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Peris-Viñé, Luis Miguel

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# Actual Models of the Chomsky Grammar\*

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Luis M. Peris-Viñe<sup>†‡</sup>

## Abstract

We defend that there is a link between the mathematical *analytical models* (characteristic of the structural tradition) and the mathematical *synthetic models* (characteristic of the generative tradition) that is peculiar to Chomsky's grammar exposed in *The Logical Structure of Linguistic Theory*, **CHG**. To identify this link helps to identify the *objects* and the *task* of the grammars in **CHG** and also to detect some inadequacies in the exposition and conception underlying in **CHG** (related to the connection between levels of representations, the conception of the objects and the conception of transformational representation). In order to clarify these inadequacies, we defend that a grammar can be conceived as a theory that assigns the values of its notions to the sentences of a language, and we propose the following basic relational notions for **CHG**: *phrase structure*, *transformed structure*, *phonemic representation* and *phonetic representation*. By means of the structural metatheory, we define the *potential models* (after formulating the *typifications* and the *characterizations* of these notions) and the *actual models* of **CHG** (after formulating its *fundamental law*).

*Keywords*: philosophy of linguistics - Chomsky grammar - structural metatheory - representation levels

## Resumen

En este trabajo defendemos que existe un vínculo entre los modelos matemáticos *analíticos* (característicos de la tradición estructural) y los modelos matemáticos *sintéticos* (característicos de la tradición generativa) que es peculiar de la gramática de Chomsky expuesta en *The Logical Structure of Linguistic Theory*, **CHG**. Identificar ese vínculo ayuda a identificar los *objetos* y la *tarea* de las gramáticas en **CHG** y también a detectar algunas inadecuaciones en la exposición y en la concepción propia de **CHG** (relativas a la conexión entre niveles de representación, la concepción de los objetos y la concepción de la representación transformacional). Para clarificar estas inadecuaciones, defendemos que una gramática puede concebirse como una teoría que asigna los valores de sus nociones a las oraciones de un lenguaje, y proponemos las siguientes nociones relacionales básicas para **CHG**: *estructura sintagmática*, *estructura transformada*, *representación fonémica* y *representación fonética*. Mediante la metateoría estructuralista definimos los *modelos potenciales* (tras formular las *tipificaciones* y

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<sup>†</sup> Departamento de Filosofía I, Facultad de Filosofía y Letras, Universidad de Granada. To contact the author, please write to: perisv@ugr.es.

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las *caracterizaciones* de esas nociones) y los *modelos actuales* de **CHG** (tras formular su *ley fundamental*).

*Palabras clave:* filosofía de la lingüística - gramática de Chomsky - metateoría estructuralista - niveles de representación

## 0. Introduction

The foundation of *generative linguistics*, since their beginning in the fifties, has been dependent on the fulfillment of some patterns of *scientific theory*. In that foundation there are still questions unresolved in three domains: prior domain (mainly centered on their relationships with the *distributional grammar*), interior domain (mainly centered on the *criteria of internal change*) and global domain (mainly centered on their linking with the *natural sciences*). They are unresolved questions because they arose when certain assumptions were adopted in the sixties without justification. The main assumptions were: the incommensurability between generative grammar and distributional grammar, the mentalist conception of grammar as a theory of the mind, the innatist conception of acquisition of the language and the pretences of naturalization of linguistics. These assumptions actively continue today in the current developments of the generative linguistics around the minimalist program, and they underlie the most recent debates on the foundations of the discipline.<sup>1</sup> Only by understanding faithfully the developments of the fifties can we capture the *novelty* of such additional assumptions, and evaluate to what *degree* they have been successfully expedited and the *solidity* of the foundation that supports them. This period, between Chomsky's earliest writing up to 1965, constitutes a *critical stage* that incorporates crucial events to understand the relationships between generative linguistics and the structural trend of the time, the peculiarities of the posterior evolution of the generative linguistics in different versions and the peculiarities of linguistics as knowledge.

Our more general proposal is that, in order to understand these constituent aspects of generative linguistics and of linguistics as a scientific knowledge, a rigorous *metatheoretical analysis* of those first years of generative linguistics is necessary. The reconstruction from the philosophy of the science allows to obtain conclusions about different aspects of the foundation of the linguistic theories: the nature of their objects, the task that they develop, the type of notions used in that task, their intertheoretical relationships, etc. These considerations justify the interest in reconstructing the first theory of the generative trend.

We will analyze and reconstruct the essential parts of the theory exposed originally in Chomsky's *The Logical Structure of Linguistic Theory* (Chomsky 1955), that we will call *Chomsky Grammar*, **CHG**. This work is the temporal and conceptual base of the whole later generative transformational trend. In our proposals of log-

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<sup>1</sup> In the minimalist program it continues open, for example, the debate on the nature of the grammar's objects delineates the possibility that the computational systems can be sensitive to the conceptual-intentional systems and to the articulatory-perceptual systems.

ical reconstruction we use the tools of analysis provided by the structural conception of theories.<sup>2</sup> In **CHG** a grammar is configured as a hierarchical set of levels of representation for the sentences of a language, and therefore can be conceived as a theory that assigns to these sentences the structural representation obtained in those different levels. The hierarchy or connection proposed between the different representation levels can be formulated in terms of a fundamental law and thus allows us to identify the actual models of the theory.

## 1. Particular grammar and general theory

In **CHG** the distinction and relation between *grammar of a particular language* (*particular grammar*) and *general theory* is very important. A *particular grammar* purports to show the *structure* of the language, the final aim being to provide a specification and description of the grammatical utterances of the language. To achieve these objectives, various representation levels are organized. Thus a sentence token can be represented as a sequence of phonemes, also as a sequence of morphemes, words, and phrases. Therefore each sentence token will have associated with it a whole set of representations, each representation being its *spelling* in terms of elements of one linguistic level. The grammar of a language must state the structure of each grammatical utterance of the language on each linguistic level. These representations are such that they constitute a specification of the grammatical sentences of a language. Furthermore, a grammar is a scientific theory,

a complete scientific theory of a particular subject matter, and if given in precise enough form, a formalized theory. Any interesting scientific theory will seek to relate observable events by formulating general laws in terms of hypothetical constructs, and providing a demonstration that certain observable events follow as consequences of these laws. In a particular grammar, the observable events are that such and such is an utterance of the language, and the demonstration that this event is a consequence of the theory consists in stating the structure of this predicated utterance on each linguistic level, and showing that this structure conforms to the grammatical rules, or the laws, of the theory. The grammar thus gives a theory of these utterances in terms of such hypothetical constructs as the particular phonemes, words, phrases, etc. of the language in question. (Chomsky 1955, p. 77)

On the other hand, the *general theory* is the upholds theory in which these systems of representation are constructed and studied in an abstract manner, and the relations between them explicitly characterized, i.e., it is the abstract theory in which the basic concepts of grammar are developed, and by means of which each proposed grammar can be evaluated. Every grammar must be compatible with the general theory in the sense that the elements set up in the grammar must exhibit the general properties required by the theory. Particular grammars must be models of general theory and they must exemplify the general theory.

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<sup>2</sup> See Sneed (1971), Balzer, Moulines & Sneed (1987), Balzer & Moulines (1996) and Balzer, Moulines & Sneed (2000).

Chomsky (1955) includes an exposition of the *general theory* as well as a *particular grammar* of English. Our purpose in this paper is to reconstruct some fundamental aspects of the general theory of the CHG.<sup>3</sup>

## 2. Linguistic levels

A grammar is configured as a hierarchical set of representation levels for the sentences of a language. In section 2.1 we will present the *general characterization of linguistic levels* offered by Chomsky (1955), in section 2.2 we will investigate the existing connection between *representation levels* and *generative grammars*, and in section 2.3 we will summarize the *description of different levels* as carried out by Chomsky (1955).

### 2.1. General characterization of representation levels

In carrying out linguistic analysis, then, we must construct on each level  $\mathbf{L}$  a set of elements (which we will call “ $\mathbf{L}$ -markers”), one of which is assigned to each grammatical utterance. The  $\mathbf{L}$ -marker of a given utterance  $T$  must contain within it all information as to the structure of  $T$  on the level  $\mathbf{L}$ . (Chomsky 1955, p. 107)

The construction of  $\mathbf{L}$ -markers, that is to say, the construction of utterance representations in the level  $\mathbf{L}$ , is achieved departing from a *finite alphabet* of elements or *primes*:

Given two primes of  $\mathbf{L}$  we can form a new element of  $\mathbf{L}$  by an operation called “concatenation”, symbolized by the arch  $\wedge$  [...] In general, given two elements  $X$  and  $Y$  of  $\mathbf{L}$ , whether primes or not, we can form by concatenation new elements  $X\wedge Y$  and  $Y\wedge X$ , and concatenation is associative for such compound elements. The elements of the system  $\mathbf{L}$  will be called *strings* in  $\mathbf{L}$ . Every nonprime string has a unique spelling in terms of primes. It is convenient to assume that the system  $\mathbf{L}$  contains an *identity* element which when concatenated with any string  $X$  yields again the string  $X$ . We will call this element, which is unique on each level, the unit  $U$  of  $\mathbf{L}$ . (Chomsky 1955, pp. 105-106)

Thus, it becomes clear that a representation level is configured as a *concatenation algebra* (to be exact, as a type of algebra called *monoid*). But a linguistic level of representation is a concatenation algebra with certain peculiarities added:

In very general terms, then, a level  $\mathbf{L}$  is a system (...)  $\mathbf{L} = [L, \wedge, R_1, \dots, R_m, \mu, \Phi, \varphi_1, \dots, \varphi_n]$  where

- (i)  $\mathbf{L}$  is a concatenation algebra with  $\mathbf{L}$  its set of primes
- (ii)  $R_1, \dots, R_m$  are classes and relations defined within  $\mathbf{L}$ .  $R_1$  is the identity relation =
- (iii)  $\mu$  is a set of  $\mathbf{L}$ -markers—elements of some sort constructed in  $\mathbf{L}$
- (iv)  $\Phi$  is a mapping which, in particular, maps  $\mu$  into the set of grammatical utterances

<sup>3</sup> The reconstruction of a grammar for some particular language requires having a previous reconstruction of the general theory. See Peris-Viñé (2010) and Peris-Viñé (2011).

