

Introduction to Formal Approaches to Functional Categories*

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Abstract

This introduction highlights most salient formal approaches to functional categories in the development of Generative Grammar and points to explanatory consequences for understanding language. In doing so, we introduce the papers contained in this volume, which provide novel working hypotheses and experimental results on the role of these categories in grammar, language acquisition, and neurodiversity.

1. Introduction

This introduction aims to show how formal approaches to functional categories have evolved in Generative Grammar starting from the Standard Theory. While advances have been made, the role of these advances in grammar, as well as in language acquisition and disabilities require further investigation.

Taken together, the articles assembled in this volume address the following questions:

- (1) a. What are functional categories and why are they part of grammar?
- b. How do they contribute to the derivation of linguistic expressions?
- c. What is their role in language acquisition, variation, and neurodiversity?

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This introduction is organized as follows. We start by stating the goal of linguistic theory. Secondly, we highlight explanatory insights provided by formal approaches to Generative Grammar and related fields. Finally, we introduce the articles that are included in this volume.

2. Linguistic theory

Linguistic theory aims to explain the basic property of language, namely, the mind's internal computational system that relates meanings to sounds, or to other modalities, on the basis of finite means. A truly explanatory linguistic theory should be the simplest theory that accounts for this basic property and for language acquisition and evolution.

The mind's internal computational system is not accessible to consciousness. The development of Generative Grammar has investigated different theories of language, each stage of the investigation providing greater explanatory adequacy, and each stage provoking new questions to explore. In this research space, the properties of functional categories attracted increasing attention. Their formal study has brought new insights into the role of these elements in syntactic derivations, their mapping to the conceptual and the sensorimotor systems, and their import in language variation, acquisition, and neurodiversity.

The following paragraphs, which are related to the articles included in this volume, point to formal approaches that have been taken to investigate the properties and the role of functional categories in the development of Generative Grammar and related fields.

2.1 The Standard Theory

The Standard Theory introduced the formal approach to syntactic categories (Chomsky 1965). This approach contrasts with the approaches of traditional and taxonomic grammars, according to which categories were labels for classes of lexical items. In the Standard Theory, categories are defined as bundles of features, which play a role in the syntactic component of the grammar.

According to the Standard Theory, the syntactic component of the grammar consists of the Base and the Transformational components. The Base consists of a phrase structure (PS) grammar, a repertoire

of categories, and a lexicon, i.e., a set of formatives (lexical items) with their features. The PS rules, whose general form is defined in (2), generate Deep Structures, interpreted by the semantic component of the grammar. The application of the transformational rules to Deep-Structure derive Surface Structures.

Syntactic categories are drawn from a universal repertoire. Major categories, such as Nouns and Verbs, are distinguished from minor categories, such as Determiner, Modal, and Auxiliary. Major and minor categories are introduced in the derivations by PS rules, as in the case for the rule generating the constituent structure of Nouns Phrases (NP) in (2), from Chomsky (1965: 91).

- (2) S → NP VP
 VP → V NP
 NP → Det N
 Det → (pre-Article of) Article (post-Article)

Chomsky proposes that lexical items are defined in terms of distinctive features on a par with phonology, where “each phonological unit is a set of features, and the phonological rules apply to all segments containing a certain feature or constellation of features” (Halle 1959, 1964). Lexical formatives (*boy*, *sincerity*, etc.) and grammatical formatives (Perfect, Progressive, etc.) are associated with distinctive syntactic features as well as phonological features in their lexical entries. Thus, lexical formatives such as *sincerity* are associated with the syntactic distinctive feature [+N] for noun, and lexical formatives such as *frighten* are associated with the distinctive syntactic feature [+V] for verb, in addition to selectional features. Grammatical formatives, like articles *the* and *a*, are also associated with syntactic features, such as the feature [±Definite], in addition to their phonological features. Lexical and grammatical formatives are inserted into the terminal nodes of a phrase marker as Complex Symbols, i.e., as bundles of distinctive features. Chomsky also introduces the notion of “feature class” (bundles of features) as groupings of grammatical features that interact. For example, inflectional features such as [Gender], [Number] and [Case], are some of the feature specifications of N and Det; and [Person] [Number] and [Tense] are some of the feature specifications of V. [Gender], [Number], and [Case] features are phi-features (φ-features), which are copied together in certain syntactic contexts. Agreement rules, such as the one in (3),

from Chomsky (1965:187-188), assign to an Article all of the feature specifications for [Gender], [Number] and [Case] of the Noun it is combined with. Chomsky notes that this rule is analogous to the rule of assimilation in the phonological component, (4).

