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The Concept of Explanatory Adequacy

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Abstract and Keywords

This chapter illustrates the technical notion of ‘explanatory adequacy’ in the context of the other forms of empirical adequacy envisaged in the history of generative grammar: an analysis of a linguistic phenomenon is said to meet ‘explanatory adequacy’ when it comes with a reasonable account of how the phenomenon is acquired by the language learner. It discusses the relevance of arguments from the poverty of the stimulus, which bear on the complexity of the task that every language learner successfully accomplishes, and therefore define critical cases for evaluating the explanatory adequacy of a linguistic analysis. After illustrating the impact that parametric models had on the possibility of achieving explanatory adequacy on a large scale, the chapter addresses the role that explanatory adequacy plays in the context of the Minimalist Program, and the interplay that the concept has with the further explanation ‘beyond explanatory adequacy’ that minimalist analysis seeks.

Keywords: syntax, language acquisition, minimalism, principles and parameters, relativized minimality, coreference, simplicity

From the point of view that I adopt here, the fundamental empirical problem of linguistics is to explain how a person can acquire knowledge of language.

(Chomsky 1977:81)

5.1 Introduction

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THE quote that introduces this chapter underscores the central role that the problem of language acquisition has had throughout the history of generative grammar (see also chapters 10, 11, and 12). Chomsky felt it was appropriate to start his foundational paper 'Conditions on Transformations' (Chomsky 1973), the first systematic attempt to structure a theory of Universal Grammar, by highlighting the importance of the acquisition issue. A few years earlier the central role of acquisition had been expressed in an even more fundamental, if programmatic, way: a particular, technical specification of the intuitive notion of explanation, 'explanatory adequacy,' was linked to the acquisition issue. An analysis of a linguistic phenomenon was said to meet 'explanatory adequacy' when it came with a reasonable account of how the phenomenon is acquired by the language learner (Chomsky 1964).

In this chapter, I would like to first illustrate the technical notion of 'explanatory adequacy' in the context of the other forms of empirical adequacy envisaged in the history of generative grammar. I will then discuss the relevance of arguments from the poverty of the stimulus, which support the view that the adult knowledge of language cannot be achieved via unstructured procedures of induction and analogy recording and organizing knowledge in a *tabula* which is *rasa* initially (see also chapter 10). These (p. 98) arguments bear on the complexity of the task that every language learner successfully accomplishes, hence they define critical cases for evaluating the explanatory adequacy of a linguistic analysis. After illustrating the impact that parametric models had on the possibility of achieving explanatory adequacy over a large scale (see chapter 14), I will then address the role that explanatory adequacy plays in the context of the Minimalist Program, and the interplay that the concept has with the further explanation 'beyond explanatory adequacy' that minimalist analysis seeks. I will conclude with a brief discussion of the connections and possible tensions arising between explanatory adequacy and simplicity, an essential ingredient of the intuitive notion of explanation.

5.2 Observational, Descriptive, and Explanatory Adequacy

Chomsky (1964) distinguished three levels of empirical adequacy that a formal linguistic analysis can meet. Given a sample of linguistic data, a corpus of sentences that the linguist takes as a starting point for his description of the language, a fragment of generative grammar can meet:

1. Observational adequacy: the relevant fragment correctly generates the sentences observed in the corpus.
2. Descriptive adequacy: the relevant fragment correctly generates the sentences in the corpus, correctly captures the linguistic intuitions of the native speaker and

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'specifies the observed data ... in terms of significant generalizations that express underlying regularities in the language' (Chomsky 1964:63).

3. Explanatory adequacy: the relevant fragment reaches descriptive adequacy, and is selected by Universal Grammar over other alternative fragments also consistent with the observed corpus.

The distinction between observational and descriptive adequacy is related to the distinction between *weak* and *strong generative capacity*: weak generative capacity has to do with the generation of the right sequences of words; strong generative capacity deals with the generation of sequences of words with appropriate structural descriptions (see further on). For observational adequacy, it does not matter what structural description (if any) the fragment of grammar associates to each sentence: the only important thing is that it generates the right sequence of words, hence, in traditional terminology, is adequate in terms of weak generative capacity. In order to meet descriptive adequacy, on the other hand, the fragment of grammar must also assign to the sentence the correct structural descriptions, able to capture certain intuitions of the native speaker and express certain generalizations: it must be adequate also in terms of strong generative capacity. An example will immediately clarify the distinction. (p. 99)

Suppose we are building a grammar of English able to generate the following sentence among others:

(1) The boy will eat the apple.