- (v)  $\varphi_1, \dots, \varphi_n$  express the relations between  $\mathbf{L}$  and other levels (Chomsky 1955, p. 108)

Given this general characterization, if we want to characterize a *particular level*  $\mathbf{L}$ , according to Chomsky (1955), we must describe the set  $\mathbf{L}$  of primes of  $\mathbf{L}$ , the set  $\mu^{\mathbf{L}}$  of  $\mathbf{L}$ -markers, the relations among elements of  $\mathbf{L}$ , the mapping  $\Phi^{\mathbf{L}}$  of  $\mathbf{L}$ -markers into grammatical utterances, and the conditions of compatibility relating  $\mathbf{L}$  to other levels.

One must distinguish between the primes of a level and the occurrences of these primes; the same prime can have more than one occurrence in an utterance. Relationships between level  $\mathbf{L}$  and other levels, mentioned in (v), can conveniently be described as mappings which associate elements of  $\mathbf{L}$  with elements of the other levels, and express the conditions of compatibility between levels;  $\Phi$ , one of the relations considered in (v), is a mapping that expresses a special relationship among levels. As far as *the manner of describing*  $\Phi$  it can be said that:

It is not necessary in general to describe the mapping  $\Phi$  as a mapping of  $\mathbf{L}$ -markers directly into grammatical utterances. If on some level  $\mathbf{L}'$  the mapping  $\Phi^{\mathbf{L}'}$  has been defined from  $\mathbf{L}'$ -markers to grammatical utterances, then  $\Phi^{\mathbf{L}}$  can be defined from  $\mathbf{L}$ -markers to  $\mathbf{L}'$ -markers. (Chomsky 1955, p. 107)

We propose to refer to these two manners of describing the mapping  $\Phi$  as *primitive description* and *derived description* respectively. In terms of the primitive description,  $\Phi^{\mathbf{L}}(\mathbf{X})$  designates the grammatical utterances whose representation in the level  $\mathbf{L}$  is the  $\mathbf{L}$ -marker  $\mathbf{X}$ . In terms of a derived description,  $\Phi^{\mathbf{L}'}(\mathbf{X})$  designates the  $\mathbf{L}'$ -marker that constitutes the representation in  $\mathbf{L}'$  of the sentences whose representation in  $\mathbf{L}$  is  $\mathbf{X}$ .<sup>4</sup> Chomsky (1955) alternates constantly between these two manners of describing the mapping  $\Phi$ , even using derived description in several degrees.

## 2.2. Representation levels and generative grammars

The specialized literature often states that a grammar consists of an organized set of representation levels. However, after a careful reading of Chomsky (1955) it becomes clear that, strictly speaking, representation levels and grammars are different things; that is to say, to define a grammar simply as a series of representation levels is not exact. To understand in what sense this is true, we will attempt to understand the position of Chomsky (1955), beginning with a distinction among types of *mathematical models* used in the study of the language.

This distinction is one that sets up the *analytical models* in opposition to the *synthetic* (or *generative*) *models*. It also reflects a difference in the perspective from which the structure of the language (or, more specifically, the structure of utterances or sentences of the language) is studied:

There are two fundamental types of models which are studied in algebraic linguistics: generative and analytic. Simplifying, we might say that within the fra-

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<sup>4</sup> This is fulfilled only if  $\mathbf{L}$  is not the phonetic level,  $\mathbf{Pn}$ ; since to markers of  $\mathbf{Pn}$  are always assigned utterances. That is to say, of  $\Phi^{\mathbf{Pn}}$  it is only possible to give a primitive description.

network of a generative model, the starting point is a certain grammar, while the object we study is the language generated by this grammar. An analytic model presents an inverse situation; here the starting point is a certain language, i.e., a certain collection of sentences, whereas the purpose of the study is to establish the structure of these sentences, their constitutive elements, and the relations among them within the framework of sentences. (Marcus 1967, p. vii)

In the structural trend the utterances of the language were the departure point, and an attempt was made to develop procedures to determine the structure of those utterances at different levels. The result was grammars conceived as *representation systems* that assign representations to utterances. This indicates that the models developed in the structural trend were analytical models. A grammar as a representation system (an analytical grammar) is formulated as an algebraic system. But from the perspective initiated by Chomsky (1955) the objective is to *derive utterances*.<sup>5</sup> In this way, grammars are conceived as *generation systems*. This indicates that the models developed in the generative transformational trend were synthetic models. A grammar as a system of generation (generative grammar) is formulated as a set of rules.

From this we can deduce that a generative grammar (formulated as a set of rules) must express the information about the utterances that the corresponding analytical grammar (formulated as an algebraic system) provides. We can say that in Chomsky (1955) a generative grammar is conceived as being associated with a corresponding analytical grammar.<sup>6</sup> Thus it is understood that the purpose of Chomsky (1955) will be to show the close connection that exists between the representation levels and the (generative) grammars:

For each linguistic level, we show how the information about utterances provided on this level can be presented as a sequence of conversions, and how the underlying algebra (i.e., the structure of the level) can be reconstructed from the sequence of conversions [...]. Then, given a corpus, we can construct a set of compatible levels, each with the proper internal structure, and such that the correlated sequence of conversions produce the corpus (along with much else). (Chomsky 1955, pp. 67-68)

In other words, given an utterance and the representation that an analytical grammar assigns to it, it should be possible to build a derivation of the utterance from the corresponding generative grammar; a derivation that furthermore expresses the information contained in the representation that the analytical grammar assigned to the utterance.

Bearing in mind this correspondence between an *analytical grammar* (formulated as a set of algebraic systems) and a *generative grammar* (formulated as a set of conversions or generation rules), we will understand the exact meaning of the idea of a *grammar* organized in *representation levels*.

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<sup>5</sup> Or *sentences*, as will be said in the subsequent development of the generative grammar (see below section 3).

<sup>6</sup> This is an additional feature of the dependency on the structural tradition displayed by the first proposals of Chomsky.

This correspondence between analytical grammars and generative grammars enables Chomsky (1955) to study certain aspects of representation systems starting from the corresponding generative grammars. It especially permits him to detect some of the deficiencies of representation systems belonging to the structural tradition, particularly the deficiencies whose solution requires the introduction of a new representation level, the transformational level. When the advantages of introducing such transformational rules in a grammar were recognized, the type of grammar that was standard up until then was proved to be inadequate. This led Chomsky (1955) to characterize the representation level corresponding to this new type of rules, the transformational representation level.

### 2.3. Description of particular levels

We will now try to summarize the description of the different representation levels that Chomsky (1955) offers in order to have a reference for our reconstruction of **CHG**. Another objective of this description is to point out the links between the *algebraic structure* of each level and the *generative rules* that produce the corpus; that is to say, the links between *analytical grammar* and *generative grammar* expressed in Chomsky (1955) (see above section 2.2).

The set of primes in the *LEVEL P OF PHRASE STRUCTURE* is a finite and nonempty set that will include, for English, such representations of strings of words as *Sentence* (S), *Noun Phrase* (NP), *Verb Phrase* (VP), *Noun* (N), *Verb* (V), etc., as well as elements corresponding to individual words and the grammatically functioning morphemes (as morphological heads and syntactically functioning affixes), as *John*, *ing*, components expressing agreement in number. For other languages, this level will also include components expressing gender agreement.<sup>7</sup> Within this level the relation  $\rho$  among the strings formed from the set of primes is defined, and it is irreflexive, asymmetrical, transitive and nonconnected.<sup>8</sup>  $\rho$  is the *relation of representation* (that is to say, it is read ‘represents to’), and it is the relation maintained, for example, between *Sentence* and *NP^VP*, between *Sentence* and *John^came^home*, between *NP^VP* and *John^came^home*. Thus, we will say that *Sentence* represents to *NP^VP*,  $\rho(\textit{Sentence}, \textit{NP}^{\textit{VP}})$ ; etc. There will be a set of strings  $X$  such that for no  $Y$ ,  $\rho(X, Y)$ , that is to say, a set of strings that do not represent any other string. Chomsky designates  $\bar{P}$  to this set.  $\bar{P}$  will have strings that correspond to non grammatical strings of words and strings that correspond to some grammatical strings of words. The strings of  $\bar{P}$  that correspond to grammatical strings of words will be called *terminal strings*.  $Gr(P)$  will be the set of these strings, the grammatical strings in  $\bar{P}$ . *Sentence*, S, is the only prime such that  $\rho(S, Y)$  for all string  $Y \in Gr(P)$ . That is, S is the only prime that represents every grammatical string. The structure of the grammatical utterances on the level P, that is, the structure of strings of  $Gr(P)$ , is expressed by P-markers. The P-marker as-

<sup>7</sup> See Chomsky (1955), p. 172.

<sup>8</sup> Note that  $\rho$  is one of the relations  $R_1, \dots, R_n$  mentioned in the general level characterization (see above section 2.1).



signed to a sentence will carry all the information about the constituent structure of this sentence. A **P**-marker can be defined as a certain set of strings that represents a terminal string associated with the sentence, and gives an analysis of a properly parenthesized expression, where each parenthesized part is represented by a prime that states what sort of constituent it is.<sup>9</sup> The representation that from the level **P** is assigned to utterances will be obtained in a generative grammar through the application of *phrase structure rules*. The description of  $\Phi^P$  oscillates between what we have called *primitive description* and *derived description*. The derived description of  $\Phi^P$  takes place in several degrees, that is to say, recurring to different representation levels lower than **P**, to levels that even Chomsky has considered on occasions to be embedded at the level of phrase structure. For different reasons provided by Chomsky 1955,  $\Phi^P$  cannot be reformulated as a sequence of rules similar to those which permit the derivation of terminal strings, but rather must be reformulated as a *compound transformation*. That is to say, the reformulation of  $\Phi^P$  in terms of a generative grammar can be accomplished only by *transformational rules*, in the *TRANSFORMATIONAL LEVEL T*.

