linguistic data develops a full, rich capacity which is essentially homogeneous with that of the surrounding community. Efforts to teach human languages to other species, however, have uniformly failed. These considerations make it plausible that human language arises in biologically based ways that are quite comparable to those directing other aspects of the structure of the organism. The language organ, in this sense, is to be interpreted in a functional sense, and not as implying an anatomical localization comparable to that of, say, the kidney.

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1 INTRODUCTION

“[H]uman cognitive systems, when seriously investigated, prove to be no less marvelous and intricate than the physical structures that develop in the life of the organism. Why, then, should we not study the acquisition of a cognitive structure such as language more or less as we study some complex bodily organ?” (Noam Chomsky [1], p. 10)

The study of language and cognition during the past several decades has given increasing credibility to the view that human knowledge of natural language results from — and is made possible by — a biologically determined capacity specific both to this domain and to our species. The functional properties of this capacity develop along a regular maturational path, such that it seems more appropriate to speak of our knowledge of our language as “growing” than as “being learned.” As with the visual system, much of the detailed structure that we find seems to be ‘wired in,’ though triggering experience is necessary to set the system in operation and to determine some of its specific properties.

The proposition that our learning of language results from a specific innate capacity rather than inductively from observation of the language around us is supported by the extent to which we can be shown to know things that we could not have learned from such observation or any plausibly available teaching. The degree of deep similarity among the world’s languages provides support for the notion that they are the product of a common human faculty, rather than mere artifacts. The manual languages which develop in Deaf communities independently of one another or of the language of the surrounding hearing community share in these fundamental properties, and we must conclude that they are neither the result of simple shared history nor necessary consequences of the articulatory/acoustic/auditory modality of spoken language. The development of structurally deficient pidgins into the essentially normal linguistic systems found in creoles, as a result of transmission through the natural language learning process in new generations of children, provides additional evidence for the richness of that process.

The domain-specificity of the language faculty is supported by the many dissociations that can be observed between control of language structure and other cognitive functions. Focal brain lesions can also result in quite specific language impairments in the presence of otherwise normal cognitive abilities; and *vice versa*. The proposal that the human language faculty is a product of our genetically determined biological nature is further supported by evidence that certain language deficits show a clear distribution within families that epidemiological and other studies show to be just what would be predicted of relatively simple heritable traits.

Finally, the species-specificity of the human language faculty is supported by the observation that (absent severe pathology) every human child exposed in even limited ways to the triggering experience of linguistic data develops a full, rich capacity which is essentially homogeneous with that of the surrounding community. Efforts to teach human languages to individuals of other species, however, even those closest to us, have uniformly failed. While a certain capacity for arbitrary symbolic reference can be elicited in certain higher apes (and perhaps even in other animals, such as parrots), syntactic systems even remotely comparable to those of human languages seem to be quite outside the capacity of non-human

animals, despite intensive highly directed training.

These considerations make it plausible that human language arises in biologically based ways that are quite comparable to those directing other aspects of the structure of the organism. The language organ, though, is not to be interpreted as having an anatomical localization comparable to that of, say, the kidney. Our understanding of the localization of cognitive function in brain tissue is much too fragmentary and rudimentary. Certain cortical and sub-cortical areas can be shown to sub-serve functions essential to language, in the sense that lesions in these regions disrupt language functioning (sometimes in remarkably specific ways), but an inference from this evidence to a claim that “language is located in Broca’s (and/or Wernicke’s) area” is quite unwarranted. The linguistic capacity which develops naturally in every normal human being appears to be best understood in functional, rather than literal anatomical terms.

2 LANGUAGE DEVELOPMENT AS GROWTH

The apparently common-sense notion that an adult speaker’s knowledge of his/her language arises by simple ‘learning,’ that is as a direct generalization of experience, turns out to pose a logical paradox. We begin with two brief examples that illustrate this point, and then explore the consequences of this for the mechanisms that must in fact underlie the development of linguistic knowledge in normal human speakers.

2.1 *We Know More Than We Learn*

A striking property of language acquisition is that children attain knowledge which, quite literally, infinitely surpasses their actual experience. On the basis of quite limited experience, a productive system, a grammar, arises in each speaker which not only encompasses (a principled subset of) the actual facts to which they have been exposed, but also permits the production and comprehension of an unlimited range of novel utterances in the language. There must, therefore, be much more to language acquisition than mimicking what is heard in childhood; and there is more to it than the simple transmission of a set of words and sentences from one generation of speakers to the next.

2.1.1 TWO GRAMMATICAL PUZZLES

Consider some subtleties that people are usually not consciously aware of. The verb *is* may be used in its full form or its reduced form: English speakers can say either *Kim is happy* or *Kim’s happy*. However, certain instances of *is* never reduce: for example, the underlined items in *Kim is happier than Tim is* or *I wonder where the concert is on Wednesday*. Most speakers are not aware of this, but we all know subconsciously not to use the reduced form in such cases. How did we come to know this? As children, we were not instructed to avoid the reduced form in certain places. Yet, all children typically attain the ability to use the forms in the adult fashion, and this ability is quite independent of intelligence level or educational background. Children attain it early in their linguistic development. More significantly, children do not try out the non-occurring forms as if testing a hypothesis, in the way that they “experiment” by using forms like *goed* and *taked*. The ability emerges perfectly and as if by magic.

Another example. Pronouns like *she*, *her*, *he*, *him*, *his* sometimes may refer back to a noun previously mentioned in a sentence (1a-c). However, one can only understand 1d as referring to two men, Jay and somebody else; here the pronoun may not refer to Jay, unlike 1a-c.

- (1) a. Jay hurt his nose.
 b. Jay's brother hurt him.
 c. Jay said he hurt Ray.
 d. Jay hurt him.

As adults we generalize that a pronoun may refer to another noun within the same sentence except under very precise conditions (as in 1d). But then, how did we all acquire the right generalization, particularly knowledge of the exception?

To extend this point, consider some more complex examples, as in 2:

- (2) a. When Jay entered the room, he was wearing a yellow shirt.
 b. Jay was wearing a yellow shirt when he entered the room.
 c. When he entered the room, Jay was wearing a yellow shirt.
 d. He was wearing a yellow shirt when Jay entered the room.
 e. His brother was wearing a yellow shirt when Jay entered the room.

In all of the sentences in 2 the pronoun (*he* or *his*) may refer to some other individual, not mentioned. It may also refer to Jay — in all cases, that is, except 2d, where the wearer of the yellow shirt can only be understood to be someone other than Jay. Again, all speakers are in essential agreement on this point, when these facts are pointed out to them, but we may legitimately be puzzled at the source of this knowledge. It is quite unlikely to have come from any explicit instruction: as far as we know, these points about the interpretation of pronouns had not been systematically noted, even by grammarians, prior to the late 1960's [2, 3, 4, 5].