And we try to do so with a grammar involving a very restrictive version of Merge (if the reader will excuse the little anachronism in terminology and formalism), call it X - YP Merge, which only permits merging a new word with a phrase, but not two phrases already formed. This grammar will be able to generate (1) with the following structural description, obtained by successively merging each word to the phrase already formed (*eat* and *the apple*, *will* and *eat the apple*, etc.):

(2) [the [boy [will [eat [the [apple]]]]]]

In terms of observational adequacy, our grammar does its job, as it generates the sequence of words in (1); but in terms of descriptive adequacy, it fails: it does not capture the fact that 'the boy' behaves as a unit with respect to a number of possible manipulations (movement, deletion, etc.), is interpreted as a unit by both interfaces (on the meaning side, it refers to an argument taking part in the event, and on the sound side it is treated as a unit in the assignment of the intonational contour), is perceived as an unbreakable unit, as shown by classical 'click' experiments (Fodor, Bever, and Garrett 1974) in experimental psycholinguistics, etc. In order to meet all these empirical constraints, we need a fragment of grammar capable of merging complete phrases (call it XP - YP Merge), hence able to assign (1) the correct representation (3):

(3) [[the [boy]]] [will [eat [the [apple]]]]

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The phrase *will eat the apple* is generated and placed in a temporary buffer; the phrase *the boy* is generated, and then the two phrases are merged together by XP – YP merge. So, the grammar endowed with XP – YP Merge is descriptively adequate, while the grammar endowed uniquely with X – YP Merge is not; on the other hand both are observationally adequate for the minute fragment of English that we are considering. Notice also that the two grammars may be equivalent in weak generative capacity, as they may generate the same sequence of words, but they are not equivalent in strong generative capacity, because the XP – YP Merge grammar can generate structural description (3), which the X – YP Merge grammar cannot.

Another important conceptual dichotomy that the distinction between observational and descriptive adequacy relates to is the dichotomy between E(xternal)-language and I(nternal)-language (see also chapter 3, section 3.5). An observationally adequate grammar describes an object of the external world, an E-language (or a fragment thereof): a sentence or a corpus of sentences. A descriptively adequate grammar describes a representational system internal to the speaker, an I-language: a generative function capable (p. 100) of generating an unbounded set of sentences and structural descriptions capturing basic generalizations of the language, for example, that the sequence determiner-noun patterns as a unit with respect to innumerable formal manipulations in English. So, the notion of observational adequacy is of very limited relevance, if any, for the study of language as a cognitive capacity in a context of cognitive science: the critical notion is descriptive adequacy, which concerns the empirical adequacy of a theory of the speaker-internal entity which is the object of inquiry: the representational system that every speaker possesses, and which allows him to produce and understand new sentences over an unbounded domain.

5.3 Explanatory Adequacy

Of an equally important cognitive significance is the distinction between descriptive and explanatory adequacy. While observational and descriptive adequacy express levels of empirical adequacy that a particular grammar can meet, explanatory adequacy has to do with the relation between a particular grammar and Universal Grammar (UG), the general system that limits the class of particular grammars. A particular descriptively adequate analysis meets explanatory adequacy when UG provides general principled reasons for choosing it over imaginable alternatives. Here too, an example will immediately illustrate the point. Given any Subject-Verb-Object structure, a priori three structural organizations can be envisaged:

(4) a. [S[V O]] b. [[SV] O] c. [SVO]

(4a) assumes a V-O constituent, which is merged with the subject; (4b) assumes an S-V constituent which is merged with the object, and (4c) assumes a flat, ternary structure. Every first year student in linguistics knows that the ‘Aristotelian’ structure (4a),

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expressing the subject–predicate relation, is the correct representation, as is shown by innumerable kinds of evidence. For instance, by the fact that the subject is systematically higher in the tree than the object: in technical terms, the subject asymmetrically c-commands the object.¹ An anaphor in object position can be bound by the (p. 101) subject, but not vice versa, and only (4a) expresses the empirically correct c-command relations:

- (5) a John saw himself.
b *Himself saw John.

A liberal enough UG (like most theories of phrase structure based on rewriting rules), consistent with the three representations in (4), would not offer any principled reason for selecting (4a), hence would not immediately meet explanatory adequacy here. A more restrictive theory of UG, restricted to generating binary branching structures with specifiers preceding complements (such as Kayne’s 1994 antisymmetric approach) would only be consistent with (4a), hence it would directly meet explanatory adequacy here.

The connection with acquisition becomes clear at this point. Consider the situation of a language learner who must acquire the phrase structure of his language, say English. If the learner is equipped with an ‘anything-goes’ UG, consistent *a priori* with (4a), (4b), and (4c), the choice cannot be made on principled grounds, and the learner must choose on the basis of the evidence available, the primary linguistic data. For instance, the fact of hearing (5a) already leads the learner to exclude (4b), which would be inconsistent with it (assuming here, for the sake of the argument, that the learner ‘knows’ independently that the antecedent must c-command the anaphor). But (5a) is consistent with both (4a) and (4c), hence excluding the latter is more tricky, particularly if the learner has no direct access to negative evidence (such as the information ‘(5b) is ungrammatical’). One cannot exclude, in this particular case, that other kinds of positive evidence may lead the child to choose the correct structure; but the fact is clear that the permissive UG does not offer any guidance for the choice: in the particular toy situation that we have envisaged, an analysis based on a permissive UG does not reach explanatory adequacy (this is particularly clear in ‘poverty of stimulus’ situations, on which see section 5.4).