The rules of  $\Phi^P$  are not the only transformational rules of a generative grammar. The transformational rules of  $\Phi^P$  must be applied to generate any utterance of language, they are *obligatory transformations*. To generate certain utterances some *optional transformations* are applied.

The set of strings which do result from  $Gr(P)$  by application of  $\Phi^P$  we call the *kernel* of the language, and we require that all other grammatical string of words be derived ultimately from kernel strings (more correctly, from the strings in  $Gr(P)$  which underlie kernel strings) by grammatical transformations. (Chomsky 1955, p. 402)<sup>10</sup>

In any case, whether we apply only the transformational rules of  $\Phi^P$  or other transformational rules, we will obtain what Chomsky (1955) calls a *string of words*. Each *transformation T* converts a string with phrase structure into a string with a derived phrase structure, that is, operates on a string  $Z$  with the constituent interpretation  $K$ , which may or may not be a **P**-marker, and converts it into a new string  $Z'$  with the derived interpretation  $K'$ . Chomsky (1955) denote ' $T(Z, K)$ ' to  $Z'$ . In general, Chomsky (1955) considers as a **T**-marker any string  $S_1 \wedge S_2 \wedge \dots \wedge S_m$  where  $S_1 = Z_1 \wedge K_1 \wedge T_1$  and each  $S_i$  is either  $T_i$  or is  $Z_i \wedge K_i \wedge T_i$ . For Chomsky, the manner of representing the sentences of a language is very different accord-

<sup>9</sup> See Chomsky (1955), pp. 69-70. In Chomsky (1955) a **P**-marker can be considered as a set of strings or as a parenthesized expression; that is, as the set of representations that integrate the derivation that concludes in the terminal string corresponding the sentence in question, or as an expression in which the class of constituents to which the elements of the terminal string belong are indicated by brackets and labels. These ideas about what a **P**-marker is are compatible if we understand that a **P**-marker (conceived as a set of representations) is similar to a box of immediate constituents, and that if we crush that box, incrusting the smaller compartments into the bigger ones, the outcome will be the parenthesized equivalent expression.

<sup>10</sup> If we keep in mind that, in some cases, certain (optional) transformations that do not belong to  $\Phi^P$  can be applied before some transformations of  $\Phi^P$ , then we can say that when all the transformations applied belong to  $\Phi^P$  and not to  $\Phi^T$ ,  $\Phi^P$  that is to say, when all the transformations are obligatory, the outcome is a kernel string (see Peris-Viñe 2011).

ing to whether we do it from the transformational level or from any other. If, in terms of previous levels, we can represent each sentence as a string of phonemes, words, syntactic categories, and, in various ways, as string of phrases, now in **T** level we will be able to represent a sentence as a sequence of operations by which this sentence is derived from the kernel of basic sentences, each such sequence of operations corresponding to a **T**-marker.<sup>11</sup> That is to say, the representation of sentences from the transformational level would consist of an indication of *what to do* to obtain a certain structure (specifically, to obtain what Chomsky calls a string of words), while from other levels the representation of sentences consists of an indication of *their structure*. As a consequence of this perspective on the representation in level **T**, Chomsky must consider as primes of this level all that appears in such indications of how to obtain the string of words corresponding to a sentence. Things include transformational rules, compound transformations (in particular,  $\Phi^P$ ), **P**-markers, strings of words and morphemes belonging to  $\bar{P}$  and also any set of these strings.<sup>12</sup>

Once transformational rules have been applied, the representation of the sentence in question can be established in terms of phonemes. However, the assignment of the phonemic representation of sentences is expressed from the **LEVEL W OF WORDS**, more exactly through the mapping  $\Phi^W$ , which is a specification of the phonemic shape of words. For Chomsky (1955)  $\Phi^W$  will be a single-valued mapping of words and strings of words into strings of phonemes. If  $X$  and  $Y$  are strings in **W**, then  $\Phi^W(X \wedge Y) = \Phi^W(X) \wedge \Phi^W(Y)$ . That is to say, given the strings of words  $X$  and  $Y$ , the phonemic representation that the grammar will assign to the string  $X \wedge Y$  will be equal to the string that results from concatenating the phonemic representation of  $X$  with the phonemic representation of  $Y$ . The assignment  $\Phi^W$  effected in the level **W**, in a generative grammar can be given by a sequence of statements of the form  $X \rightarrow Y$ , so that derivations of phonemic sequences from word sequences can be constructed. The primes that appear in these rules will be words, morphemes, morphophonemes and phonemes. Note that Chomsky (1955) calls this level 'level **W** of words'. However, as we can appreciate, representations in terms of words are not obtained from this level, but phonemic representations. Something similar occurs with levels **Pm** and **Pn**, in which the values of the assignment do not belong to these levels. This contrasts with, for example, the level **P** of phrase structure from which the representation of sentences in terms of phrase structure is obtained.

The phonetic representation of sentences is obtained from the **PHONEMIC LEVEL Pm**. In this level  $\Phi^{Pm}$  carries strings of phonemes into strings of phones and is single-valued, that is, the reading of a phonemic representation must be unambiguous. For Chomsky (1955) the mapping  $\Phi^{Pm}$  assigns a physical content to the symbols of the phonemic alphabet. If  $X$  and  $Y$  are strings in **Pm**, then

<sup>11</sup> See Chomsky (1955), p. 306.

<sup>12</sup> See below section 4.2 for our critical commentaries regarding this perspective adopted by Chomsky (1955) about the nature of the transformational representation and his conception about the output of the transformational component as mere strings of words.

$\Phi^{Pm}(X^{\wedge}Y) = \Phi^{Pm}(X)^{\wedge}\Phi^{Pm}(Y)$ . That is to say, given the phonemic representations  $X$  and  $Y$ , the phonetic representation that the grammar will assign to the  $X^{\wedge}Y$  string will be equal to the string that results from concatenating the phonetic representation of  $X$  with the phonetic representation of  $Y$ . The assignment that  $\Phi^{Pm}$  fulfils can be obtained in a generative grammar through rules of a certain type that rewrite phonemes in phones depending on the context. The physical content of phonemic representations is provided by the phonetic level.

The *PHONETIC LEVEL P<sub>n</sub>* is the lowest level of representation and provides a physical description of phones. The primes of this level are phonetic symbols, and with each of them is associated a certain set of  $S$  of defining physical properties. This level is taken as an *absolute* level, fixed and available for all linguistic description. According to Chomsky (1955) the level **P<sub>n</sub>** relates phonetic representations with those utterance tokens which are represented by them. To be more specific:

if  $X$  is a string of phones, then “ $\Phi^{Pn}(X)$ ” will designate the set of utterance tokens which are represented by  $X$  on the level **P<sub>n</sub>**. [...] Thus  $\Phi^p$  gives a specification of strings in **P<sub>n</sub>** in terms of certain physical properties associated with the alphabet  $P_n$ . A string  $X$  in **P<sub>n</sub>** may represent (by  $\Phi^{Pn}$ ) utterances of the corpus [...] or it may represent grammatical or nongrammatical utterances which do not happen to be in the corpus. (Chomsky 1955, pp. 158-159)

That is to say, in this level representations would not be assigned but rather sets of utterances. If a generative grammar must reformulate the assignment of representations accomplished by the mappings of the different levels by way of rules, then, a question emerges immediately: what are the rules by which the mapping  $\Phi^{Pn}$  is reformulated in a generative grammar? The reading of Chomsky (1955) does not allow us to imagine what such rules would be (see below section 4.2).

In general, in **CHG**, the linguistic analysis formulated in terms of representation levels is reproduced through different types of rules. This linguistic analysis begins by considering a corpus of utterance tokens upon which conformity has been defined by the paired utterance test. This test

gives us a classification of utterance tokens into utterance types. To apply this test we must have an initial segmentation of the corpus into sentence tokens. These sentence tokens are further segmented into discrete units which may be called *phone tokens*. We might extend the primitive notion of conformity to cover all sequences of one or more phone tokens, deriving the notion of phone type and phone sequence type. [...] The next step in the development of linguistic theory is the definition of the notion *phoneme* [...]. The development of a system of phonemic representation does not conclude the process of linguistic analysis. We also want to discover the morphemes, words, and phrases of the language, and to determine principles of sentence construction that could hardly be stated directly in terms of phonemes. (Chomsky 1955, pp. 98-99)

Now then, this entire *analysis process*, which starts with the identification of phones (as minimal acoustic units of the phonetic description), should be reproduced in the *generation process* of sentences, but in the inverse order. The steps of this process are:

(i) Derive a terminal string from *Sentence* by the first part of the sequence of conversions. From this derivation, we can reconstruct uniquely the **P**-marker of this string. (ii) Select a **T**-marker and apply it to the terminal string with the given phrase structure. If the **T**-marker is just  $\Phi^p$ , we have a kernel string; otherwise, a transform. In either case, we have a string of words. (iii) Derive a string of phones from this string of words by the remaining conversions. From this derivation we can reconstruct the lower-level representations of the derived string. (Chomsky 1955, pp. 73-74)

### 3. Domain of objects and the task of the grammar

In this section we will try to specify what the objects of a grammar are and the characteristic task or action a grammar carries out on such objects. It is evident that both problems are closely connected; furthermore, the response given to these problems will radically condition basic aspects of our logical reconstruction of **CHG**, for instance, the form of the fundamental law proposed. In Chomsky (1955) we do not always find an explicit response to such problems. Thus, on some occasions, it seems that the objects of the grammar are *sentences*, while at others it seems that they are *utterances* and on still other occasions it seems that they are certain *representational structures*. On the other hand, sometimes it seems that Chomsky (1955) defends that grammars effect a *representational task* (assigning representations to objects) but sometimes it seems that what is defended is that the peculiarity of grammars is a *generative task* (assigning sentences to their representations). To begin to handle these problems we will depart from the existing connection between *representation levels* and *generative grammars* (see above sections 2.2 and 2.3).