As adults we generalize that a pronoun may refer to another noun within the same sentence except under very precise conditions (as in 1d or 2d). But then, how did we all acquire the right generalization, particularly knowledge of the exceptions? In the case of 2d, we might be tempted to say that it is only natural that a pronoun should not be able to refer to an individual mentioned only later in the sentence, but the evidence of 2c,e shows that such 'backwards anaphora' is in fact possible under some circumstances.

2.1.2 WHERE DOES THIS KNOWLEDGE COME FROM?

In approaching both of these problems, recall the nature of our childhood experience: we were exposed to a haphazard set of linguistic expressions. We heard various sentences containing both the full verb *is* and its reduced form 's; we also heard sentences containing pronouns, in some of which the pronoun referred to another noun in the same sentence, and in others to a person not mentioned there. The problem is that, because we were not informed about what **cannot** occur, our childhood experience provided no evidence for the "except" clause(s), the cases in which the contracted form is impossible or where a pronoun and a noun in the same sentence may not co-refer. That is, we had evidence for generalizations like "*is* may be pronounced [z]¹" and "pronouns may refer to an

¹We follow the convention in Linguistics of enclosing phonetic representations in square brackets.

individual named by a noun in the same sentence,” but no evidence for where these generalizations break down.

As children, we came to know the generalizations and their exceptions, and we came to this knowledge quickly and uniformly. Yet our linguistic experience was not rich enough to determine the limits to the generalizations. We call this the problem of **the poverty of the stimulus**. Children have no data which show them that *is* may not be reduced in some contexts and they have no data showing that *him* may not refer to Jay in 1d. These two small illustrations are examples of the form that the poverty-of-stimulus problem takes in language. It may look as if children are behaving magically, but there is no magician and magic is no answer.

There are two ‘easy’ solutions to the poverty-of-stimulus problem, but neither is adequate. One is to say that children do not over-generalize, because they are reliable imitators. That is, children do not produce the reduced *'s* in the wrong place or use a pronoun in 1d or 2d wrongly to refer to Jay, because they never hear language being used in this way. In other words, children acquire their native language simply by imitating the speech of their elders. We know this cannot be literally true, because everybody constantly says things that they have never heard. We express thoughts with no conscious or subconscious consideration of whether we are imitating somebody else’s use of language. This is true of the most trivial speech: in saying *I want to catch the 3:25 PM bus, which leaves from outside Border’s bookstore*, one is using a sentence that one has almost certainly not heard.

The alternative of saying that we form new sentences ‘by analogy’ with specific sentences we have heard before simply conceals the problem, because it does not account for the fact that some possible ‘analogies’ are good and others are not. Why, that is, does not the existence of the contracted *'s* in *Tim’s happy* provide an analogical foundation for a similar reduced form in *Kim’s happier than Tim is*? Why do the sentences 2a-c,e not provide an analogical basis for coreference between *Jay* and *he* in 2d? The point is that language learners arrive at certain very specific generalizations, and fail to arrive at certain other logically possible ones, in ways that cannot be founded on any independent general notion of induction or analogy.

An alternative approach is to claim that children learn not to say the deviant forms because they are corrected by their elders. Alas, this view offers no better insight for several reasons. First, it would take an acute observer to detect and correct the error. Second, where linguistic correction is offered, young children are highly resistant and often ignore or explicitly reject the correction. Third, in the examples discussed, children do not over-generalize and therefore parents have nothing to correct; this will become clearer when we discuss experimental work on young children.

So the first ‘easy’ solution to the poverty-of-stimulus problem is to deny that it exists, to hold that the environment is rich enough to provide evidence for where the generalizations break down. But the problem is real, and this ‘solution’ does not address it.

The second ‘easy’ answer would be to deny that there is a problem, because there would be nothing to be learned if we could maintain that a person’s language is fully determined by genetic properties. Yet this answer also cannot be right, because people speak differently, and many of the differences are environmentally induced. There is nothing about a person’s genetic inheritance that makes her

a speaker of English; if she had been raised in a Dutch home, she would have become a speaker of Dutch.

The two ‘easy’ answers either attribute everything to the environment or everything to the genetic inheritance. Neither position is tenable. Instead, language emerges through an interaction between our genetic inheritance and the linguistic environment to which we happen to be exposed. English-speaking children learn from their environment that the verb *is* may be pronounced [ɪz] or [z], and native principles prevent the reduced form from occurring in the wrong places. Likewise, children learn from their environment that *he*, *his*, etc are pronouns, while native principles entail where pronouns may not refer to a preceding noun. The interaction of the environmental information and the native principles accounts for how the relevant properties emerge in an English-speaking child.

We will sketch some relevant principles below. It is worth pointing out that we are doing a kind of Mendelian genetics here, in the most literal sense. In the mid-nineteenth century, Mendel postulated genetic “factors” to explain the variable characteristics of his pea plants, without the slightest idea of how these factors might be biologically instantiated. Similarly, linguists seek to identify information which must be available independently of experience, in order for a grammar to emerge in a child. We have no idea whether this information is encoded directly in the genome or whether it results from epigenetic, developmental properties of the organism; it is, in any case, native. As a shorthand device for these native properties, we shall write of the linguistic genotype, that part of our genetic endowment which is relevant for our linguistic development. Each individual’s genotype determines the potential range of functional adaptations to the environment ([6, p.36]), and we assume that the linguistic genotype (what linguists call **Universal Grammar** or “UG”) is uniform across the species (in the absence of fairly severe and specific pathology). That is, linguistically we all have the same potential for functional adaptations and any of us may grow up to be a speaker of Catalan or Hungarian, depending entirely on our circumstances and not at all on variation in our genetic make-up.

It is important to understand that Universal Grammar in this sense is not to be confused with the grammar of any particular language: to say that would be close to the second fallacious approach to the problem of the poverty of the stimulus which we discussed above. Rather, Universal Grammar can be seen as the set of principles by which the child can infer, on the basis of the limited data available in the environment, the full grammatical capacity which we think of as a mature speaker’s knowledge of a language.

Since children are capable of acquiring any language to which they happen to be exposed between infancy and puberty, the same set of genetic principles which account for the emergence of English (using “genetic” now in the extended sense we have indicated) must also account for the emergence of Dutch, Vietnamese, Hopi, or any other of the thousands of languages spoken by human beings. This plasticity imposes a strong empirical demand on hypotheses about the linguistic genotype; the principles postulated must be open enough to account for the variation among the world’s languages. The fact that people develop different linguistic capacities depending on whether they are brought up in Togo, Tokyo, or Toronto provides a delicate tool to refine claims about the nature of the native component.