In contrast, consider a restrictive UG endowed with binary branching constraints and ordering constraints of the kind ‘specifier precedes complement.’ A language learner endowed with such a restrictive UG automatically selects (4a) as the representation for transitive sentences, with correct consequences for the binding facts in (5) and for innumerable other cases. An analysis of such facts based on the restrictive UG thus meets explanatory adequacy. The language learner chooses representation (4a) because the system he is endowed with offers him no other choice.

Explanatory adequacy is thus intimately connected to the ‘fundamental empirical problem’ of language acquisition. Humans acquire a natural language early in life, without specific instruction, apparently in a non-intentional manner, with limited individual variation in spite of the fragmentary and individually variable courses of experience that ground individual knowledge of language. A restrictive theory of UG can

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thus offer (p. 102) a plausible account of the rapidity and relative uniformity of language acquisition: children endowed with a restrictive UG can converge quickly and efficiently on the adult grammar because they have only few options to choose from: the convergence can thus take place in the empirical conditions (of time and limited exposure to the data) which are observed in the study of actual language development (see also chapter 12).

5.4 On Poverty of Stimulus

The arguments for a restrictive UG are made particularly cogent in special situations, some of which have been illustrated and discussed in detail in the literature, the so-called 'poverty of stimulus' situations. In such situations the 'primary linguistic data,' the data available to the language learner, would be consistent with the postulation of a number of grammatical mechanisms over and above the ones that adult speakers seem to unerringly converge on. In such cases, it appears to be legitimate to attribute the choice of a particular mechanism to an internal pressure of the learning system, rather than to a data-driven induction (see chapters 10 and 11).

In order to acquire some concrete argumentative force, such arguments must typically envisage and compare two hypotheses, say A and B, both with some initial plausibility and appeal, and both plausibly consistent with the data available to the child: then, if it can be shown that B is always part of the adult linguistic knowledge, while A is systematically discarded, then it is legitimate to conclude that the selection of B by the learner must be based on some general principle that is part of the initial endowment of the mind.

One example that has very often been taken as an effective illustration of this situation, both in presentations of the issue and in critical appraisals, is the so-called 'structure dependency' of rules. In line with modern linguistic analysis, I would like to illustrate it in terms of the acquisition of particular constraints on movement, rather than in terms of the form of a particular construction-specific rule (as in the original discussion; see Chomsky 1968/1972/2006 for the original formulation and much recent discussion, in particular Crain et al. 2010, and Berwick et al. 2011; with responses to critiques of the argument in Lewis and Elman 2001, Reali and Christiansen 2005, and Perfors, Tenenbaum, and Regier 2006).

Consider familiar cases of subject-auxiliary inversion in English, characterizing questions and a few other constructions:

- (6) a The man is sick.
b Is the man sick?

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Informally, the relevant movement operation takes an occurrence of the copula (or of other functional verbs, auxiliaries, modals, etc.) and moves it to the front. Which occurrence of the copula is selected? In simple cases like (6) there is no choice to be made, but (p. 103) in more complex cases, some locality constraint is needed for choosing between alternatives. If two potential candidates are involved, the one that is closer to the front is selected, i.e., is_p in (7b), and the operation cannot take a ‘distant’ occurrence, such as is_q in (7c); put slightly differently, a distant occurrence of a certain kind of element, cannot ‘jump over’ an intervening occurrence, and the closer occurrence always wins:

- a. The man is_p aware that he is_q sick
(7) b. Is_p the man ____p aware that he is_q sick?
c. * Is_q the man is_p aware that he ____q sick?

The locality effect illustrated by (7) can be seen as a special case of a very general and natural intervention effect which can be captured by a formal principle roughly expressible in the following terms:

In a configuration like:

- (8) ... X... Z... Y ...
X cannot attract Y if there is a closer potential attractee Z that intervenes between X and Y.

(This formulation is something of a synthesis between Relativized Minimality, Rizzi 1990, and the Minimal Link Condition, Chomsky 1995b, etc.). So, (7c) is ruled out because in the source structure (7a) is_p (Z) intervenes between the clause-initial complementizer, the attractor (X), and is_q (Y):²

- (9)

C	The man	is_p	aware that he	is_q	sick
↑		*			
X		Z		Y	

How is ‘intervention’ calculated, here? A very simple idea that immediately comes to mind is that the calculation is performed linearly: so, is_p linearly intervenes in the sequence of words between C and is_q , so that the latter cannot be attracted to C:

- (10) Linear intervention: Z intervenes between X and Y when X precedes Z and Z precedes Y in the sequence of words.