$$(3) \quad \text{Article} \rightarrow \left[\begin{array}{l} \alpha \text{ Gender} \\ \beta \text{ Number} \\ \gamma \text{ Case} \end{array} \right] / _ \dots \left[\begin{array}{l} +N \\ \alpha \text{ Gender} \\ \beta \text{ Number} \\ \gamma \text{ Case} \end{array} \right]$$

$$(4) \quad [+nasal] \rightarrow \left[\begin{array}{l} \alpha \text{ grave} \\ \beta \text{ compact} \end{array} \right] / _ \left[\begin{array}{l} +\text{consonantal} \\ \alpha \text{ grave} \\ \beta \text{ compact} \end{array} \right]$$

The feature-based definition of categories and the role of formal features in syntactic operations remain constant throughout the development of Generative Syntax. The parallelism between syntax and phonology has been investigated in different work, including the article written by D'Alessandro and Oostendrop's in this volume.

2.2. "Remarks on nominalizations"

The hypothesis that major categories are defined in terms of binary syntactic features is further detailed in "Remarks on nominalizations" (Chomsky 1970), where the categories verb (V), noun (N) adjective (A), and preposition (P), are defined in terms of two binary features, [+N] and [+V], as identified in the table in (5).

(5)

	-V	+V
+N	N	A
-N	P	V

Defining categories in terms of bundles of syntactic features enables syntactic generalizations to be stated with fewer symbols. Syntactic features such as [+N] or [-N] provide a formal means of identifying natural classes of categories with respect to syntactic operations, that is, categories that undergo the same operations.

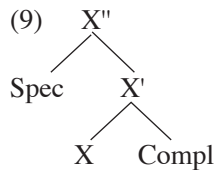
Regularities emerge between sentential and nominal structures, as illustrated in (6) and (7). The examples in (6) illustrate parallelism

between nominalizations and sentences in constituent structure.¹ The examples in (7) illustrate the effect of two Transformations—NP reposing and Agent Postposing—in the derivation of sentences and nominalizations.

- (6) a. The students criticize this book.
 b. the students criticising this book (gerundive nominal)
- (7) a. This book was criticized by the students.
 b. this book's criticism by the students

The syntactic regularities between sentences and related nominalizations led to the formulation of X-bar Theory, according to which the general rule schemata in (8) imposes an endocentric structure on the PS rules of the Base. According to this theory, a Head X, where X is a major category, such as N, V, and A, is immediately followed by its Complement (Compl), forming the syntactic constituent X', and X' is immediately preceded by a Specifier (Spec), forming the syntactic constituent X'', as represented in (9). The category-specific PS rules of the Base were eliminated given X-bar Theory, which captured linguistic generalizations with fewer symbols and thus provided a higher level of explanatory adequacy.

- (8) X'' : Spec X'
 X' : X Compl



Summarizing then, insights on major and minor categories emerge from “Remarks on Nominalizations.” Major categories are defined with two binary features. X-bar Theory defines the syntactic form of major phrasal categories.

¹ Given differences in productivity and regularity of form, gerundive *-ing* nominals, such as *criticising*, are derived in the syntactic component of the grammar, whereas derived nominals, such as *criticism* are part of the lexicon. The grammatical formative “of” was inserted in the derivation of derived nominal structures such as *the students' criticism of this book* by a local transformation. In the Government and Binding Theory (Chomsky 1981), the presence of the preposition *of* in nominalizations follows from Case Theory, according to which all lexical NPs must be Case marked, and only [-N] categories, i.e., V and P, can assign structural Case (Nominative, Accusative) under the structural relation of government.

2.3 Government and Binding Theory

The formal properties of functional categories and their syntactic projections are explored further in the “Government and Binding (GB) Theory” (Chomsky 1981 et seq.).

GB Theory formalizes the relation between Universal Grammar (UG) and language variation, discussed in previous works (Chomsky 1955, 1965, 1981) in terms of a highly modular system of universal principles and associated parameters of variation. This brings about a radical revision of linguistic theory.