We conclude that there is a biological entity, a finite mental organ, which develops in children along one of a number of paths. The range of possible paths

of language growth is determined in advance of any childhood experience. The language organ that emerges, the grammar, is represented in the brain and plays a central role in the person's use of language. We have gained some insight into the nature of people's language organs by considering a wide range of phenomena: the developmental stages that young children go through, the way language breaks down in the event of brain damage, the manner in which people analyze incoming speech signals, and more. At the center is the biological notion of a language organ, a grammar.

2.2 The Nature of Grammars

Children acquire a productive system, a grammar, in accordance with the requirements of the genotype. If asked to say quite generally what is now known about the linguistic genotype, we would say that it yields finite grammars, because they are represented in the finite space of the brain, but that they range over an infinity of possible sentences. Finite grammars consist of a set of operations which allow for infinite variation in the expressions which are generated. The genotype is plastic, consistent with speaking Japanese or Quechua. It is modular, and uniquely computational.

By 'modular' we mean that the genotype consists of separate subcomponents each of which has its own distinctive properties, which interact to yield the properties of the whole. These modules are, in many cases, specific to language. Research has undermined the notion that the mind possesses only general principles of 'intelligence' which hold of all kinds of mental activity. One module of innate linguistic capacity contains abstract structures which are compositional (consisting of units made up of smaller units) and which fit a narrow range of possibilities. Another module encompasses the ability to relate one position to another within these structures by movement, and those movement relationships are narrowly defined. Another module is the mental lexicon, a list of word-forms and their crucial properties.

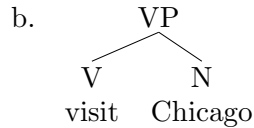
These modules may or may not be separately represented in neural tissue: for example, Grodzinsky [7] has recently argued that movement relations — and not other aspects of syntactic form — are computed by specific tissue within the classical Broca's area. The claim of modularity does not in any sense rest on such physical separation, however. It refers, rather, to the fact that various aspects of linguistic knowledge are logically and functionally independent of one another, yielding the full complexity of human language through the interaction of individually rather simple systems.

To see the kind of compositionality involved, consider how words combine. Words are members of categories like noun (N), verb (V), preposition (P), adjective/adverb (A). If two words combine, then the grammatical properties of the resulting phrase are determined by one of the two words, which we call the head: we say that the head **projects** the phrase. If we combine the verb *visit* with the noun *Chicago*, the resulting phrase *visit Chicago* has verbal and not nominal properties. It occurs where verbs occur and not where nouns occur: *I want to visit Chicago*, but not **the visit Chicago*² nor **we discussed visit Chicago*. So the expression *visit Chicago* is a verb phrase (VP), where the V *visit* is the head projecting the VP. This can be represented as a labeled bracketing (3a) or as a tree

²Following a standard convention in Linguistics, we indicate phrases or sentences which are not grammatical in English with a preceding “*”

diagram (3b). The verb is the head of the VP and the noun is the complement.

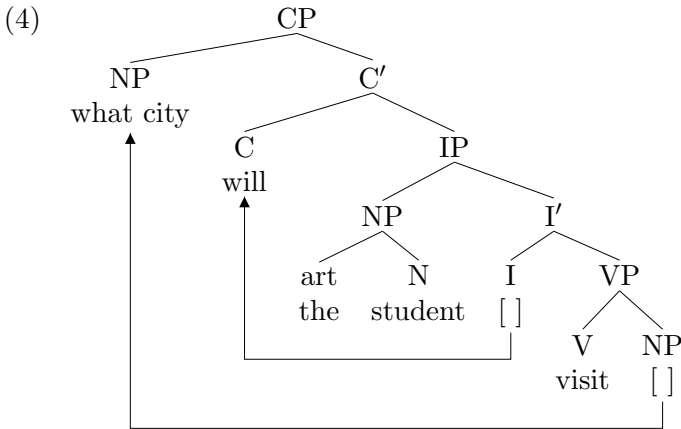
(3) a. [_{VP} [_V visit] [_N Chicago]]



In general, two categories merge to form a new category. So an ‘inflectional’ element like *will* might combine with the VP *visit Chicago*, to yield the more complex expression *will visit Chicago*, with a structure [_{IP} [_I will] [_{VP} visit Chicago]]. The auxiliary, inflectional *will*, heads the new phrase and projects to a phrasal category IP. This means that *visit Chicago* is a unit (VP), which acts as the complement of *will*, but *will visit* is not a unit; that is, there is no single node which dominates *will visit* and nothing else in this example.

The units defined by these trees are the items which the computational operations manipulate; they are the items which move and delete and to which reference (including co-reference) can be assigned. Non-units are not available to these operations.

One of the computational operations involved is that of overt movement to account for the fact that in the surface forms of many sentences, elements occur in positions other than those with which their syntactic function is naturally assigned. We describe such ‘displaced’ elements with the metaphor of movement. This does not, of course, entail a claim that speakers go through some process of re-adjustment of structure in producing or understanding the relevant sentences: it is only a way of characterizing explicitly the relation between the sentential position in which a word or phrase appears and that with which its grammatical functions are associated. For example, an expression like *What city will the student visit?* (where *what city* is understood as the complement of *visit*) can be described by a structure along the lines of (4). Here we need more structure to enable the subject *the student* to combine with *will* and its complement VP to form a full IP, and then to enable *what city* to merge with the rest of the clause. *Will* is a head (labeled C for ‘complementizer’), which in such question constructions precedes the rest of the IP, and *what city* is a specifier to that head. We indicate the positions from which these elements have moved with empty pairs of brackets.



The syntactic component of a speaker's knowledge of a language, then, can be represented by a system of rules that describes (or 'generates') the set of structures (similar to that in 4) occurring in sentences of the language, characterizes the range of possible structural relations between 'moved' elements and their functional positions, etc. Other aspects of a full grammar provide explicit accounts of the relation between this kind of syntactic organization and the way the words of sentences are constructed and pronounced, etc. The set of possible grammars of this type is narrowly limited by the principles of Universal Grammar, which require that systems within this range (and no others) are in principle attainable by the specific principles available to the child, with differences among them corresponding to differences in the Primary Linguistic Data available in the child's experience.