(p. 104) This linear definition of intervention is very simple and seems to work for cases like (7), but clearly it does not express the ‘right’ concept of intervention for natural language syntax in general, as is shown by examples like the following (and innumerable others):

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- a. The man who is_p here is_q sick.
(11) b. $*Is_p$ the man who ____p here is_q sick?
c. Is_q the man who is_p here ____q sick?

Here is_p is closer to the front than is_q linearly (it is separated from the beginning of the sentence by three words vs. five), and still the 'distant' occurrence is_q is selected, as in (11c), and the linearly intervening is_p does not yield any intervention effect.

Why is that so? It appears that the notion of 'intervention' relevant for natural language syntax is hierarchical, expressed in terms of c-command, rather than linear precedence. For example:

- (12) Z intervenes between X and Y when X c-commands Z and Z c-commands Y.

If we think of the relevant structural representations, it is clear that is_p intervenes hierarchically between C and is_q in (7c), but not in (11c), where it is embedded within the relative clause, hence it does not c-command is_q :³

- (7') c $*Is_q$ [the man [is_p aware [that he ____q sick]]]?
(11') c Is_q [[the man [who is_p here]] ____q sick]?

(p. 105) Here comes the acquisition question. Adults unerringly opt for hierarchical intervention, as everybody has crystal-clear intuitions on such contrasts as (7c)–(11c) and the like. Moreover, as Crain and Nakayama (1987) showed, children at the age of three already sharply make such distinctions and unerringly opt for hierarchical formulations of rules and constraints. So, how does the child come to know that syntactic properties like intervention must be calculated hierarchically, not linearly? Most of the data available to the learner, that is, simple alternations like (6), are consistent with both linear and hierarchical analyses, and linear notions are immediately given by the input, while hierarchical notions require the construction of complex and abstract structures. So, why does the language learner unerringly opt for the complex hierarchical notions, the evidence for which is absent or at best very marginal in the primary data, and discard the much simpler linear notions?

The natural conclusion seems to be to attribute the choice of hierarchical notions to the inner structure of the mind, rather than to experience. Opting for hierarchical computations is not a property that the learner must figure out inductively from the primary data, but is an inherent necessity of his cognitive capacities for language: language, as a mental computational capacity, is designed in terms of mechanisms (such as Merge) producing hierarchical structures, so what the mind sees and uses in linguistic computations is hierarchical information. There is nothing to learn here: other notions, no matter how simple and plausible they may look, are discarded *a priori* by the language learner for linguistic computations.

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The structure dependency of movement rules is a classical case for the illustration of the poverty of stimulus arguments, but such cases are ubiquitous (see again chapter 10). To introduce a little variation on a classical theme, I will consider a second case, having to do with the interface between syntax and semantics: the constraints on coreference. Every speaker of English has intuitive knowledge of the fact that a pronoun and a noun phrase can corefer (refer to the same individual(s)) in some structural environments but not in others: for instance, in (13) and (15), but not in (14) and (16) (following standard practice, I express coreference by assigning the same index to the expressions to be interpreted as coreferential):

- (13) John_i thinks that he_i will win the race.
- (14) *He_i thinks that John_i will win the race.
- (15) John_i's opinion of his_i father is surprising.
- (16) *His_i opinion of John_i's father is surprising.

(14) and (16) are of course possible if the pronominal forms *he* and *his* refer to some other individual, Peter for instance, but coreference with John is barred (this is what the asterisk expresses in these cases). Clearly, speakers of English tacitly possess some procedure for the interpretation of pronouns that they can efficiently use to compute the network of possible coreference relations in new sentences. Again, a very simple (p. 106) possibility would refer to linear order (we define the generalization in negative terms, following Lasnik's insight, on which see further on in this section):

- (17) Coreference is impossible when the pronoun precedes the NP in the linear order (and possible otherwise).

This linear principle is quite plausible and reasonable, it would seem: first the NP must introduce a referent, and then a pronoun can refer to it. Nevertheless, there are good reasons, in this case too, to discard a linear characterization in favor of a hierarchical characterization. The linear formulation is falsified by innumerable examples of the following types, in which the pronominal element precedes the noun phrase, and still coreference is fine:

- (18) When he_i wins, John_i is very happy.
- (19) All the people who know him_i well say that John_i can win the race.
- (20) His_i father thinks that John_i can win the race.

C-command plays a critical role here as well; in fact, the relation was introduced by Tanya Reinhart (see Reinhart 1976) in connection with the issue of referential dependencies; the relevant empirical generalization was identified by Lasnik (1976):

- (21) Coreference is impossible when the pronoun c-commands the NP (and possible otherwise).