Which is the task that characterizes a grammar? As we have seen in section 2.2 the task that an analytical grammar accomplishes is one of representational character, i.e., the objective is to represent utterances. Furthermore, Chomsky (1955) proposes generative grammars as a means to express the type of information that was already expressed by analytical grammars and to detect their deficiencies; therefore we could accept that the basic objective of a *generative grammar* and of an *analytical grammar* is the same: to *represent utterances of a language*, to assign to utterances their representation, even though this assignment is carried out (or is expressed) through a generation process. Therefore, if the task is fundamentally of representational character, then the objects cannot be the representations, but those entities to which the representations are assigned.<sup>13</sup>

What are the objects to which the grammar assigns representations? Chomsky (1955) uses indistinctly the terms *utterance* and *sentence* for designating the objects of the grammar. Also he speaks of *sentence tokens* and *utterance tokens* without establishing differences. As he uses both terms (*grammatical utterance* and *grammatical sentence*) we can infer that both *utterances* and *sentences* can be either

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<sup>13</sup> Some aspects of the description of mappings  $\Phi$  effected by Chomsky (1955) could lead us erroneously to think that the objects of **CHG** are representations.

grammatical or not. It is possible that this use, apparently equivocal, was coherent with the general use of those terms in the fifties. According to Harris (1951), Chomsky's teacher, an utterance is any stretch of talk, by one person, before and after which there is silence on the part of the person, and sentences are utterances which satisfy certain *structural formulae* (or sequence of categories). In any case, after an unbiased reading of Chomsky (1955), we would have to assign to **CHG** the following theses:

*T1* The objects of a grammar are sentences

*T2* The objects of a grammar are utterances

*T3* Utterances and sentences are objects of the same type

Somebody can consider *T2* to be coherent with the structural tradition. But neither *T2* nor *T3* is coherent with the subsequent development of the transformational generative trend that Chomsky (1955) begins: in this trend, a sentence is not a stretch of talk, a sentence does not consume time, it is not a physical object or event; the objects of grammars are sentences, not utterances. That is to say, in the subsequent development of the generative transformational trend, *T1* is maintained but *T2* and *T3* are rejected: we should not confuse utterances with sentences; an utterance can express more than one sentence, or exactly one sentence, or only a part of a sentence; furthermore, the same sentence can be expressed by many utterances.

A reconstruction of **CHG** could be limited to verifying the initial coexistence of two types of objects. But this is not our intention, since we believe that in Chomsky (1955) there are elements that would have permitted its author to reject theses *T2* and *T3*, as indeed happened thereafter. Our reconstruction, at this point, intends to emphasize those elements that reconcile **CHG** with its future. Those elements are none other than the new methods of representation assignment proposed in Chomsky (1955): the generative rules. The change proposed in the procedures of representation assignment (*generative grammars* versus *analytical grammars*) should have been accompanied by a change in the type of objects of those representations (*sentences* versus *utterances*). *New methods* are incompatible with *old objects*: the generation and representation of all utterances of a language is an impossible objective and theoretically uninteresting; while the generation and representation of all the sentences of a language is a possible and interesting objective. We can say that the new (generative) methods could have expressly promoted the constitution of new objects (sentences) in Chomsky (1955), which is precisely what happened in the subsequent development of the generative transformational trend. This incoherence of Chomsky (1955) with its underlying assumptions should not prevent us from considering that the actual objects of **CHG** are sentences and not utterances; otherwise its principal and effective contributions to linguistics would not be understood. In fact the objects of **CHG** cannot be utterances. Accordingly, in our reconstruction of **CHG**, the term *sentence* is a primitive term that designates the *objects* that integrate the *domain* of a grammar, and the grammar of a language is a theory of the set *L* of *sentences* of that language.

But there are different conceptions about what constitutes a sentence. What notion of *sentence* is used in **CHG**? In Chomsky (1955) a sentence is a string of signs, an entity that we can build and obtain by mathematical tools. These mathematical tools are employed in the construction of a derivation of the sentence. That is to say, to conceive a sentence as a string of signs is coherent with assigning to grammar a generative task: a grammar generates sentences-as-strings. But against this notion of sentence-as-string we can argue that a sentence of a natural language is not a string of signs; a sentence is somewhat more than that, although it is difficult to specify, it is an abstract object. This is sometimes forgotten, like when a grammar is equated with an automaton. Automata (examples of generative grammars) generate the sentences of the language for which they have been conceived, sentences that, because they belong to an *artificial* language, can be considered strings of signs. But the grammar of a *natural* language does not generate sentences of this language (since sentences are not things that can be generated). What a grammar generates are certain strings of signs associated with sentences and used as representation of these sentences. Therefore, to reject the notion of sentence-as-string is coherent with the rejection of the view that the task of a grammar is to generate sentences. At the same time, a conception according to which the task of a grammar is to represent sentences is coherent with a notion of sentences not as mere strings of signs. We conclude saying that the task of a grammar is to represent sentences of a language, for which it generates representations-as-strings.

As we have already indicated, in relation to the terms *utterance* and *sentence*, Chomsky's line of thought underwent an evolution: utterances stopped being considered objects of the grammar and that role was performed only by sentences. This change concerning objects was accompanied by a corresponding change concerning his global perspective on language. If we keep in mind that analytical models depart from objects in order to be able to formulate their grammar, while synthetic models depart from the formulation of the grammar in order to derive objects, it is understandable that in the *analytical models* (characteristic of the structural tradition) the objects in question will not be sentences-as-strings (they will be utterances), while in the *synthetic models* (characteristic of the generative tradition) the objects in question will be sentences-as-strings. The structural (empirical) linguist *finds utterances* (concrete physical objects) while the generative (mathematical) linguist *derives sentences-as-strings* of signs. Chomsky ended a first and short period in which he considered that utterances as well as sentences-as-strings were objects of the grammar (which prompted him perhaps to make his interest in analytical models compatible with his interest in synthetic models), and proceeded to a second and extended period in which he was interested only in synthetic models (which prompted him to maintain that the objects of a grammar are sentences-as-strings).

The *representational character of the task of a grammar* (analytical as well as generative) is similar to the one we can identify in other theories, especially in the natural sciences. That is to say, it is normal for scientific theories to be conceived

as procedures which assign values of certain notions to their objects. Those values represent or interpret basic aspects of objects of the theory, and they will be used to express regularities with which the theory is concerned. The basic notions of a theory are relations (and in some cases functions). This analysis has been shown to be useful and fruitful in approaching theories belonging to various fields and we believe that it can also be applied successfully to linguistics and especially to **CHG**. Thus, one of the basic assumptions of our reconstruction of **CHG** is that its structure can be reflected adequately by conceiving it as a theory that assigns to its *objects* the values of certain notions, i.e., its *basic notions*. The basic notions of **CHG** express its representational character. Therefore, as an important step in our reconstruction, we should specify the basic notions of **CHG** and the values assigned.

## 4. Basic notions

According to Chomsky, a grammar is a theory of the *sentences* of a language, and it can be conceived as a procedure to assign different *grammatical representations* to those sentences. This permits us to analyze the **CHG** as a theory that assigns values of certain basic notions (grammatical representations) to objects of its domain (sentences). Chomsky (1955) examines different representations and different representation levels wherein such representations are administered. In order to identify the basic notions of **CHG** and establish their structure, we will analyze the sometimes confused account of Chomsky (1955) about the organization of representations levels and its conception of transformational representation.

In the representation levels considered in **CHG** certain mappings  $\Phi$  occupy a fundamental position. But the basic notions of **CHG** are not directly expressed by the mappings  $\Phi$ . The mappings  $\Phi$  assign sentences to **L**-markers and they are elements of the (*algebraic*) *formulation context*. The mappings  $\Phi$  do not formulate the task of a grammar, which we already saw to be of representational character. On the other hand, basic notions of the grammar, which, as we have already said, must perform a representational task, are elements of the *linguistic analysis context*. The basic notions assign **L**-markers to sentences.

### 4.1. Identification and nature of basic notions

What are the basic notions of **CHG**? We can obtain the answer to this question by examining Chomsky's (1955) way of organizing the representational levels of a grammar (see above section 2.3). The conduct of Chomsky (1955) seems to be guided, in part, by a *maxim* about when to build a *representation* and when to characterize a *representation level*. We will call 1-1M (*one-representation-one-level maxim*) to this hypothetical maxim. 1-1M consists of *two paths*:

**1-r** PATH: if there is a grammatical *representation level* from which some representation is assigned, then we will be able to build a *representation* (through a set of *rules* that generate it)

**r-l PATH:** if there is a *representation* (generated through a *set of rules*), then we will be able to characterize a *representation level* from which to assign said representation.

Chomsky (1955) seems to be acting under this maxim when, having identified a certain transformational representation, insists that with reference to this representation it is possible to configure a representation level similar to other levels of the grammar. A consequence that we would expect from this maxim is that between the representations assigned in the linguistic analysis and the representation levels that formulate this assignment there must be a certain *correspondence*. Such a correspondence that, for example, if the representation *r* is formulated in the level **R**, then **R** will assign the representation *r* to sentences. We will soon see if this correspondence is manifested or not in the account of Chomsky (1955). Bearing in mind 1-1M, let us pay special attention to how Chomsky (1955) organizes levels of the grammar.