2.3 Back to the Puzzles

Let us return now to the problems raised above in section 2.1, beginning with that of 's, the reduced form of *is*. In a sentence like *Kim's happy*, the auxiliary element 's is grammatically the head of the IP, taking the Adjective Phrase *happy* as its complement. In pronunciation, however, it forms part of a single unbroken unit with the preceding word *Kim*, as the apostrophe in the conventional spelling 's suggests, despite the fact that the sequence *Kim — 's* does not constitute a phrase syntactically.

We thus see that the correspondence between syntactic phrases and units of sound (**phonological** words and phrases) is not a strict isomorphism. The relation is not, however, simply arbitrary and unconstrained. In particular, every syntactic phrase, if pronounced at all, must correspond to at least one phonological word, even though not every *syntactic* word constitutes a full phonological word of its own. This condition on the relation between syntactic and phonological form seems not to be a fact about English *per se*, but rather about language in general.

In the case that interests us, reduced forms of auxiliaries such as 's (as well as 've, 're, and the reduced forms of *am*, *will*, *would*, *shall*, and *should*) do not have enough phonological 'substance' to be words on their own, and thus necessarily combine with a word on their left to make up a single phonological word in the pronunciation of sentences in which they occur. In terms of pronunciation, that is, *Kim's* in *Kim's happy* is just as indissoluble a unit as *birds* in *Birds fly*.

Even though 's in *Kim's happy* is not itself a phonological word, this does not compromise the principle that every syntactic phrase corresponds to at least one phonological word, however, since 's is not itself a phrase and the phrase of which it is the head, 's *happy*, is represented by the word *happy*. Consider the case of the underlined *is* in *Kim's happier than Tim is*, though. In this structure the underlined *is* is the only representative of its phrase (which consists of *is* and understood, but unpronounced, *happy*). If this *is* were to be replaced with the non-word 's, the result would be a syntactic phrase that corresponded to no phonological word. It is this that is responsible for the fact that we cannot say **Kim's happier than Tim's*. Poets make linguistic jokes from these principles: the Gershwins were famous for contraction jokes such as that in *Girl Crazy* (1930) where a chorus begins *I'm bidin' my time / 'Cause that's the kind of guy I'm*.

A sentence-internal understood element can have similar effects, as in *I wonder where_x the concert is []_x on Wednesday*. Here *where_x* has moved from the position indicated as []_x, but is still understood there. This shows that the reduced *is* has to be combined with a word that stands in a certain kind of structural relationship to it: it forms a phrase together with its complement, and this phrase is represented by at least that complement as a phonological word even though 's itself would not suffice to supply a well formed phonological correspondent to a syntactic phrase. *On Wednesday* is not the complement of *is* in this example. In 5a, *happy* is the complement of *is* and therefore reduced 's may attach to the preceding word without leaving the phrase it heads stranded. The same is true for the first *is* of 5b. However, *Tim* is not the complement of the underlined *is* in 5b; in this case, the subject *Tim* and the copula verb *is* have permuted. AS a result, the underlined *is* is the only overt representative of its phrase, and cannot be reduced.

- (5) a. Kim's happy.
b. Kim is happier than is Tim.

So now we have an answer to the problem sketched at the outset: a reduced *is* may not be the only phonological material representing the syntactic phrase of which it is the head. This follows from principled restrictions which are in fact quite general: in natural languages, syntactic phrases must be represented, if at all, by at least one phonological word, and reduced auxiliary Verbs do not consist of enough material to satisfy this requirement. One productive approach is to treat reduced *is* as a clitic. Clitics are little words which occur in many, perhaps all languages, and have the property of not being able to stand alone. In some languages, these elements attach systematically to the word to their left; in others, to the right, and in others the direction attachment depends on details of the syntactic and/or phonological structure. What is consistently the case, however, is that syntactic elements that do not constitute words in their own right must attach to some other word as clitics in order to be pronounced at all; and also that these clitics cannot be the only overt representative of a syntactic phrase.

Part of what a child growing a grammar needs to do is to determine the clitics in his or her linguistic environment, knowing in advance of any experience that these are small, unstressed items attached phonologically to an adjacent word in ways that may be contrary to the syntactic relations they bear to surrounding material. This predetermined knowledge — the nature of clitics and the fact that they cannot by themselves satisfy the requirement that phrases be represented by

at least one phonological word — is contributed by the linguistic genotype and is part of what the child brings to language acquisition. The environment provides examples such as *Pat's happy, Bob's happy, and Alice's happy too*. The child can observe that the three instances of 's in these cases vary in their pronunciation ([s] after *Pat*, [z] after *Bob*, and [ɪz] after *Alice*). This variation is quite systematic, and in fact follows the same principles as those that determine the form of the plural ending in *cats, knobs, palaces*: a fact which confirms that 's forms part of a single phonological unit with the preceding word just as the plural ending does, and thus must be a clitic.

Under this approach, the child is faced with a chaotic environment and scans it, looking for clitics... among many other things, of course [8]. This is the answer that we provide to our initial problem and it is an answer of the right shape. It makes a general claim at the genetic level (clitics and their behavior are predefined) and postulates that the child arrives at a plausible analysis on exposure to a few simple expressions. The analysis that the child arrives at predicts no reduction for the underlined *is* in *Kim is happier than Tim is, I wonder where the concert is on Wednesday*, and countless other cases, and the child needs no correction in arriving at this system. The very fact that 's is a clitic, a notion defined in advance of any experience, dictates that it may not occur in certain contexts. It is for this reason that the generalization that *is* may be pronounced as 's breaks down at certain points and does not hold across the board.

Consider now the second problem, the reference of pronouns. An initial definition might propose that pronouns refer to a preceding noun, but the data of 1 and 2 show that this is both too strong and too weak. It is too strong because, as we saw, in 1d *him* may not refer to Jay; in 1b *him* may refer to Jay but not to Jay's brother. The best account of this complex phenomenon seems to be to invoke a native principle which says that pronouns may not refer back to a local nominal element, where 'local' means contained in the same clause or in the same NP.

In 6 we give the relevant structure for the corresponding sentences of 1. In 6b the NP *Jay's brother* is local to *him* and so *him* may not refer back to that NP: we express this by indexing them differently. On the other hand, *Jay* is contained inside the NP and therefore is not available to *him* for indexing purposes, so those two nouns do not need to be indexed differently — they may refer to the same person and they may thus be co-indexed. Again we see the constituent structure illustrated earlier playing a central role in the way in which the indexing computations are carried out. In 6d *Jay* is local to *him* and so the two elements may not be co-indexed; they may not refer to the same person. In 6c *Jay* is not local to *he*, because the two items are not contained in the same clause: *Jay* and *he* may thus refer either to the same person or to different people. In 6a *his* is contained inside a NP and may not be co-indexed with anything else within that NP; what happens outside the NP is not systematic; so *his* and *Jay* may co-refer and do not need to be indexed differently.