To illustrate this effect, in the following examples I have indicated by a pair of brackets the domain of c-command (or c-domain) of the pronoun:

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- (13') John thinks that [he will win the race].
- (14') *[He thinks that John will win the race].
- (15') John's opinion of [his father] is surprising.
- (16') *[His opinion of John's father] is surprising.
- (18') When [he wins], John is very happy.
- (19') All the people who [know him well] say that John can win the race.
- (20') [His father] thinks that John can win the race.

What singles out (14') and (16') is that only in these structures does *John* fall within the c-domain of the pronoun, regardless of linear ordering, a generalization that Lasnik's statement (21) correctly captures.

Let us now go back to the acquisition issue. The first question to ask is rather radical: why should the learner postulate a structurally-determined ban on coreference at (p. 107) all? Consider the evidence that learners have access to: they hear utterances containing pronouns corresponding to the sentence types in (13)–(20), and undoubtedly to innumerable others, for instance, 'John thinks he is sick,' sometimes with intended coreference, sometimes not (I am assuming that enough contextual information is available to the child to decide if coreference is intended or not in a number of actual utterances available to him), and that's all. As no negative information is directly provided to the learner (information of the type 'coreference is barred in this particular environment'), the positive evidence available to the child does not seem to offer any reason to postulate any ban on coreference. So, if induction and generalization from positive evidence were the only learning mechanism here, why wouldn't the language learner simply assume that coreference, patently a free option in some cases, is a free option in all cases?

The very fact that every adult speaker unerringly postulates a ban on coreference in particular structural environments is more likely to stem from some pressure internal to the learning system than from an induction from experience. Moreover, such an internal pressure must be quite specific to enforce a ban of a very particular structural form; the same question arises as in the case of movement rules: why does the learner always choose the hierarchical constraint (21) over the plausible and simpler linear constraint (17)? Again, this could hardly be determined on an inductive basis from the available evidence. So, the selection of (21) over (17) must be the consequence of some specific pressure internal to the learning system. Presumably, the inherently hierarchical nature of language is not just a property of the mental device generating structures: it is a property that pervades the mental representations of linguistic objects, and also deeply affects the interfaces with the interpretive systems.

This conclusion is forcefully confirmed by experimental results such as those reported in Crain (1991), which show that the child is sensitive to the hierarchical non-coreference effect as soon as the relevant experimentation can be conducted, i.e., around the age of three, or even before (see also Guasti and Chierchia 1999/2000 for relevant evidence).

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It should now be clear what conceptual link exists between the notion of explanatory adequacy and the arguments from the poverty of the stimulus. An analysis of the adult competence of the speaker of a given language reaches explanatory adequacy when the theory of UG is able to explain how that aspect is acquired by the language learner on the basis of the evidence available to him. Poverty of stimulus situations are cases in which the evidence available to the learner is insufficient to choose, over imaginable alternatives of some plausibility, one particular feature of the adult competence, for instance that locality constraints on movement and referential dependencies are computed on the basis of hierarchical, not linear, principles. In such cases, explanatory adequacy can be reached by assuming that the relevant feature follows from some pressure internal to the learning system, i.e., explanatory adequacy can be achieved by properly structuring the theory of UG. (p. 108)

5.5 Explanatory Adequacy, Invariance, and Variation

Can the level of explanatory adequacy be reached over a large scale? Natural languages involve invariant properties (linguistic universals) and properties that vary from language to language. The program of meeting explanatory adequacy in a systematic way thus requires plausible mechanisms for the acquisition of invariant and variable properties. If the knowledge of invariant properties may stem from the internal structure of UG, the acquisition of cross-linguistically variable properties inevitably involves the role of experience: the learner must figure out all sorts of language-specific properties, from the set of phonetic features with distinctive value, to the association of word forms with particular concepts, to morphological paradigms, properties of word order, etc. So, addressing the issue of explanatory adequacy over a large scale requires a full-fledged theory of language invariance and variation.

The theory of principles and parameters introduced such a comprehensive framework. Pre-parametric models, such as the Extended Standard Theory (EST) of the 1970s, were based on the concept of particular grammars, conceived of as systems of language-specific, construction-specific rules. A particular grammar, say the grammar of English or of Japanese, would be a system of rules specific to the particular language and giving a precise characterization of the language particular way in which various linguistic constructions were expressed. So, the grammar of English would have phrase structure rules for the NP, the VP, and so forth, and transformational rules for the interrogative, relative, passive construction, etc. Universal Grammar was conceived of as a grammatical metatheory, expressing the format for phrase structure and transformational rules, hence providing the basic ingredients from which the language particular rules could be built. UG would also provide some general constraints on rule application expressing island properties.