Since we can represent sentences of a language specifying their *phrase structure*, we will be able, according to the **r-l** path of 1-1M, to characterize the phrase structure level **P**. Transformational rules are applied to the *phrase structure* of a sentence in order to build the sentences' representation that Chomsky (1955) calls *string of words*; our author considers that the *sequence of transformational rules* applied is also a representation for sentences; then, continuing the **r-l** path of 1-1M we can speak of the transformational level **T** and of the level **W** of words. However, curiously, the representation *string of words* is not assigned from the level **W** of words (in the manner that happens in the level **P** of phrase structure) but from the transformational level **T**. Could it be that the level **W** of words lacks representation to assign? Not so, since the **l-r** path of 1-1M guarantees its existence and that of rules that generate it. Therefore what is then the representation that is assigned in the level **W** of words? Chomsky (1955) responds that in the level **W** of words *phonemic representations* are assigned. We find that this level is not designated according to the representation that it generates (as happens in the level **P** of phrase structure) but rather according to the representation assignable from another level (the transformational level **T**). Now that there are *phonemic representations*, we can characterize the phonemic level **Pm** following the **r-l** path of 1-1M. But, according to Chomsky (1955), *phonemic representations* are not assigned from this level (as happens in the level **P** of phrase structure) since, as we have seen, such representations are assigned in the level **W** of words. What representation is assigned in the phonemic level **Pm**, and whose existence (together with the existence of rules that generate it) is guaranteed by the **l-r** path of 1-1M? Chomsky (1955) responds that in the phonemic level **Pm** *phonetic representations* are assigned. Again, just as occurred in the level **W** of words, this level is designated not according to the representation that it generates (as happens in the level **P** of phrase structure) but with respect to the representation assignable from another level (the level **W** of words). Now we have *phonetic representations*, so if we continue with the **r-l** path of 1-1M we will be able to characterize the phonetic level **Pn**. But we can already see that



*phonetic representations* are not assigned at this level, since these are assigned at the phonemic level **Pm**. Once again, as occurred in the level **W** of words and at the phonemic level **Pm**, this level is designated considering not the representation that it generates but rather the representation assignable at another level (the phonemic level **Pm**). But what representation does this level assign and what are the rules that generate that representation? since the **l-r** path of 1-1M guarantees the existence of both of these. Perhaps this representation level assigns some type of representation to objects of the domain of the grammar? The answer is no. This level of *representation* would simply assign the objects themselves (*sentences* or *utterances*; see above section 3). But what are the rules that *generate* objects?

This short analysis of the exposition of Chomsky (1955) helps us identify certain erroneous consequences or features of his proposal for the organization of representation levels in a grammar: one of the representations would include rules; certain levels would not assign the corresponding representation; in the transformational level **T** two representations would be assigned; the representation phonetic level **Pn** would not assign representation, but rather sentences. We believe that these erroneous consequences do not proceed from the 1-1M maxim, but from other assumptions or factors that interact with it, and mainly of Chomsky's (1955) *conception of the nature of transformational representation*.<sup>14</sup>

## 4.2. The nature of transformational representations

According to **CHG**'s conception of the nature of transformational representation, one of the representations that the grammar assigns to sentences from the transformational level is integrated by (*transformational*) *rules* and by certain *structures* to which those rules are applied. But we believe that rules in a grammar should be conceived as auxiliary or as formal procedures, originating from a previous theory more basic than the grammar of a language, namely the *general rules theory*, **GRUT** (see below section 8.1). The role of rules in a grammar is similar to that fulfilled by arithmetic operations and set theory operations (or even certain experimental procedures) in theories of other disciplines, particularly those operations which are employed to formulate (*fundamental* or *special*) laws and not to characterize the range of basic notions of theories. We must distinguish between the values that basic notions assign and the (auxiliary) procedures through which those values are obtained, calculated or reconstructed. This difference is basic in analyzing the structure of any theory and is also exemplified perfectly in **CHG**: the difference in question is the one that exists between the representation assigned to sentences from different levels, on the one hand, and, on the other, conversions, rules and transformations that are the means used by a grammar to reconstruct those representations assigned to sentences. Furthermore, this difference is present in Chomsky (1955) at all levels except at level **T**.

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<sup>14</sup> Some of those factors are the fluctuation between *representations* and *sentences* as the objects for grammar, the influence of the study of *artificial languages*, and the persistence of *utterances* as objects of the grammar. These assumptions were considered in detail in Peris-Viñé (1996), being shown how they produce those consequences.

Chomsky's position leads him to consider such heterogeneous items as *transformations*, *compound transformations*, *strings*, *sets of strings* as primes of the level **T**. Thus, while in levels other than **T** the **L**-markers are strings (with structure) of signs belonging to basic vocabularies, according to Chomsky's (1955) conception, the **T**-markers would end up being indications of what operations one must perform and on what particular structured sign strings. We believe that the values of basic notions of a theory are not integrated by the auxiliary procedures used to obtain the values of the notions of such a theory. What is more, the practice of grammarians in their linguistic analysis corroborates this view. Grammarians do not stop their linguistic analysis when they have indicated what transformational rules one must apply, but rather they apply them and consider that the result of that application is what represents the sentence in question.

We think that what results after applying transformational rules cannot be conceived as a mere string of words, but as a string of words with a characteristic structure. If each transformation converts a string with phrase structure into a string with derived phrase structure, as Chomsky (1955) asserts, then the output of the transformational level can be conceived as the derived phrase structures obtained after the last applied transformation. We will designate these structures *transformed structures*. Chomsky (1955) himself does not seem so distant from this interpretation when he says that one must provide *derived constituent structure* to the results of the application of transformations<sup>15</sup> or when he says that the string of words obtained by transformations "has a constituent structure by virtue of the fact that transformations impose a derived interpretation on the strings which they yield." (Chomsky 1955, p. 409) Furthermore, usually, the structure obtained from level **P**, i.e., the structure on which different transformations begin to be applied, is very different from the structure obtained from level **T**; this last structure cannot be obtained through phrase structure rules, since within it are found a certain order, a certain hierarchy and even certain morphological items that only can be introduced at the level **T**. In other words, what results from applying transformations constitutes a different representation of sentences, and therefore the grammar must offer a concept which reflects that difference. Consequently, our proposal is that the result of applying transformational rules should be considered to be a *structured grammatical string of words* (what we have called *transformed structure*) rather than a mere *string of words*.

In our reconstruction of **CHG** we will now move away from the exposition of Chomsky (1955) and try to reflect on the practice of a grammarian working in the sphere of transformational generative grammar for linguistic analysis. In the presence of a sentence, this grammarian would apply phrase structure rules and obtain the *phrase structure* of the sentence, upon which he/she would apply transformational rules and obtain a *structured string of words*, upon which he/she would apply phonemic rules and obtain a *phonemic representation*, upon which, finally, he/she would apply phonetic rules and obtain a *phonetic representation*. To conclude

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<sup>15</sup> See Chomsky (1955), pp. 320-321, and Sections 86 and 87.

in summary, we propose the following as basic notions of **CHG**: *phrase structure*, *transformed structure*, *phonemic representation* and *(acoustic) phonetic representation*; and we will use the letters  $p$ ,  $t$ ,  $f$  and  $\alpha$  respectively to refer to these notions.<sup>16</sup>

We will now try to indicate the structure of each one of these notions, prior to which we argue that, besides the particular conclusions on the reconstruction of the **CHG** that we have been able to make up until now, our analysis also permits the formulation of a general conclusion that affects the reconstruction of any theory: to adequately reconstruct the structure of a theory not only must one attend to expositions of that theory but also to practical situations in which the theory is applied. In other words, it is desirable to listen to what grammarians say that they do, but it is also necessary to watch what they do.<sup>17</sup>

## 5. Base sets

A grammar is a theory that assigns the values of certain *notions* (corresponding to various representation levels) to sentences of a language. *Grammatical* sentences of the language will be only those sentences that can be described by the grammar for this language. But what is the structure of such notions? Some aspects of the response to this question have already been advanced, but for a complete response we must establish the *typification* corresponding to each one of the basic notions of **CHG**.

From a mathematical point of view, basic notions of theories are usually *relations*. A relation, also from a mathematical and extensional point of view, is conceived as a *set*. On the other hand the conceptual structure of a basic notion is expressed indicating how the corresponding set is built from certain base sets. Technically, the conceptual structure of a notion is expressed formulating the *typification* for that notion:

Intuitively, a typification is a statement expressing that some given set  $R$  has a definite set-theoretic type over other, given, sets,  $D_1, \dots, D_k$ . Such an indication of the set-theoretic type is necessary for the relations of functions occurring in a theory, for otherwise one could not know what kinds of arguments the function takes or the relation applies to. (Balzer, Moulines & Sneed 1987, p. 6)<sup>18</sup>

It is clear that the formulation of typifications for a theory is of great importance in the definition of models of that theory.

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<sup>16</sup> In Chomsky (1955) other levels are studied, such as the level of words, the level of morphemes and the level of syntactic categories, but its effective proposal of grammatical description is formulated by levels corresponding to the four notions mentioned above. To be more exact, one must say that the level of words and the level of morphemes are considered to be embedded into the level of phrase structure, and that the latter is intended to remedy the inadequacy of the analysis of grammaticality provided by the level of syntactic categories.

<sup>17</sup> Certainly, this is neither a surprising nor a daring recommendation. What is surprising is that there are those who dare to describe the structure and function of grammars without taking that recommendation into account. Metalinguistic analysis can constitute a valuable contribution to analyzed linguistic theories. So, the reconstruction of a theory may not only be contrary to some metalinguistic analysis performed by linguists; it can even alter certain aspects of the formulation of the linguistic theory itself.

<sup>18</sup> See Bourbaki (1970), Ch. IV, Sec. 1.

The typification of basic notions of a theory is established from certain sets called *base sets*; some of these are *principal base sets* and others are *auxiliary base sets*. The auxiliary base sets are normally those sets to which elements that constitute values of basic notions of a theory belong. Therefore they are available prior to the configuration of such notions. For example, purely mathematical sets such as the *set of natural numbers* or the *set of real numbers* are sets of this type corresponding to certain physics theories. On the other hand, the principal base sets of a theory make up the *domains* or sets of *objects* of the theory.