- (6) a. [_{IP} Jay_i hurt [_{NP} his_{i/j} nose]]
 b. [_{IP} [_{NP} Jay_i's brother]_k hurt him_{i/j/*k}]
 c. [_{IP} Jay_i said [_{IP} he_{i/j} hurt Ray]]
 d. [_{IP} Jay_i hurt him_{j/*i}]

The proposal that pronouns refer to a preceding noun is shown to be too weak because sometimes, as in 2c,e, the pronoun refers to a **following** noun. In this case, the relevant principle seems to be that such ‘backwards anaphora’ is not possible if the pronoun not only precedes the noun, but is also ‘higher’ (in a precise sense whose details are not relevant to our present concerns) in the syntactic structure than the noun which is to serve as its antecedent. In 2c, the pronoun precedes *Jay*, but this is acceptable because the pronoun appears within a subordinate clause. In 2e, the pronoun is subordinated by virtue of appearing as a possessor within a larger NP. In 2d, however, the pronoun appears as subject of the main clause, and is thus (in the relevant structural sense) syntactically higher than the following noun, which therefore cannot serve as its antecedent.

We could have illustrated these points equally well with data from French or from Dutch, or from many other languages, because the principles apply quite generally, to pronouns in all languages. If we assume a native principle, available to the child independently of any actual experience, language acquisition is greatly simplified. Now the child does not need to ‘learn’ why the pronoun may refer to Jay in 6a or 6b,c but not in 6d; in 2a-c,e but not in 2d, etc.. Rather, the child raised in an English-speaking setting has only to learn that *he*, *his*, *him* are pronouns, i.e. elements subject to our principles. This can be learned by exposure to a simple sentence like 1d (structurally 6d), uttered in a context where *him* refers to somebody other than Jay.

One way of thinking of the contribution of the linguistic genotype is to view it as providing invariant principles and option-points or **parameters**. There are invariant principles that clitics attach phonologically to adjacent words, that a (non-null) syntactic phrase must correspond to at least one phonological word, that pronouns cannot be locally co-indexed and that they cannot both precede and be structurally higher than a full NP with which they are co-referential. Meanwhile, there are also options: direct objects may precede the verb in some grammars (German, Japanese) and may follow it in others (English, French), some clitics attach to the right and some to the left. These are parameters of variation and the child sets these parameters one way or another on exposure to her particular linguistic experience. As a result a grammar emerges in the child, part of the linguistic phenotype. The child has learned that *'s* is a clitic and that *he* is a pronoun; the genotype ensures that *'s* cannot be the only phonological material corresponding to a syntactic phrase and that *he* is never used in a structurally inappropriate context.

2.4 *The Acquisition Problem*

In the preceding sections we have looked at some specific acquisition problems and considered what ingredients are needed for their solution. Now let us stand back and think about these matters more abstractly.

The child acquires a finite system, a grammar, which generates structures which correspond more or less to utterances of various kinds. Some structural principle prevents forms like **Kim's happier than Tim's* from occurring in the speech of English speakers, as we have seen. Children are not exposed to pseudo-sentences like this and informed systematically that they are not to be produced. Speakers come to know subconsciously that they cannot be said and this knowledge emerges somehow, even though it is not part of the environmental input to the child's development. It is not enough to say that people do not utter such forms

because they never hear them: people say many things that they have not heard, as we have noted. Language is not learned simply by imitating or repeating what has been heard.

2.4.1 THE POVERTY OF THE STIMULUS

This poverty-of-stimulus problem defines our approach to language acquisition. Over the last forty years, much of the linguistic literature has focused on areas where the best description cannot be derived directly from the data to which the child has access, or is under-determined by those data, as in the examples with the clitic 's and the pronouns discussed above. If the child's linguistic experience does not provide the basis for establishing a particular aspect of linguistic knowledge, another source must exist for that knowledge.

This is not to say that imitation plays no role, but only that it does not provide a sufficient explanation. This is worth emphasizing, because antagonists sometimes caricature this approach to language acquisition as "denying the existence of learning," when in fact we merely deny that learning is the whole story, a very different matter. The quotation is from a remarkable article in *Science* [9], in which the authors assert that "Noam Chomsky, the founder of generative linguistics, has argued for 40 years that language is unlearnable" and that they, on the other hand, have "rediscovered" learning!

Caricatures of this type show up in the writing of people who claim that all information is derived from the environment and that there is no domain-specific genetic component to language acquisition. These people deny the poverty-of-stimulus problems, claiming that children may derive all relevant information from their linguistic environment. Bates and Elman provide a recent and particularly clear and striking instance of this line, claiming that artificial neural networks can learn linguistic regularities from imperfect but "huge computerized corpora of written and spoken language."

Nobody denies that the child must extract information from the environment; it is no revelation that there is 'learning' in that technical sense. Our point is that there is more to language acquisition than this. Children react to evidence in accordance with specific principles.

The problem demanding explanation is compounded by other factors. Despite variation in background and intelligence, people's mature linguistic capacity emerges in fairly uniform fashion, in just a few years, without much apparent effort, conscious thought, or difficulty; and it develops with only a narrow range of the logically possible 'errors.' Children do not test random hypotheses, gradually discarding those leading to 'incorrect' results and provoking parental correction. In each language community the non-adult sentences formed by very young children seem to be few in number and quite uniform from one child to another, which falls well short of random hypotheses. Normal children attain a fairly rich system of linguistic knowledge by five or six years of age and a mature system by puberty. In this regard, language is no different from, say, vision, except that vision is taken for granted and ordinary people give more conscious thought to language.

These, then, are the salient facts about language acquisition, or more properly, language growth. The child masters a rich system of knowledge without significant instruction and despite an impoverished stimulus; the process involves only a narrow range of 'errors' and takes place rapidly, even explosively between two

and three years of age. The main question is how children acquire so much more than they experience.

A grammar represents what a speaker comes to know, subconsciously for the most part, about his or her native language. It represents the fully developed linguistic capacity, and is therefore part of an individual's phenotype. It is one expression of the potential defined by the genotype. Speakers know what an infinite number of sentences mean and the various ways in which they can be pronounced and rephrased. Most of this largely subconscious knowledge is represented in a person's grammar. The grammar may be used for various purposes, from everyday events like expressing ideas, communicating, or listening to other people, to more contrived functions like writing elegant prose or lyric poetry, or compiling and solving crossword puzzles, or writing an article about the language organ.