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Here is an illustrative example, taken from Baker (1978:102), an influential introductory textbook. English would have a transformational rule for passive with the following shape:

	Passive										
(22)	Structural description:	NP	-	Aux	-	V	-	NP	-	X	
		1		2		3		4		5	→
	Structural change:	4		2		be+en+3		0		5+by+1	

The rule would apply to a tree meeting the structural description of the rule (essentially, the tree corresponding to a transitive sentence), and would introduce a structural change consisting of the movement of the object to subject position, the demotion of the subject to a PP headed by *by*, and the insertion of the passive morphology. The grammar (p. 109) would include rules expressed in a similar format for raising, question and relative clause formation, topicalization, and so forth.

As I stressed at the outset, language acquisition was a crucial issue at the time of the EST model, and in fact this framework went with a theory of acquisition, at least programmatically. The assumption was that the language learner, equipped with the format of rules provided by UG, would figure out inductively, on the basis of experience, the particular rule system that constitutes the grammar of the language he is exposed to. The learner would thus implicitly act as a 'little linguist,' formulating hypotheses within the class of formal options permitted by UG, and testing them on the empirical ground provided by the primary data.

Among many other problems, this approach had to face a major obstacle concerning acquisition: no operative concept of 'rule induction' was introduced, so it remained unclear how the language learner could arrive at figuring out rules of the level of complexity of (22). Given this difficulty, the program of achieving explanatory adequacy over a large scale remained a distant goal.

Things changed rather dramatically, in this and other respects, with the introduction of Principles and Parameters model around the late 1970s. According to the new model (Chomsky 1981a), Universal Grammar has a much more substantive role than just functioning as a grammatical metatheory, and directly provides the basic scaffolding of every particular grammar. UG is a system of universal principles, and specifies a finite number of parameters, binary choice points expressing different options that individual languages may take. The ambitious program was to reduce all morphosyntactic variation to such primitive elements, the values that parameters can take at each choice point. The program turned out to have an exceptional heuristic value for comparative studies, and comparative syntax flourished in the following decade and afterward (see chapters 14 and 16 for further discussion and illustration).

What is more important in the context of this chapter is that the Principles and Parameters approach provided the tools for meeting explanatory adequacy on a systematic basis. Universal properties could be connected to the structure of principles of

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Universal Grammar, and the fixation of binary choice points on the basis of experience offered a promising device to account for the acquisition of variable properties. The fixation of a substantial number of parameters is by no means a trivial task because of the complex interactions that may arise, possible ambiguities of the primary data in relation to distinct patterns of fixation, and so forth, a complexity which has been highlighted by the computational modeling of parameter fixation (e.g., Gibson and Wexler 1994; see chapter 11). Nevertheless, the very fact that precise computational models could be built on that basis shows that the parametric approach to variation offered an operative device to concretely address the issue of the acquisition of grammatical systems.

Not surprisingly, the study of the development of syntax in the child received a major impulse from the introduction of parametric models: from the viewpoint of such models, the fundamental empirical question of the study of language development was to chart the temporal course of the process of parameter fixation, both experimentally and (p. 110) through the naturalistic study of production corpora (see Hyams' 1986 seminal proposal along these lines and, among many recent references, Rizzi 2006; Thornton 2008 for discussion of some corpus-based results, and Gervain et al. 2008; Franck et al. 2013 for experimental research bearing on the fixation of fundamental word order parameters).

5.6 Explanatory Adequacy and Further Explanation

A properly structured UG can provide a realistic account of how a particular language is acquired and hence meet 'explanatory adequacy' in the technical sense discussed in this chapter. But then the further question arises of what explains the structure of UG. Why are linguistic computations universally organized the way they are and not in some other imaginable way? Here the question of explanation is raised at a further level: the *explanandum* is not the particular grammar that the adult speaker has acquired, but the structure of UG, the nature and properties of the human language faculty.

The Principles and Parameters framework made it possible to achieve explanatory adequacy over a large range of phenomena; the Minimalist program has tried to ask the further explanatory question, going 'beyond explanatory adequacy,' in the technical sense (Chomsky 2004). What could be the 'further explanation' of the properties of UG? If UG is a biological entity, a kind of mental organ, one explanatory dimension of its properties must be evolutionary: much as it is reasonable to investigate the evolutionary history of the shape and structure of the liver, or of the eye, so it would make sense to trace back the structure of UG to its evolutionary roots. The study of the human language faculty in a biological setting can't avoid coming to terms with the evolutionary aspects.

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The strategy that the Minimalist Program has adopted to pursue explanation 'beyond explanatory adequacy' is to isolate the different factors that enter into the growth of language in the individual. Three factors are identified in Chomsky (2005) and subsequent work, as follows:

1. Task-specific genetic endowment, which 'interprets part of the environment as linguistic experience ... and which determines the general course of the development of the language faculty' (Chomsky 2005:6).
2. Experience.
3. Principles not specific to the language faculty.