According to GB Theory, syntactic structures are generated and filtered at different levels of representations: Deep Structure, Surface Structure, Logical Form, and Phonetic Form. X-bar Theory becomes a principle of UG, along with several other principles, including the Extended Projection Principle (EPP), Theta-theory, Case Theory, Bounding Theory, Binding Theory, and Full Interpretation. Logical Form and Phonetic form are both derived from Surface Structure and lead to semantic interpretation on the one hand, and phonetic interpretation on the other.

GB Theory enabled generalizations to be expressed in simpler terms. For example, the large number of transformational rules proposed in the Standard Theory are reduced to the general operation Move α , where α is a syntactic constituent. NP-preposing and NP-postposing are subsumed under Move NP. The Bounding Theory simplified the statement of conditions on transformations (Chomsky 1965, 1973, Ross 1967, a.o.) and it enabled parametric variation to be expressed in terms of differences in bounding nodes.²

In this model, new functional categories are added to syntactic theory and generalizations are stated on their syntactic projections. A novel hypothesis is formulated on the locus of variation in grammar, and functional features are part of the Principles and Parameters of UG. We shall detail these advances in the following paragraphs.

There are more syntactic categories than N, V, A and P. Additional categories, including quantifier (Q), adverb (Adv), degree (Deg), Determiner (D), Case (K), Inflection (INFL), Complementation

² According to the Bounding Theory, a constituent cannot move across more than one bounding node, and the category of the bounding nodes is subject to parametric variation. Chomsky (1973) showed that the blocking categories for English are NP and S'. Rizzi (1982) showed that bounding nodes for Italian are NP and S'. Similar claims were made for French in Sportiche (1981) and for Spanish in Torrego (1984).

(COMP), were introduced in the GB framework.³ Different proposals emerged to define these categories in terms of binary features. For example, Abney (1987: 225) differentiates lexical from functional categories by introducing new functional features, including the binary feature [\pm F], (10). This feature has been used in several works, including in the analysis of complex modal structures in the verbal system (Cinque 2017).

(10)

	-Adj		+Adj	
	-N	+N	-N	+N
-F	V, P	N	—	A, Q, Adv
+F	I, C	D, K	—	Deg

In addition to the feature-based definition of a larger set of functional categories, X-bar Theory is generalized to all categories. Furthermore, Abney (1987) argues that the nominal system is not defective with respect to the verbal system. He argues that in the nominal system, NP projects a DP structure, on a par with INFL and C in the verbal system. There are strong arguments in favour of the DP hypothesis, discussed in Fukui and Speas (1986), Szabolsci (1983, 1989) and Taraldson (1991). Larson, in this volume, provides further support for the DP hypothesis on the basis of current analyses of features and agreement. Moreover, Grimshaw (1991) shows that different categories share c-selection features and proposes the notion of extended functional projections, whereby functional categories occupy hierarchically higher positions than lexical categories. The notion of extended projections gave rise to extensive research in syntactic Cartography (Cinque 1999, 2002 et seq.).

Functional elements are central to the description and the explanation of linguistic variation. According to the Borer-Chomsky conjecture, all parameters are attributable to differences in the features of particular items — e.g., functional elements — in the lexicon (Chomsky 1981, Borer 1984). According to this conjecture, syntactic variation is encoded on functional heads. For example, Rizzi (1982) argues that the surface effects of the null subject parameter in languages such as

³ Supporting arguments for functional categories as syntactic projections have been discussed in several works in GB theory. For example, Complementizer (COMP) and Inflection (INFL) were proposed as syntactic categories in Emonds (1978), den Besten (1981) and Platzack (1983); INFL was split into Agreement (AGR) and Tense (T) in Pollock (1989); Determiner (D) was proposed in Abney (1987) and further discussed in Taraldsen (1991).

Italian (as opposed to English) can be traced back to the properties of Tense (T). Pollock (1989) argues that verbs, in particular [+finite] verbs, move to T, (= Inflection (I)), in French verb-object sentences, which accounts for the fact that negation precedes the verb in languages such as French but follows it in languages such as English. See (11)-(12) from Pollock (1989: 367).

(11) [_{IP} NPI [_{INeg} not/pas]] [_{VP} (Adv) V . . .

- (12) a. Jean likes not Mary.
 b. Jean (n') aime pas Marie.