We do not want to give the impression that all linguists adopt this view of things. In fact, people have studied language with quite different goals in mind, ranging from the highly specific (to describe Dutch in such a way that it can be learned easily by speakers of Indonesian), to more general goals, such as showing how a language may differ from one historical stage to another (comparing, for example, Chaucerian and present-day English). However, the research paradigm we sketch has been the focus of much activity over the last forty years and it construes a grammar as a biological object, the language organ.

2.4.2 THE ANALYTICAL TRIPLET

A grammar, for us, is a psychological entity, part of the psychological state of somebody who knows a language. For any aspect of linguistic knowledge, three intimately related items are included in a full account of this state. First, there is a formal and explicit characterization of what a mature speaker knows; this is the grammar, which is part of that speaker's phenotype. Since the grammar is represented in the mind/brain, it must be a finite system, which can relate sound and meaning for an infinite number of sentences.

Second, also specified are the relevant principles and parameters common to the species and part of the initial state of the organism; these principles and parameters make up part of the theory of grammar or Universal Grammar, and they belong to the genotype.

The third item is the trigger experience, which varies from person to person and consists of an unorganized and fairly haphazard set of utterances, of the kind that any child hears (the notion of a trigger is from ethologists' work on the emergence of behavioral patterns in young animals). The universal theory of grammar and the variable trigger together form the basis for attaining a grammar; grammars are attained on the basis of a certain trigger and the genotype.

In 7 we give the explanatory schema, using general biological terminology in 7a and the corresponding linguistic terms in 7b. The triggering experience causes the genotype to develop into a phenotype; exposure to a range of utterances from, say, English allows the UG capacity to develop into a particular mature grammar. One may think of the theory of grammar as making available a set of choices; the choices are taken in the light of the trigger experience or the Primary Linguistic Data ("PLD"), and a grammar emerges when the relevant options are resolved. A child develops a grammar by setting the open parameters of UG in the light of her particular experience.

- (7) a. linguistic triggering experience (genotype \rightarrow phenotype)
 b. Primary Linguistic Data (Universal Grammar \rightarrow grammar)

Each of the items in the triplet — trigger, UG, and grammar — must meet various demands. The trigger or PLD must consist only of the kinds of things that children routinely experience and includes only simple structures. The theory of grammar or UG is the one constant and must hold universally such that any person's grammar can be attained on the basis of naturally available trigger experiences. The mature grammar must define an infinite number of expressions as well-formed, and for each of these it must specify at least the sound and the meaning. A description always involves these three items and they are closely related; changing a claim about one of the items usually involves changing claims about the other two.

The grammar is one subcomponent of the mind, which interacts with other cognitive capacities or modules. Like the grammar, each of the other modules is likely to develop in time and to have distinct initial and mature states. So the visual system recognizes triangles, circles, and squares through the structure of the circuits that filter and re-compose the retinal image [10]. Certain nerve cells respond only to a straight line sloping downward from left to right within a specific, narrow range of orientations; other nerve cells to lines sloped in different directions. The range of angles that an individual neuron can register is set by the genetic program, but experience is needed to fix the precise orientation specificity [11]. In the mid-sixties David Hubel, Torsten Wiesel, and their colleagues devised an ingenious technique to identify how individual neurons in an animal's visual system react to specific patterns in the visual field (including horizontal and vertical lines, moving spots, and sharp angles). They found that particular nerve cells were set within a few hours of birth to react only to certain visual stimuli, and, furthermore, that if a nerve cell is not stimulated within a few hours, it becomes totally inert in later life. In several experiments on kittens, it was shown that if a kitten spent its first few days in a deprived optical environment (a tall cylinder painted only with vertical stripes), only the neurons stimulated by that environment remained active; all other optical neurons became inactive because the relevant synapses degenerated, and the kitten never learned to see horizontal lines or moving spots in the normal way.

Therefore, we see learning as a selective process: parameters are provided by the genetic equipment and relevant experience fixes those parameters [12, 13]. A certain mature cognitive structure emerges at the expense of other possible structures which are lost irretrievably as the inactive synapses degenerate. The view that there is a narrowing down of possible connections out of an overabundance of initially possible ones is now receiving more attention in the light of Hubel and Wiesel's Nobel Prize winning success. For the moment, this seems to be a more likely means to fine tune the nervous system as 'learning' takes place, as opposed to the earlier view that there is an increase in the connections among nerve cells.

So human cognitive capacity is made up of identifiable properties that are genetically prescribed, each developing along one of various pre-established routes, depending on the particular experience encountered during the individual's early life. These genetic prescriptions may be extremely specialized, as Hubel and Wiesel showed for the visual system. They assign some order to our experience. Experience elicits or triggers certain kinds of specific responses but it does not determine the basic form of the response.

This kind of modularity is very different from the view that the cognitive faculties are homogeneous and undifferentiated, that the faculties develop through general problem-solving techniques. In physical domains, nobody would suggest that the visual system and the system governing the circulation of the blood are determined by the same genetic regulatory mechanisms. Of course, the possibility should not be excluded that the linguistic principles postulated here may eventually turn out to be special instances of principles holding over domains other than language, but before that can be established more, much more must be known about what kinds of principles are needed for language acquisition to take place under normal conditions. The same is of course true for other aspects of cognitive development. Only on such a basis can meaningful analogies be detected. Meanwhile, “we are led to expect that each region of the central nervous system has its own special problems that require different solutions. In vision we are concerned with contours and directions and depth. With the auditory system, on the other hand, we can anticipate a galaxy of problems relating to temporal interactions of sounds of different frequencies, and it is difficult to imagine that the same neural apparatus deals with all of these phenomena [...] for the major aspects of the brain’s operation no master solution is likely” [14, p. 28].

2.4.3 REAL-TIME ACQUISITION OF GRAMMARS

In the domain of language, our colleagues at the University of Maryland have shown that the sophisticated distinctions that we discussed at the beginning of this article do not result from learning and that the hypothesized genetic constraints seem to be at work from the outset. The experimenters constructed situations in which the overriding temptation for children would be to violate the relevant constraints. The fact that children conform to the hypothesized constraints, resisting preferences they show in other contexts, is taken to be evidence that the constraints under investigation are active for them, and that this is true at the earliest stage at which they might be manifested [15].

Stephen Crain and Rosalind Thornton [16] developed an elicitation task that encouraged children to ask questions like **Do you know what that’s up there*, if these were compatible with their grammars. They hypothesized that children would generally show a preference for the reduced *’s* form whenever this was consistent with their grammars. This preference would be revealed in a frequency count of legitimate forms, like *Do you know what that’s doing up there?* Comparing the frequency of the reduced forms in the contexts where adults find reduced forms unacceptable with that of non-adult reduced forms more generally would indicate whether or not children’s grammars contained the hypothetical genetic constraint. If the genetic constraint is at work, there should be a significant difference in frequency; otherwise, not.