The last category may include very diverse entities: principles of data analysis and organization proper to humans, higher mammals, or also to other forms of animal intelligence; principles of optimal computation, which may hold at different levels of generality for complex computational systems, within or outside the realm of cognitive (p. 111) systems (see chapter 6). So, the question about explanation 'beyond explanatory adequacy' can be asked of each factor.

As for the first factor, the further explanation is of an evolutionary kind, so it makes sense to try to identify the evolutionary events that gave rise, presumably quite recently in human phylogeny, to the particular neural circuitry that makes human language possible with its unique characteristics among animal communication systems. As for the second factor, the data that the learner has access to, this has to do with the external world and its historical contingencies, wars, migrations, sociocultural stratifications, and so forth. Hence, it is not directly part of the study of cognitive capacities.⁴

As for the third factor, it potentially breaks down into a vast array of subfactors that may be quite different in nature, so that the 'further explanation' may take very different shapes. Principles of data analysis not specific to language and not specific to humans, but presumably shared with different forms of animal intelligence, evoke an evolutionary explanation, presumably over a very long temporal course. As for principles of optimal computation (principles of economy, locality, conservation), they may also demand an evolutionary explanation, to the extent to which they are specific to computational systems implemented in the biological world; or else, they may instantiate 'natural laws' operative in computational systems in general, even outside the sphere of biology.

Needless to say, the very interesting questions raised by the attempt to distinguish first and third factor are extremely hard to state in scientifically satisfactory terms, hence they are at the border of current scientific inquiry on the topic (see again chapter 6).

The attempt to go beyond explanatory adequacy is a program of great intellectual fascination, and it is a merit of minimalism to have focused attention on such an ambitious goal for linguistic research. But the goal of achieving explanatory adequacy does not dissolve into finer goals and research questions in minimalist analysis. Rather, having an analytic apparatus capable of reaching explanatory adequacy over a large scale remains a necessary point of departure for asking minimalist questions. And poverty of

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stimulus arguments continue to underscore the role of inner constraints of the human mind, now broken down into different factors in determining a richly structured body of linguistic knowledge (see Berwick and Chomsky 2011).⁵

(p. 112) 5.7 Explanatory Adequacy and Simplicity

In a certain sense, the intuitive notion of explanation is closely linked to simplicity. A better explanation of a certain domain of empirical data is a simpler explanation, we choose between two hypotheses or two models of comparable empirical adequacy on simplicity grounds, etc. Also the technical notion of explanatory adequacy is traditionally linked to simplicity: in the pre-parametric EST models, it was assumed that the language learner chooses between different fragments of grammars compatible with the primary data through an 'evaluation metric' choosing the simplest fragment (where simplicity can be computed in terms of number of symbols, of rules, etc.). Nevertheless, explanatory adequacy is a level of empirical adequacy, not an *a priori* criterion. In certain cases, a tension may arise between the needs of explanatory adequacy and imaginable criteria of optimal simplicity. If we take 'simplicity' as corresponding to 'lack of structure,' i.e., an unstructured system is simpler than a more structured one, the tension is clear.

Consider again, in this connection, the issue of the choice of the correct structural representation of the Subject Verb Object sequence (or, in fact, of any configuration of three elements, specifier, head, and complement). A restrictive theory of Merge, limited to binary applications (hence, ensuring binary branching structures) constrains the choice to (4a) and (4b), ruling out (4c). If the theory is further supplied with a version of Kayne's (1994) Linear Correspondence Axiom (or any principle stating or deriving the compulsory linear order Specifier-Head), then (4a) is the only possible choice for any transitive sentence like *John loves Mary*. So, a language learner equipped with binary Merge and the Linear Correspondence Axiom (or equivalent) has no choice, the 'correct' structure is enforced by the shape of his cognitive system, a desirable result from the viewpoint of the needs of explanatory adequacy. Clearly, a system not specifying the LCA (or equivalent) is simpler than a system with the LCA. And arguably, a system not putting any binary constraint on Merge, hence permitting *n*-ary Merge, (p. 113) may be considered simpler than a system-limiting Merge to binary applications. Such unstructured systems could arguably be considered simpler than more structured systems; still, they clearly put a heavier burden on the language learner, implying that the choice between (4a), (4b), and (4c), all *a priori* possible, must be determined through data analysis, a step in the wrong direction from the perspective of aiming at explanatory adequacy.