According to GB Theory, parameters are options left open in the principles of UG. For example, given X-bar theory, the head-directionality parameter (Fukui and Speas 1986, Baker 2001) differentiates head initial languages, such as English, from head final languages, such as Japanese. Parameter hierarchies are proposed to account for the dependencies between macro parameters and micro parameters. Macro parameters are analyzed as constellations of micro parameters, which identify smaller-grained linguistic variations.

The Principles and Parameters Model is an important milestone in linguistic theory as it provides a formal approach to language variation and acquisition. There is a close connection between language variation, language learning, and the historical development of a language, where functional elements (categories and features) are key. This gave rise to important advances within GB theory and beyond (e.g., Lightfoot 1991, 1989, Baker 1996, Roberts and Roussou 1999, 2003, Longobardi 2001, Longobardi and Guardiano 2009, Cinque 2005. See also Etxepare and Gallego's and Cerrodo and Gallego's articles in this volume).⁴

Summarizing then, several insights emerge from the role of functional categories and functional features in GB Theory. These include the feature-based definition of functional categories, the notion of extended functional projections, and the role of functional categories/features in language variation. These insights are further investigated in the Minimalist Program, which draws attention to the explanatory capacity of linguistic theory.

⁴ In recent works, principles external to UG intervene in language variation. See Kayne (2013), Bibebauer, Holmberg and Roberts (2014), Robert (2019), Di Sciullo, Nicolis and Somesfalean (2020), Lightfoot (2020) for discussion.

2.4 The Minimalist Program

The Minimalist Program (Chomsky 1995 et seq.) is a research program aiming at reducing the grammar to its simplest form with a view toward further explaining the basic property of language.

From this perspective, the internal interface levels postulated in GB Theory, D-Structure and S-Structure, are eliminated along with the Principles applying to these representations. The effects of X-bar and move α , are derived from a simple operation, which recursively applies to two syntactic objects, α and β , (α , β), and derives a set $\{\alpha, \beta\}$, as in (13). This operation is necessary in a recursive system. MERGE is external if α and β have not participated in previous applications of MERGE, or being directly taken from the lexicon; if they are not, MERGE is internal.⁵ The grammar also includes the operation AGREE, as in (14), (from Chomsky 2000) which is necessary to account for agreement phenomena. This operation is structure dependent and asymmetric, and relates formal (syntactically active) features, such as ϕ -features. It takes place between a Probe and a Goal between which a Matching (identity) relation holds. It eliminates unvalued features of the Probe, and thus contributes to constructing hierarchically structured expressions by matching inherent valued features of the Goal which are located in the Probe's minimal search space. Furthermore, the syntactic objects derived in core syntax must be mapped to representations accessible to the semantic and the sensorimotor interfaces respectively; so the grammar must include operation TRANSFER that ensures this mapping.⁶ The formal properties of MERGE, AGREE and TRANSFER are under investigation as well as their status in core syntax in the perspective of providing the simplest explanation to the basic property of language, as discussed below.

(13) Merge $(\alpha, \beta) = \{\alpha, \beta\}$

(14) Agree $\alpha > \beta$ Agree (α, β) , where α is a probe and β is a matching goal, $\alpha > \beta$ is a c-command relation, and uninterpretable features of α and β are checked/deleted.

⁵ MERGE generates unordered and unconstrained sets of syntactic objects unboundedly, and imposes no intrinsic ordering among its members or a label to the new object, contrary to previous formulations of this operation. See Chomsky (1995, 2000), and Collins (2002, 2017), Rizzi (2015), Collins and Stabler (2016), Collins and Groat (2018), Chomsky, Gallego and Ott (2019), for discussion.

⁶ Given that MERGE applies freely, labels are not assigned to syntactic constituents by MERGE, thus simplifying the previous formulation of this operation. The labelling algorithm, proposed in Chomsky (2013, 2015), intervenes at the interface level and determines the label of a phase after it has been built. The derivations are

Functional and lexical items are subject to MERGE and their formal features are related by AGREE. Functional features play an active role in AGREE.⁷ For example, *v** (transitive *v*)⁸ and *C* are lexically endowed with unvalued features, which make them Probes as soon as they are introduced in the derivation.