The target productions were evoked by the following protocols, in which Thornton and Crain provided children with a context designed to elicit questions.

(8) Protocols for cliticization:

- a. **Experimenter:** Ask Ratty if he knows what that is doing up there.
Child: Do you know what that’s doing up there?
Rat: It seems to be sleeping.
- b. **Experimenter:** Ask Ratty if he knows what that is up there.
Child: Do you know what that is up there?

Rat: A monkey.

In 8a, the child is invited to produce a sentence where *what* is understood as the object of doing: *do you know what_x that is doing []_x up there?* Since the resulting phrase of which *is* is head, [_{VP} is [_{VP} doing []_x]], contains at least one phonological word in addition to *is* itself, *is* can be replaced with the clitic form *'s* without resulting in an ill-formed correspondence between syntactic and phonological structure. However, in 8b, the child produces a sentence where *what* is understood as the complement of *is*, but is not pronounced in that position: *do you know what_x that is []_x up there?* (cf. *That is a bottle up there*). As a result, the phrase of which *is* is the head ([_{VP} is []_x]) only corresponds to a phonological word to the extent that *is* itself is a word — and not merely a clitic. This fact prevents the *is* from cliticizing in adult speech; no adult would use the reduced form to produce **Do you know what that's up there* (cf. *That's a bottle up there*).

Thornton and Crain found that young children behaved just like adults, manifesting the hypothetical genetic constraint. The children tested ranged in age from 2 years, 11 months to 4 years, 5 months, with an average age of 3 years, 8 months. In the elicited questions there was not a single instance of the reduced form where it is impossible in adult speech. Children produced elaborate forms like those of 9, but never with *'s*, the reduced form of *is*.

- (9) a. Do you know what that black thing on the flower is? (4 years, 3 months)
 b. Squeaky, what do think that is? (3 years, 11 months)
 c. Do you know what that is on the flower? (4 years, 5 months)
 d. Do you know what that is, Squeaky? (3 years, 2 months)

There is, of course, much more to be said about grammars and their acquisition, and there is an enormous technical literature [16]. Meanwhile, we have an approach to the riot of differences that we find in the languages of the world and even within languages. As children, our linguistic experience varies tremendously; no two children experience the same set of sentences, let alone the same pronunciations. Nonetheless, the approach we have sketched enables us to understand the universality of our development: why we categorize the linguistic world so similarly and can talk to each other despite the enormous variation in our childhood experience.

3 THE ORGANIC BASIS OF LANGUAGE

Human knowledge of natural language results from — and is made possible by — a richly structured and biologically determined capacity specific to this domain. It appears, furthermore, that much of this capacity is also specific to humans, lacking significant parallels even in those species closest to us, including the higher apes. This conclusion follows from the failures of a half century of intensive efforts to teach human languages to individuals of other species, especially chimpanzees and other primates.

The failure of initial attempts to teach spoken languages to non-human primates was initially attributed to deficiencies in these animals' vocal apparatus, and attention shifted in the 1960's to studies based on manual languages such as American Sign Language [17]. Research has demonstrated, as we note below,

that ASL and other natural signed languages have the structural properties of spoken languages (see [18, 19] and a rich technical literature), and are well within the dexterity of chimpanzees and other primates. Despite this, however, the animals in these experiments have never been shown to acquire even the rudiments of the syntactic organization of natural languages [20, 21, 22]. This conclusion has been repeatedly challenged by members of the ape language research community, especially in connection with experiments involving pygmy chimpanzees (*pan paniscus*) [23], but the fact remains that nothing resembling the natural human capacity for free, recursive syntactic combination has been shown in any serious scientific work to date.

In contrast to the failure of these attempts to instill in primates a syntactic ability comparable to that which appears naturally and spontaneously in every remotely normal human child, a certain capacity for arbitrary symbolic reference has undoubtedly been elicited in some higher apes [24, 25, 26, 27, 28, 29, 30] and perhaps even in other animals, such as parrots [31]. Such use of arbitrary symbols does not, apparently, occur in nature in non-human species, and the demonstration that in some cases it is nonetheless within their cognitive capacities is extremely interesting and important. It does not, however, compromise the conclusion that the syntactic properties of human language are provided to our language organ as a consequence of our specific genotype, and as such are well outside the capacity of non-humans. This should hardly come as a great surprise, since very species has unique systems and capacities that are determined by its specific genotype and inaccessible in the absence of the appropriate biology. It is not far-fetched to compare the situation regarding language in other primates with the fact that humans, even with intensive training, are incapable of free flight.

The functional properties of our language capacity develop along a regular maturational path, such that it seems more appropriate to see our linguistic knowledge as ‘growing’ rather than being ‘learned.’ As with the visual system, much of the detailed structure we find is ‘wired in,’ though triggering experience is necessary to set the system in operation and to determine some of its specific properties. In this respect, human language shows fascinating and detailed analogies (as well, of course, as significant dis-analogies) with the development of song in birds [32, 33], a system which is quite uncontroversially to be attributed to properties of the animal’s specific biology and not to some system of generalized learning or the like.

The notion that the world’s languages are the product of a common human faculty, rather than mere culturally determined accidents, is supported by the deep similarity that evidently exists among them, as the research of the past forty years or so in particular has made clear. A particularly striking instance of the commonality of the human language faculty is supplied by the manual languages which develop in Deaf communities independently of one another or of the language of the surrounding hearing community, and which share fully in these fundamental properties. We must conclude that the profound structural similarities between signed and spoken languages [34, 35, 36], including not only the basic principles of their organization but the specific path of their development, the brain regions associated with their control, and many others, are neither the result of simple shared history nor necessary consequences of the articulatory/acoustic/auditory modality of spoken language but rather derive from shared biology.

The notion that human language acquisition is primarily a matter of cultural transmission, rather than biologically driven maturation in the presence of relevant experience, is also controverted by instances of the development of structurally deficient pidgins into the essentially normal linguistic systems found in creoles. The deep reorganization of pidgins into creoles which takes place as an essentially automatic result of transmission through the natural language learning process in new generations of children, provides additional support for the richness of the genotypic system involved in linguistic development [37, 38, 8].

The language faculty has properties typical of a bodily organ, a specialized structure which carries out a particular function. Some organs, like the blood and the skin, interact with the rest of the body across a widespread, complex interface, and all organs are integrated into a complex whole. Often the limits to an organ are unclear, and anatomists do not worry about whether the hand is an organ or whether this designation should be reserved for one of its fingers. It is clear that the body is not made up of cream cheese, and the same seems to be true of the brain.