According to our section 3, notions of **CHG** are configured starting from a principal base set—the *set L of sentences* of a language—and from several auxiliary base sets. To understand what the auxiliary base sets of **CHG** are we should bear in mind the description of the representation levels of the grammar proposed by Chomsky (1955) (see above section 2). In each one of those levels there was a procedure to build certain strings that were used to represent sentences. To be more exact, the starting points were an *alphabet of primes* (or primitive symbols) for each level and also an operation of *concatenation*. The strings formed by concatenating primes of the alphabet for a particular level and/or by concatenating compound elements are the elements for this level. Some of these strings may represent the structure of sentences on this level; these strings form the set of **L**-markers for each level **L** and they are the values that the basic notion corresponding to that level can assign to sentences.<sup>19</sup> In other words, not every *string* of primes is a marker; that is, it is not necessarily a representation of some sentence. In abstract construction of linguistic theory we must determine what sort of elements appear as markers on each level.<sup>20</sup> To do so, the general linguistic theory would have to specify certain (*linguistic*) *conditions of formation* that the strings should fulfill in order to be considered representations of sentences. Having done this, the auxiliary base sets for basic notions of **CHG** will be *sets of possible representations*: the *set of possible phrase structures*,  $\mathbb{P}$ ; the *set of possible transformed structures*,  $\mathbb{T}$ ; the *set of possible phonemic representations*,  $\mathbb{F}$ ; and the *set of possible phonetic representations*,  $\mathbb{A}$ . Additionally we will make use of the set  $\mathbb{N}$  of natural numbers. The sets  $\mathbb{P}$ ,  $\mathbb{T}$ ,  $\mathbb{F}$ ,  $\mathbb{A}$ , and  $\mathbb{N}$  are the auxiliary base sets for **CHG**, and the values of its basic notions belong to the first four sets.

We consider establishing alphabets, formulating conditions of concatenation and specifying (as far as possible) the content of sets of possible representations to be a *previous and auxiliary task* with regards to the task of assigning representations to sentences that **CHG** accomplishes. This auxiliary task is clearly accomplished by the *general linguistic theory*, or to be exact, with a portion of the general

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<sup>19</sup> We consider that, to a sentence *s*, the notion *p* assigns the string in  $\text{Gr}(P)$  (the grammatical terminal string) corresponding to *s* along with the **P**-marker of that string. Or we can simply consider that the **P**-markers themselves already contain the corresponding string of  $\text{Gr}(P)$ , as Chomsky seems to when he says that “Each **P**-marker is a set of strings in **P**-containing exactly one *lowest level* string of  $\text{Gr}(P)$ ” (Chomsky 1955, p. 205). In any case the **P**-markers are not merely strings but sets of strings, and therefore, to be more exact, we would have to incorporate set-theory procedures in addition to procedures of concatenation to specify the **L**-markers.

<sup>20</sup> See Chomsky (1955), p. 107.

linguistic theory we call the *general representations theory*, **GRET**. The characterization of auxiliary base sets sought by **GRET** is not complete, it is only a partial characterization. Specifically, the intention is not to determine each and every one of the linguistic conditions of formation. In fact, Chomsky (1955) does not offer a complete list of such conditions. Furthermore these conditions can be determined only progressively during the application of the grammar.

## 6. Typifications and characterizations

Typifications and characterizations state the structure of notions of a theory and also express additional properties. The general procedure to establish typifications and characterizations consists of indicating for each basic notion  $R$  of a theory the set to which the set corresponding to  $R$  belongs.<sup>21</sup> This is achieved by indicating the operations of set-theory that are applied on base sets  $D_1, \dots, D_k$  of the theory in question. The operations used are: *projection*, *cartesian product* and *power set*; these operations can be applied repeatedly and in combination with each other. The result will indicate the conceptual structure of  $R$ . In this section we will specify the typifications and characterizations of basic notions of **CHG**.<sup>22</sup>

For each notion  $R$ , operations that should be applied on base sets  $D_1, \dots, D_k$  are indicated through several *schemes* (*schemes of type of base  $k$* , in short, *types of base  $k$* , or simply  *$k$ -types*). A  $k$ -type is a rule used to build a set of that type from the sets  $D_1, \dots, D_k$ ; if  $\sigma$  is a  $k$ -type,  $\sigma(D_1, \dots, D_k)$  will be that set. Such sets are designated *echelon sets*. As we have said, there are six base sets of **CHG**, therefore for this theory the number  $k$  is 6.  $L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}$  and  $\mathbb{N}$  will be echelon sets of 6-type for **CHG**. But there are more. What is the complete range of echelon sets that express the type of set-theoretical entity corresponding to the basic notions of **CHG**? For an answer to this question we will begin by making two important assumptions: the first is that the notion  $p$  takes elements of the sets  $L$  and  $\mathbb{N}$  as its arguments, and the second is that  $p$  and  $t$  are ternary relations and  $f$  and  $\alpha$  are binary relations. Later on we will justify both assumptions. Given the aforementioned, these echelon sets would be the following:

- (1)  $Pot((\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_6\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle) \times \pi_2\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$   
 $Pot((\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_2\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle) \times \pi_3\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$   
 $Pot(\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_4\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$   
 $Pot(\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_5\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$

Thus, given echelon sets of (1), typifications of basic notions of **CHG** would be the following:

- (2)  $F_1: p \in Pot((\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_6\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle) \times \pi_2\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$   
 $F_2: t \in Pot((\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_2\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle) \times \pi_3\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$

<sup>21</sup> See Balzer, Moulines & Sneed (1987), pp. 7-8, and Moulines (1991), p. 228.

<sup>22</sup> The different steps of this general procedure are applied with detail in Peris-Viñé (1996) to obtain the typifications and the characterizations of **CHG**.

$$F_3: f \in \text{Pot}(\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_4\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$$

$$F_4: \alpha \in \text{Pot}(\pi_1\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle \times \pi_5\langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N} \rangle)$$

But establishing typifications of basic notions of a theory is not the same as thoroughly establishing the conceptual structure of such notions. Supplementary information on the structure of basic notions is articulated through expressions of a more generic nature designated *characterizations* and usually are included in the definition of potential models of theories. A characterization expresses no connection at all among relational notions, though it can express some connection among base sets. For this reason, *typifications* will be a subset of characterizations. Characterizations that are not typifications usually indicate certain formal or mathematical properties of base sets or of relations. In our case, characterizations will indicate if notions of **CHG** must be reconstructed as functions or as relations.

## 7. Potential models

In this section we justify our assumptions about typifications, as well as determine if the basic notions of **CHG** are functions or not. Results will later be expressed in the definition of the set of potential models of **CHG**.

We begin by considering the notions *phonemic representation*,  $f$ , and *phonetic representation*,  $\alpha$ . According to Chomsky (1955), the projection that assigns phonemic representations and the projection that assigns phonetic representations are *single-valued*: the first of these projections is the one designated  $\Phi^W$ , while the second is the one designated  $\Phi^{Pm}$ .  $\Phi^W$  is a single-valued mapping of words and strings of words into strings of phonemes, and  $\Phi^{Pm}$  carries strings of phonemes into strings of phones. Now then, we should take into account that the mappings  $\Phi^W$  and  $\Phi^{Pm}$  found in Chomsky (1955) do not represent notions  $f$  and  $\alpha$ , therefore we cannot say that these two notions are functions simply because  $\Phi^W$  and  $\Phi^{Pm}$  are functions. However, since for each sentence there is only one string of words, and since  $\Phi^W$  and  $\Phi^{Pm}$  are functions, there will be only one phonemic representation and one phonetic representation for each sentence. That is to say, the notions *phonemic representation* and *phonetic representation* will have the structure of a function. This feature of both notions will be expressed through one of the aforementioned characterizations.

We will now consider the notions *phrase structure*,  $p$ , and *transformed structure*,  $t$ . The issue of whether these notions of **CHG** are functions or simply relations can be handled by investigating the way in which the grammar assigns the values of those notions in cases of constructional homonymity.<sup>23</sup> The existence of such cases of constructional homonymity or structural ambiguity could make, in

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<sup>23</sup>“We have a case of constructional homonymity on the level **L** when the mapping **M** assigns two or more **L**-markers to a single utterance. This utterance then falls in the overlap of two distinct patterns, and, if our theory is adequate, such utterances should be, intuitively, cases of structural ambiguity” (Chomsky 1955, p. 108).

theory, the structure of affected notions be that of a *relation* and not that of a *function*.

In level **P** constructional homonymity will be produced when several **P**-markers are assigned to a given string in  $\text{Gr}(P)$ ; that is, if the notion  $p$  assigns more than one value to the same sentence. Let us look at some examples of such sentences:

- (3) 1. *I saw many old men and women*  
 2. *They are flying planes*  
 3. *Flying planes can be dangerous*

These sentences can be represented from the level **P** in two different ways. Such differences are shown partially in the following structures:

- (4) 1.a *I saw many [old men] and [women]*  
 1.b *I saw many [old [men and women]]*  
 2.a 

[They]	are	[flying planes]
NP	are	NP

  
 2.b 

[They]	[are flying]	[planes]
NP	Verb	NP

  
 3.a 

[Flying]	[planes]	can be dangerous
Adj	N	
NP	NP	

  
 3.b 

[Flying]	[planes]	can be dangerous
Verb	N	
NP	NP	

The grammar must account for these cases by assigning two (or more) representations on the level **P** to the same sentence. Therefore, if the basic notion  $p$  must express this representation assignment, one could consider that the relation  $p$  assigns elements of  $\mathbb{P}$  to elements of  $L$  and that it is not a function. In (1), we assumed that  $p$  takes as arguments elements from both  $L$  and  $\mathbb{N}$ ; now we will try to justify that assumption.

It is true that a sentence can have more than one *phrase structure*, but in each case we can find out how many there are and what they are, and also derive them through the grammar. That is to say, we cannot always speak of *the* phrase structure of the sentence  $s$ , but we can always speak of *the first*, *the second* (etc.) phrase structure of the sentence  $s$ . Something similar occurs with the notion *force* in classic particle mechanics: we cannot speak of *the* force that acts on a particle, since more than one force can act on a particle according to that theory, but we can speak of *the  $i$ -th* force that acts on a particle. Nevertheless we said that *force* is a function. For the same reason we will speak of “the  $i$ -th phrase structure of sentence  $s$ ” and we will consider that  $p$  is a function that takes two arguments: one element of  $L$  and one element of  $\mathbb{N}$  greater than 0. This is the reason for our assumption about  $p$  of (1) and (2).

The consideration of cases of constructional homonymity in the level **T** by Chomsky (1955) has the general purpose of arguing in favor of a syntactic analy-





transformation PASSIVE would also be applied. This analysis, which certainly accounts for the ambiguity of (5), has the consequence that two values of  $p$  are assigned to (5): one is (6) itself and the other is a structure like (7) on which the PASSIVE transformation can be applied.