In some such cases the tension may be genuine, in others it may stem from the ambiguity of the concept of 'simplicity.' For instance, in our case, if we do not take 'simpler' as meaning 'involving less structure,' but as 'involving fewer computational resources,' the binary Merge, yielding systematic binary branching may be taken as simpler than *n*-ary Merge, as the former involves at most two slots in operative memory, while the latter involves *n* slots. And perhaps partly analogous (if less straightforward) considerations can be made in connection with the LCA. So, it may well be that in some cases the apparent tension between explanatory adequacy and simplicity dissolves if we disentangle different

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facets of an ambiguous concept. In the following passage in 'Derivation by Phase' Chomsky highlights the subtle border between *a priori* concepts like good design and simplicity, and empirical discovery: 'Even the most extreme proponents of deductive reasoning from first principles, Descartes for example, held that experiment was critically necessary to discover which of the reasonable options was instantiated in the actual world' (Chomsky 2001:1-2). The example of simplicity as oscillating between 'lack of structure' and 'computational parsimony' illustrates the point. The first interpretation is in conceptual tension with the level of empirical success that goes under the name of 'explanatory adequacy,' while the second is fully congruent with it.

Notes:

(¹) I adopt here Chomsky's (2000b) definition of c-command:

(i) A c-commands B iff B is dominated by the sister node of A For example, in the following:

(ii) ...[A[x...B...]]

B is dominated by X, which is the sister node of A. So, A c-commands B, according to (i). The notion was originally introduced by Reinhart (1976), where the formal definition was slightly different.

(²) This analysis can be immediately generalized to cases not involving the copula: if in general C attracts T, the position expressing tense, the attraction must involve the closest occurrence of T; in other words, an intervening occurrence of T, whatever its morpholexical realization (as a copula, auxiliary, modal, or as simple verbal inflection) determines an intervention effect. It should be noticed here that in at least certain versions of Phase Theory (Chomsky 2001a), (9) is independently excluded by Phase Impenetrability because *is_q* is in a lower phase.

(³) The hierarchical definition (12) accounts for the lack of intervention effect in (11c), but it does not say anything on the impossibility of (11b). In fact in this case neither occurrence of *is* c-commands the other; therefore, no intervention effect is expected. In fact, the conclusion that (11b) is not ruled out by intervention is desirable, because it is excluded independently; the relative clause is an island, from which nothing can be extracted (Ross 1967 and much subsequent work). For instance, the locative *here* cannot be replaced by its interrogative counterpart *where* and questioned (we illustrate the phenomenon with an indirect question to avoid complications with inversion):

- ((i)) a The man who is here is sick
b* (I wonder) where [the man [who is ___]] is sick

So, the non-extractability of *is* in (11b) follows from the island character of the construction (Berwick and Chomsky 2011), and there is no need to appeal to intervention here (and no possibility, if intervention is hierarchically defined, as in (11)).

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On the other hand, in (7) the embedded complement clause is not a general island, as a *wh*-phrase is extractable from it:

((ii)) *How sick is the man aware that he is ___?*

So that intervention is relevant to rule out (7c) (but see note 2, this chapter, for a possible independent reason to rule out (7c)).

(⁴) Of course, the process through which the ‘input’ can become ‘intake,’ and the external data are integrated as ‘experience,’ is a cognitively relevant issue, presumably involving factors of the first and third kind.

(⁵) A terminological note may be in order here. Explanatory adequacy evokes UG, but how does the classical concept of UG relate to the factors mentioned in (23)? The decision of how the term ‘UG’ cuts the cake in (23) may seem to be an arbitrary terminological matter, but terminological choices may not be entirely neutral and inconsequential in the context of a rich intellectual history. One possible terminological choice is to restrict the term UG to solely refer to the first factor, species-specific, task-specific genetic endowment (this seems to be the choice made by mainstream minimalism; see also chapter 6). Another possible terminological choice is to go along the externalism/internalism dichotomy and keep the term UG for the initial state of the cognitive system including both first and third factors, which are both internal and constitutive factors of the mental computational system for language; this system can be coherently defined, along the internal/external dichotomy, in opposition to the external data, which the internal system takes as input and operates on. It seems to me that this second terminological choice still permits us to construe the concept of UG in a way consistent with the intellectual history of generative grammar, i.e., as ‘part of the innate schematism of mind that is applied to the data of experience’ and that ‘might reasonably be attributed to the organism itself as its contribution to the task of the acquisition of knowledge’ (Chomsky 1971).

The two terminological choices correspond, in essence, to what Hauser, Chomsky, and Fitch (2002) have called ‘faculty of language in a narrow/broad sense,’ the first identifying task-specific genetic endowment, the latter also including an array of non-task-specific properties and capacities, arising from a long evolutionary history and recruited for language at some point; analogously, one could think of a narrow and a broad characterization of UG, the latter including both task-specific and domain-general properties and principles that are operative in language, understood as a cognitive capacity. As the term UG has come, for better or worse, to be indissolubly linked to the core of the program of generative grammar, I think it is legitimate and desirable to use the term ‘UG in a broad sense’ (perhaps alongside the term ‘UG in a narrow sense’), so that much important research in the cognitive study of language won’t be improperly perceived as falling outside the program of generative grammar.

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