The language organ is not (at least in the present state of our knowledge) comparable to, say, the kidney, in having a clear and specifiable anatomical localization. Our understanding of the localization of cognitive function in brain tissue is currently too fragmentary and rudimentary to allow for clear claims of this sort. While certain areas of the brain (both cortical and sub-cortical) can be shown to sub-serve functions essential to language, in the sense that lesions in these areas disrupt language functioning (sometimes in remarkably specific ways) [39], the inferences from this evidence to claims that e.g. “language is located in Broca’s (and/or Wernicke’s) area” is quite unwarranted. Indeed, even the overall localization of language function in the left cortical hemisphere has been seen in recent years to be a significant oversimplification [40]. But in fact, even if it were to become clear that there is no clear segregation between language-related and non-language-related brain tissue, it would still be useful and important to treat the language capacity as a discrete and specifiable human biological system in functional if not anatomical terms, on the basis of arguments of the sort we have adduced above.

The domain-specificity of the language faculty is supported by the extensive literature documenting dissociations between control of language structure and of other aspects of cognition. Where a system operates and is subject to discrete impairment independently of other systems, it is a candidate for modular status. Thus in the domain of senses, one can be deaf without being blind, and *vice versa*, which supports (though it does not by itself require) the claim that hearing and sight are the products of distinct systems. Neil Smith [41] provides an excellent discussion of this point. He discusses the case of a linguistic ‘savant’ Christopher, whose hand-eye coordination is severely impaired and whose psychological profile shows “moderate to severe disability in performance tasks, but results close to normal in verbal tasks.” Despite low general intelligence, not only is his language essentially unimpaired, but in fact he has an astonishing capacity to pick up languages; see [42] for more extensive documentation and analysis.

In contrast, the phenomenon known as Specific Language Impairment (SLI; for an overview, see [43]) represents an apparently genetically determined condition in which language ability is impaired in fairly precise ways in the presence of otherwise normal abilities in other domains: most SLI children are cognitively normal but fail to develop age-appropriate linguistic capacities [44]. The homo-

geneity of the cases which have been grouped together under this diagnosis is quite controversial, but in support of the biological nature of the faculty in question, the distribution of SLI in some well-studied populations has been shown (in both epidemiological and genetic studies [45]) to be that of a relatively simple Mendelian trait [46, 47], perhaps even on with a specific, identifiable chromosomal location. Researchers have postulated a range of grammatical deficits associated with this genetic abnormality [48, 49, 50]; see [51] for a useful overview.

Smith [41] points to other dissociations: “Just as intelligence and language are dissociable, so also is it possible to separate linguistic ability and Theory of Mind, with autistic subjects lacking in the latter but (potentially, especially in the case of Asperger’s Syndrome — see [52]) language being retained within normal limits. Some Down Syndrome children provide a contrary scenario, with their Theory of Mind being intact, but their linguistic ability moderately to severely degraded.”

Similarly we find ‘sub-modular’ dissociations within the language organ, suggesting that grammars have their own internal modules. Smith points to dissociations between the lexicon and the computational system. Christopher’s talent for learning second languages “is restricted largely to mastery of the morphology and the lexicon, whilst his syntactic ability rapidly peaks and then stagnates [... A] reverse dissociation [is] found in the case of children with Spinal Muscular Atrophy, who seem to develop a proficient syntactic rule system but have correspondingly greater difficulty with lexical development (see [53]).” Edwards and Bastiaanse [54] address this issue for some aphasic speakers, seeking to distinguish deficits in the computational system from deficits in the mental lexicon.

We also know that focal brain lesions can result in quite specific language impairments in the presence of normal cognitive abilities, and *vice versa* [55]. Friedmann and Grodzinsky [56] argue that agrammatic aphasics may be unable to compute certain abstract structural elements (‘functional categories’), while Grodzinsky [7] identifies much of agrammatism with a disorder specifically impairing the computation of ‘movement’ relations, localized in the classical “Broca’s area.” Ingham [57] describes a young child in similar terms, arguing that she lacked one particular functional category.

This modular view runs contrary to a long tradition, often associated with Jean Piaget, which claims that language is dependent on prior cognitive capacities and is not autonomous and modular [58, 59]. Such a claim is undermined by the kinds of dissociations that have been observed, however. Bellugi et al [60] have shown, for example, that Williams Syndrome children consistently fail to pass seriation and conservation tests but nonetheless use syntactic constructions whose acquisition is supposedly dependent on those cognitive capacities. Clahsen and Almazan [61] demonstrate that Williams syndrome children have good control of the rule-governed aspects of syntax and word formation, but are severely impaired in certain irregular, memory-based functions; while SLI children display an essentially symmetrical pattern of affected and spared abilities. More generally, language and other cognitive abilities dissociate in development just as they do in acquired pathology [62].

4 CONCLUSION

Recent theoretical developments have brought an explosive growth in what we know about human languages. Linguists can now formulate interesting hypothe-

ses and account for broad ranges of facts in many languages with elegant abstract principles. They understand certain aspects of language acquisition in young children and can model some aspects of speech comprehension.

Work on human grammars has paralleled work on the visual system and has reached similar conclusions, particularly with regard to the existence of highly specific computational mechanisms. In fact, language and vision are the areas of cognition that we know most about. Much remains to be done, but we can show how children attain certain elements of their language organs by exposure to only an unorganized and haphazard set of simple utterances; for these elements we have a theory which meets basic requirements. Eventually, the growth of language in a child will be viewed as similar to the growth of hair: just as hair emerges with a certain level of light, air, and protein, so, too, a biologically regulated language organ necessarily emerges under exposure to a random speech community.

From the perspective sketched here, our focus is on grammars, not on the properties of a particular language or even of general properties of many or all languages. A language (in the sense of a collection of things people within a given speech community can say and understand) is on this view an epiphenomenon, a derivative concept, the output of certain people's grammars (perhaps modified by other mental processes). A grammar is of clearer status: the finite system that characterizes an individual's linguistic capacity and that is represented in the individual's mind/brain. No doubt the grammars of two individuals whom we regard as speakers of the same language will have much in common, but there is no reason to worry about defining 'much in common,' or about specifying precise conditions under which the outputs of two grammars could be said to constitute one language. Just as it is unimportant for most work in molecular biology whether two creatures are members of the same species (as emphasized, for example by Monod [63, ch. 2] and by Dawkins [64]), so too the notion of a language is not likely to have much importance if our biological perspective is taken and if we explore individual language organs, as in the research program we have sketched here.

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