(7) [the new methods] [ed] [frighten] [John]  
 $NP_1$   $VP_A$   $V_T$   $NP_2$

Another result is that (5) will have two transformed structures: one which is very similar to (6), since it would be obtained by applying only obligatory transformations, and another (8), which results after applying the optional PASSIVE transformation to (7) amongst other transformations.<sup>24</sup>

(8) [John] [ed] be en [frighten] by [the new methods]  
 $NP_2$   $VP_A$   $V_T$   $NP_1$

From this last statement, one could conclude that the notion  $t$  cannot be reconstructed as a function. However, this conclusion would be rash. This is because the fact that a sentence has more than one transformed structure does not prevent the reconstruction of the notion  $t$  as a function. This reconstruction can be obtained if we assign transformed structures not to sentences alone, but rather to pairs formed by a sentence and a phrase structure. That justifies our proposal of typification of  $t$  expressed in  $F_2$  of (2). We would be presented with a case akin to the notion *velocity* in certain physical theories, wherein multiple values of that notion correspond to the same *particle*. However, this does not prevent the reconstruction of this notion as a function, specifically as a function dependent on *time*. Hence the notion *velocity* does assign a single value to each pair formed by a particle and a temporal instant. A close consideration of the examples of constructional homonymity analyzed in Chomsky (1955) finds no case in which more than one transformed structure is assigned to the same pair formed by a sentence and a phrase structure.

This provides the following typifications of the basic notions of CHG (once the operations  $\pi_i$  of (2) are carried out):

- (9)  $F_1: p \in Pot((L \times \mathbb{N}) \times \mathbb{P})$
- $F_2: t \in Pot((L \times \mathbb{P}) \times \mathbb{T})$
- $F_3: f \in Pot(L \times \mathbb{F})$
- $F_4: \alpha \in Pot(L \times \mathbb{A})$

This permits us finally to define the potential models of CHG, wherein we express the characterizations of the relational notions of that theory including its typifications:

- (10)  $x$  is a potential Chomsky Grammar ( $x \in \mathbf{M}_p(\text{CHG})$ ) iff there exist  $L, p, t, f, \alpha$ , such that

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<sup>24</sup> Notice that the values of  $p$  are deeper syntactic representations of  $s$  that the syntactic representations of  $s$  offered by the values of  $t$ . This shows that in 1955 there were already antecedents of the notion *deep structure* developed in the sixties. And that therefore the main requirement to develop the semantics starting from the sixties, a *deep level of syntactic representation*, was already present in the fifties.

- 1)  $x = \langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N}, p, t, f, \alpha \rangle$
- 2)  $L$  is a numerable and non empty set
- 3)  $p: L \times \mathbb{N} \rightarrow \mathbb{P}$
- 4)  $t: L \times \mathbb{P} \rightarrow \mathbb{T}$
- 5)  $f: L \rightarrow \mathbb{F}$
- 6)  $\alpha: L \rightarrow \mathbb{A}$

## 8. The fundamental law

The definition of actual models of a theory is accomplished by formulating the most basic connection among the values of the different notions of the theory upon which its proponents agree. This connection is summarized in the denominated *fundamental law* of the theory. The fundamental law of **CHG** must formalize the correlation between the representations at each level of sentences of a language, representations which are the values that basic notions of **CHG** assign to sentences. Our purpose in this section is to formulate the fundamental law of **CHG** and define actual models of **CHG**.

### 8.1. Previous auxiliary notions: rules and derivations

The fundamental law of **CHG** is formulated using some *previous auxiliary notions*, such as the notion *rule* and the notion *derivation*. These notions fulfill in **CHG** a role like the role of the notions *sum*, *multiplication*, *derivative*, *integral*, etc. in some physics theories. Therefore the definition of these auxiliary notions for **CHG** is not a task to accomplish from **CHG** itself, but from a theoretical and conceptual previous ambit to **CHG**, which we design the *general rules theory*, **GRUT**. This would be a second theory, together with the *general representations theory*, **GRET**, which is auxiliary and previous to **CHG**. **CHG** uses the notions *rule* and *derivation* but it does not define them. Rules and derivations are the typical procedures that a generative grammar uses to express the assignation of representations to sentences that was accomplished from an analytical grammar conceived as an algebraic system (see above section 2.2).

Representations of sentences can be obtained through the application of certain rules (see above section 2.3). A rule is an operation that assigns one string to another string, both strings being formed using the alphabets provided by the **GRET**, i.e., using the sets of primes of each level. This demonstrates a point of contact between **GRUT** and **GRET**. In fact, we use four notions of rules to formulate the fundamental law of **CHG**, one for each level of representation. Thus, the **GRET** defines the **P**-rules (rules of the phrase structure level), **T**-rules (rules of the transformational level), **F**-rules (rules of the phonemic level) and **A**-rules (rules of the acoustic phonetic level). The definition of these rules is accomplished using procedures of the field of *formal grammars*. **P**-rules, **F**-rules and **A**-rules are basically of the same type, while **T**-rules are of a different type. The first three are of the type *rewrite X as Y*, where  $X$  and  $Y$  are strings, and they establish

the relation *it follows from* between representations integrated in derivations constructed at different levels. More explicitly, the relation of representation  $\Delta$  defined in the level **P** can be expressed in terms of the notion *rule*. A **P**-rule assigns a string of elements of its alphabet to one element of this alphabet. An **F**-rule assigns a string of phonemes to a string of morphemes. An **A**-rule assigns a string of phones to a string of phonemes. As for the **T**-rules, what they do is to assign a parenthesized terminal string of morphological heads and syntactically functioning affixes to another string of this sort. Some elementary transformations are known as *deformation*, *permutation*, or *adjunction*.

Besides defining these four types of rules, the **GRUT** defines certain *conditions for each type of rule*, conditions relating to the order of rules, to the repeated application and recursive use of certain rules, to the obligatory or optional character of some rules, to possible combinations of elementary operations that make up the transformational rules and so on. In general, the different conditions will be expressed in a language made up of resources derived from set theory and from formal grammars. In this way, **GRUT** defines **P**-conditions for **P**-rules, **T**-conditions for **T**-rules, **F**-conditions for **F**-rules and **A**-conditions for **A**-rules. In our reconstruction:  $C^P(P)$  will mean that the **P**-rules of the set **P** satisfy different **P**-conditions  $c_1, \dots, c_n$ ;  $C^T(T)$  will mean that the **T**-rules of the set **T** satisfy different **T**-conditions  $c_1, \dots, c_n$ ;  $C^F(F)$  will mean that the **F**-rules of the set **F** satisfy different **F**-conditions  $c_1, \dots, c_n$ ;  $C^A(A)$  will mean that the **A**-rules of the set **A** satisfy different **A**-conditions  $c_1, \dots, c_n$ . We can define these predicates in the following way:

- (11)  $C^P(P)$  iff  $\forall r \in P \exists c_1, \dots, c_n \in \mathbf{P}\text{-conditions: P-rules } (r) \wedge c_i(r)$   
 $C^T(T)$  iff  $\forall r \in T \exists c_1, \dots, c_n \in \mathbf{T}\text{-conditions: T-rules } (r) \wedge c_i(r)$   
 $C^F(F)$  iff  $\forall r \in F \exists c_1, \dots, c_n \in \mathbf{F}\text{-conditions: F-rules } (r) \wedge c_i(r)$   
 $C^A(A)$  iff  $\forall r \in A \exists c_1, \dots, c_n \in \mathbf{A}\text{-conditions: A-rules } (r) \wedge c_i(r)$

These conditions are specified in the reconstruction of specific applications of the net of specializations corresponding to the particular grammars.

Representations that a generative grammar assigns to sentences of a language are obtained from certain *sequences of strings* built through the application of rules of the grammar. These sequences of strings are called derivations. Strings integrated in derivations are those strings that **GRET** permits us to build from alphabets of primes; that is, **GRUT** makes use of objects provided by **GRET**, this being another point of contact between the two theories. A derivation is a sequence of representations  $\langle R_1, \dots, R_n \rangle$  so that for each  $i$  ( $1 \leq i < n$ ),  $R_{i+1}$  follows from  $R_i$  by one rule, and where  $R_1$  is the representation *Sentence*,  $R_n$  is an (acoustic and articulatory) phonetic spelling, and  $R_2, \dots, R_{n-1}$  are intermediate representations. It can therefore be said that  $\langle R_1, \dots, R_n \rangle$  is a derivation of  $R_n$ . Nevertheless, we can delimit different portions of a derivation, those portions corresponding to different representation levels; thus **GRUT** can define one type of (partial) derivation for each type of rule: **P**-derivations for **P**-rules, **T**-derivations for **T**-rules, **F**-derivations for **F**-rules and **A**-derivations for **A**-rules.

In our reconstruction:  $\Delta^P[S]$  denotes the string derived from the prime *Sentence* by rules of the set  $P$  of **P**-rules;  $\Delta^T[p]$  denotes the string derived from the string  $p$  by rules of the set  $T$  of **T**-rules;  $\Delta^F[t]$  denotes the string derived from the string  $t$  by rules of the set  $F$  of **F**-rules;  $\Delta^A[f]$  denotes the string derived from the string  $f$  by rules of the set  $A$  of **A**-rules. Strings so denoted are those that Chomsky (1955) calls the *product* of derivations, with which we can specify the representation that each basic notion of **CHG** assigns.

## 8.2. Actual models

We know that in a fundamental law the different basic notions of the theory should be related to each other. How does this occur in the case of **CHG**?

Chomsky (1955) repeatedly insists that the representations assignment to the sentences of a language, carried out by particular grammar at its different levels (what he sometimes calls *the structure of a language*) must be obtained by applying (the rules of) a generative grammar. This requirement about the connection between *levels of representation* and *generative grammar* constitutes a basic precept of general linguistic theory (see above section 2.2).