Functional categories also play a role in Phase theory as phase heads. According to the theory of cyclic spell-out, derivations proceed by phases (Uriagereka 1999, Chomsky 2000, 2001, 2008, Gallego 2010, Chomsky, Gallego and Ott 2019). Phases are units of derivation and interpretation. According to Chomsky (2000, 2001), phases are propositional, i.e., limited to *v*P* (transitive *vP*) and *CP*.⁹ Furthermore given the Phase Impenetrability Condition (PIC), the Head and the edge (Specifier) of a phase are spelled out at a later point in the derivation than the complement.

Chomsky (2005) identifies three factors in language design which determine the growth of language in the individual. The first is the human being's genetic endowment for language, the second is experience, and the third is principles of efficient computation akin to natural laws. The simplest theory is the one that accounts for the basic property of language in terms of the first and the third factors.

From this perspective, derivations are generated by genetically determined simplest MERGE, and subject to principles of efficient computation external to the grammar. AGREE is either assumed to be part of the computational procedure of the language faculty or attributed to principles of efficient computation. Previously proposed principles and constraints are subsumed under third factor principles

cancelled at the interfaces when a labelling issue arises. See Fukui and Narita (2014), Rizzi (2015), Seeley (2016), Collins and Groat (2018), Epstein, Kitahara & Seely (2014, 2016), Chomsky, Gallego and Ott (2019) for discussion.

⁷For the difference between interpretable and uninterpretable, valued and unvalued features see Chomsky (1955, 2000), Pesetsky and Torrego (2004/2007), Di Sciullo and Isac (2003, 2008a,b), Svenonius (2007), Adger and Svenonius (2009), Zeijlstra (2012), Chomsky, and Gallego and Ott (2019).

⁸Small *v* is introduced in Chomsky (1981) to implement the VP-internal Subject Hypothesis, according to which subjects are generated within the verbal project and located in a structurally higher position than complements (See Kuroda 1988, Koopman and Sportiche 1991, Hale and Keyser 2002, and related works). Small *v* is a functional category as opposed to *V*. Several other functional categories have been proposed, including Aspect and Voice in the verbal extended projection, Ordinal Numeral, and Numeral classifier in the nominal extended projection, Degree, Relative View and *AxPart* in the extended prepositional projection. See, for example, Rizzi and Cinque (2016) and the references therein.

⁹Other constituents than *v*P* and *CP* have been proposed to be phases. See for example Legate (2003) for the view that unaccusative and passible VPs are phases as well, and Di Sciullo (2004, 2005) for morphological phases."

of efficient computation. This is the case for Case Theory (Chomsky 1981), the Constraint on Extraction Domain (Huang 1982), the Complement/Non-complement Asymmetry (Nunes and Uriagereka (2000), the PIC (Muller 2010). See Chomsky, Gallego and Ott (2019), as well as Etxepare and Gallego's and Cerrudo and Gallego's articles in this volume for discussion.

Functional categories play a central role at the interfaces with the external systems, in the linearization and externalization of linguistic constituents as well as in the mapping to the conceptual structure, as we point to in the following paragraphs.

Starting with the linearization of syntactic constituents, according to Kayne's (1994) Universal Base Hypothesis, languages universally have a fixed Specifier-Head-Complement order, and any difference in ordering is derived by movement. The linearization of syntactic constituents is subject to the Linear Correspondence Axiom (LCA), according to which the ordering of terminal nodes follows from the asymmetrical c-command relation between non-terminal nodes. Given simplest MERGE, the linearization of linguistic constituents is not derived in core syntax, as discussed in Chomsky (2005, 2013) and Berwick and Chomsky (2016). In Kayne's article in this volume, a more local relation of precedence holds in syntactic derivations, while precedence between syntactic constituents is derived in the morpho-phonological component of the grammar.

Furthermore, Kayne (2016) argues that most functional heads must be taken to be silent, and considers the possibility that X in $\{H, HP\}$ is invariably silent, see also Kayne (2005). This is the case with the locative preposition in English—*here* and *there*—as well as in locative constructions including light nouns such as *home* discussed in Collins (2007). Di Sciullo's article in this volume argues that the pronunciation or silence of the preposition in some variants of Italian locative pro-forms follows from Internal Merge and Principles of efficient computation.

Considering the mapping of functional structure to conceptual structure, questions arise with respect to the semantic contribution of functional categories and how functional projections contribute to conceptual structure. One approach would be to relate these questions to the duality of semantics. Functional categories and projections are generally located in the upper layer of syntactic projections and contribute to discourse structure instead of argument structure. Arsenijevic's article in this volume addresses these questions from

the perspective of a grammar as a storage and retrieval system and attributes a special role to functional categories in the mapping to conceptual structure.