It should be remembered that a system of representation levels offers different representations for the same sentence. Now then

We must be able to recover from a grammar a sequence of representations  $(R_1, \dots, R_n)$  for each sentence, where  $R_1$  is the representation *Sentence*,  $R_n$  is a phonetic spelling, and  $R_2, \dots, R_{n-1}$  are intermediate representations in terms of phrases, words, phoneme, etc. We can generate these representation sequences by rules of the form

$1 X \rightarrow Y$

interpreted as the instruction “rewrite  $X$  as  $Y$ ”. We call each such rule a *conversion*. The string  $Z^A Y^B W$  is said to *follow from* the string  $Z^A X^C W$  (where  $Z, W$ , or both may be the identity element  $U$ ) by the conversion 1. We say that the sequence  $(R_1, \dots, R_n)$  is a *derivation* of  $R_n$ , *generated* by a set  $C$  of conversions, if  $R_1$  is *Sentence* and for each  $i$  ( $1 \leq i < n$ ),  $R_{i+1}$  follows from  $R_i$  by one of the conversions of  $C$ . (Chomsky 1955, p. 114)

Thus, for each representation level of an analytical grammar, it is necessary to specify the set of rules of the corresponding generative grammar that permits us to generate the representation assigned from that level.<sup>25</sup> The assignment of **L**'-markers to **L**-markers accomplished by the *mappings*  $\Phi^L$  of an analytical grammar can be conceived, from a generative perspective, to be the result of the application of certain *rules* on the **L**-markers to the point of converting them into the **L**'-markers. So, the characterization of the different mappings  $\Phi^L$  can be achieved by a reformulation using rules, indicating which rules permit the conversion of **L**-markers into the corresponding **L**'-markers. The following quotation concisely states this relation between the structure (or the representation) of sentences (or of the language) from the level **P** and the form of the grammar in terms of rules:

<sup>25</sup> Chomsky's (1955) manner of speaking in these and other passages can be interpreted as a way of defending that a generative grammar, conceived as a system of rules, can provide at the very least the analysis in *immediate constituents* of sentences that was being performed by the structural linguistics at that moment.

we want (...) [the] grammar to be related to  $\mathbf{P}$  in such a way that given  $\mathbf{P}$ , we can derive the grammar, and given the grammar, we can determine the underlying system of phrase structure  $\mathbf{P}$  on which it is based, and the constituent analysis that this underlying  $\mathbf{P}$  carries along with it. (Chomsky 1955, p. 186)

We think that the definition of the fundamental law for **CHG** must reflect this connection between the structure of the language and a generative grammar. Thus, in terms of our reconstruction, for example, if  $z$  is the *phrase structure* that the grammar assigns to the sentence  $s$  from the level  $\mathbf{P}$  through its basic notion  $p$ , then we would have to be able to specify the rules of the grammar whose application permits the derivation of  $z$ . That is, the fundamental law for **CHG** must express the *connection* between the *values of the basic notions* and the *procedure* used in a generative grammar to obtain these values; in short, an expression that formulates the connections that are established (through rules of the grammar) among the different representations assigned to sentences by a grammar. More specifically, the fundamental law of **CHG** will indicate the type of derivation –and in so doing the type of rules– that allows the generation of values that basic notions assign to sentences. It will indicate the first string of all of these derivations, and it will also indicate several conditions that rules of each type must satisfy. Bearing this in mind, and making use of auxiliary notions that we have mentioned let us define the actual models of **CHG**:

(12)  $x$  is a Chomsky Grammar ( $x \in \mathbf{M}(\mathbf{CHG})$ ) iff there exist  $L, p, t, f, a$ , such that

$$1) x = \langle L, \mathbb{P}, \mathbb{T}, \mathbb{F}, \mathbb{A}, \mathbb{N}, p, t, f, a \rangle$$

$$2) x \in \mathbf{M}_p(\mathbf{CHG})$$

$$3) \forall s \in L \exists \mathbf{P} \mathbf{T} \mathbf{F} \mathbf{A}:$$

$$p_i(s) = \Delta^{\mathbf{P}}[S] \wedge C^{\mathbf{P}}(\mathbf{P}) \wedge t(s, p_i(s)) = \Delta^{\mathbf{T}}[p_i(s)] \wedge C^{\mathbf{T}}(\mathbf{T}) \wedge$$

$$f(s) = \Delta^{\mathbf{F}}[t(s, p_i(s))] \wedge C^{\mathbf{F}}(\mathbf{F}) \wedge \alpha(s) = \Delta^{\mathbf{A}}[f(s)] \wedge C^{\mathbf{A}}(\mathbf{A})$$

Thus, the actual models of **CHG** will be those potential models of **CHG** (constituted by a set  $L$  of sentences, several sets of possible representations, the set of natural numbers and by certain assignments of linguistic representations to sentences of  $L$ ) that satisfy the fundamental law 12.3. According to 12.3, for every sentence  $s$  exists a set  $\mathbf{P}$  of **P**-rules, a set  $\mathbf{T}$  of **T**-rules, a set  $\mathbf{F}$  of **F**-rules and a set  $\mathbf{A}$  of **A**-rules such that: the notion  $p_i$  assigns to the sentence  $s$  the string derived from  $S$  by the rules of  $\mathbf{P}$  that satisfies certain **P**-conditions; the notion  $t$  assigns to the pair  $(s, p_i(s))$  the string derived from  $p_i(s)$  by the rules of  $\mathbf{T}$  that satisfy certain **T**-conditions; the notion  $f$  assigns to the sentence  $s$  the string derived from  $t(s, p_i(s))$  by the rules of  $\mathbf{F}$  that satisfy certain **F**-conditions; the notion  $a$  assigns to the sentence  $s$  the string derived from  $f(s)$  by rules of  $\mathbf{A}$  that satisfy certain **A**-conditions.

The linguist will try to specify the rules of the sets  $\mathbf{P}$ ,  $\mathbf{T}$ ,  $\mathbf{F}$  and  $\mathbf{A}$  and its conditions in order to be able to recover representations of every sentence of (a corpus of) the language. His/her conviction is that this will be possible for all sentences of the language and only for them. The fundamental law of **CHG** shares characteristic features with fundamental laws of theories of other sciences, in form as

well as in function. This can be easily accepted if we note that the fundamental law of **CHG** constitutes a complex formula which connects all the relational terms of the theory, in which universal and existential quantification appear, and in which it is shown that the value of most of the relational terms depend on the value of other relational terms. Existential quantification affects to sets of rules and to conditions for those rules, and appears in an implicit manner upon utilizing auxiliary procedures of derivation.

Additional features of this law are: it is neither a *description of a fact* nor a *definition*, it is an *irrefutable* statement, it represents a *promise* (more than an achievement) and it is the base for *puzzle resolution*.<sup>26</sup> That the fundamental law of **CHG** is *indisputable* is evidenced in the practice of grammarians when faced with an unsuccessful attempt to specify the rules that permit the derivation of the value that a function of **CHG** assigns to a kind of sentence. This practice that basically consists of not giving up on the fundamental law but beginning a new attempt in the search for adequate rules, assuming, perhaps, the modification of some of the factors that intervene in the derivation process. (Sometimes that modification will even consist of an alteration of the value that some other basic notion assigns to the sentence in question.) That is to say, the grammarian will try to make the assumptions and the results of his/her investigation compatible with the fundamental law. But if these things are not compatible in some respect, he/she will propose modifications in the assumptions as well as in the results, until the latter harmonize with what is anticipated by his/her fundamental law. What the grammarian will not do, in the task of *normal investigation*, is renounce to the fundamental law when the first problems arise. If this occurred, it would be a sign of the fact that a period of *extraordinary investigation* is starting, in the sense that this expression has in the work of Kuhn, and this will give rise afterwards to the consolidation of a new fundamental law. The *irrefutable* nature of the fundamental law of **CHG** has to do with its character of *promise*. To assert the existence of something without showing it is equivalent to promising that something exists and justifies the search for it. To be committed to the fundamental law of **CHG** is compatible with failing in this search, since the fundamental law expresses the conviction of a future success, a promise. On the other hand, the attempts at giving substance to that promise constitute attempts to find the solution to a *puzzle* or *enigma*, the results of which depend on the ability of the grammarian.

## 9. Conclusions

The reconstruction of **CHG** will be completed with successive steps that we cannot undertake here. The most immediate steps are the application of the *criterion of T-theoreticity* to the basic notions of **CHG**, the definition of their *constraints*, the definition of the *links* with diverse theories and the configuration of the *theory-net*

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<sup>26</sup> See Moulines (1982) for an analysis of the form and function of fundamental laws.

into which it participates. Some relevant results in these areas already exist but we lack a complete picture. In general, it is possible to affirm that the characteristic instruments of the *structural metatheory* are applicable to *generative linguistics* and with results of interest for the linguistics as discipline.

We believe that a structural analysis of linguistic theories is necessary to develop an adequate *foundation* for these theories. Some foundation proposals defended by linguists themselves are mere expressions of the desire of the authors, who on occasions are unaware of or confused about the nature of their theories or about the still influential past of their discipline. The metatheoretical analysis permits us to obtain conclusions about various central aspects of the linguistics' foundation, for example, the nature of the *objects* a grammar is concerned with, the *task* that a grammar performs, and the *type of notions* employed in that task. Clarification of these aspects will make it possible to outline, with some probability of success, certain problems about the *intertheoretical relationships* and about the nature of theories.

In the case of **CHG**, the metatheoretical analysis permits us to outline problems on the relationships between this theory and *structural linguistics*. These problems affect the foundation of the *generative trend* in its entirety, in which there is a debate on whether this foundation has been *mentalist* from the beginning and also on whether it should be mentalist or not. The metatheoretical analysis also permits the study of the relationships between *various versions of the generative trend* which have been developed over time, and thereby assesses whether the change criteria have been empirical and scientific criteria (as say the linguists) or not. The metatheoretical analysis of linguistic theories is especially useful to evaluate the recent proposals of *naturalization of linguistics* based on the interrelationship between linguistics and some of the natural sciences. Such proposals would be justified only if a metatheoretical analysis revealed these supposed interrelationships.

The strength, brilliancy and transcendency of the proposals made by linguists deserve the attention of the philosophers of science.

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