Regarding the role of functional structure in the mapping to conceptual structure, Syntactic Cartography gave rise to extensive research on functional projections leading to fine-grained articulations of clauses and phrases, see Rizzi (1997), Cinque (1999), Rizzi (2010), Cinque and Rizzi (2012), Rizzi and Cinque (2016), and the references cited therein. In this research program, each functional head is associated with one semantic feature and a difference in the semantics of a functional head correlates with a structural difference.

Syntactic maps, such as the PP map in (15) from in Rizzi and Cinque (2016:154), or parts thereof, could contribute to the mapping from functional structure to conceptual structure. As acknowledged in Rizzi (2013), the descriptive generalizations provided by syntactic cartography need to be derived from independently motivated principles. See also Larson (2017, 2021) for discussion.

- (15) PP map: [PP_{direction} (from)
 [PP_{stative} (at)
 [DegreeP(two inches)
 [Mode_{direction} P(diagonally)
 [AbsoluteViewP(south)
 [RelativeViewP_{vertical} P (down)
 [RelativeView_{in/out} P (in)
 [DeicticP (there)
 [AxPartPX⁰(under)
 [NP_{place} DP (the table)
 [PLACE]

Other hierarchies have been proposed based on specific correlations between linguistics and cognitive structure. This is the case for example for Wiltscko's (2014) Universal Spine, (16), where the four hierarchically ordered functions of linking, anchoring, point of view, and classification may be instantiated by different grammatical categories in different languages. Focusing on the higher functional layer of the DP, (17), proposed in Martin and Hinzen (2014), Hinzen and Schroeder's article in this volume suggest that further understanding of neurodiversity rely on understanding the mapping of higher functional projections to specific areas of the cognitive

architecture. See also Hinzen & Schroeder (2015) and Hinzen and Sheenan (2005) for discussion.

(16) Universal Spine:

[linking [anchoring [point of view [classification]]]]

(17) Layers in the DP:

[Person [Deixis [Definite [Indefinite [NP]]]]

Summarizing then, several insights on functional categories emerged in the Minimalist Program, including the following: functional categories are introduced and displaced in the derivation by a unique set formation operation, MERGE; functional categories are phase heads, the unvalued features of which are valued by a unique operation, AGREE. As expected, the simplification of the grammar brought about in the Minimalist Program provided greater understanding of functional elements, as well as giving rise to questions for further inquiry. These include, whether the externalization of functional categories at the sensorimotor interface could be related to displacement in most cases, whether their role in variation could be attributed to third factor Principles of efficient computation, and whether mapping to conceptual structure could mainly rely on the properties of extended functional projections.

Results from experimental studies in psycholinguistics and in neurosciences also point to the central role of functional categories in language acquisition and language disabilities, to which we now turn.

3. Functional categories in language acquisition and neurodiversity

Language matures in the child's brain in a short period of time without formal instruction and on the basis of partial evidence. Notwithstanding poverty of the stimulus, children will develop grammars for the languages to which they are exposed. Chomsky's 1959 review of Skinner's *Verbal Behavior* provides strong arguments against the behavioral view of language acquisition and in favor of the innateness of language. Language develops naturally in the child whatever language or social context he/she is exposed to, as discussed for example in Lenneberg (1969).

The lexical/functional divide has been shown to be central in the understanding of early language acquisition and language disorders, as we point out in the following paragraphs.

Experimental research in language acquisition provided evidence that functional categories are developed, produced, and processed differently than lexical categories in child's language. For example, for Radford (1990), the lexical system emerges earlier than the functional system, in the following sequence of acquisition stages:

(18) pre-categorial > lexical > functional

In the pre-categorial system, one-word utterances are produced; however, no categorial structure would be available. At the lexical stage, attained around 20 months of age, the system of lexical categories would be in place. At the functional stage, reached around 24 months, the system of functional categories would be available. The sequence of acquisition stages in (18) would be biologically determined stages of maturation of UG. However, results from more recent experimental studies show that functional categories are available to children even in newborns when studied through sophisticated experimental techniques. Experimental evidence indicates that functional categories are innate and not necessarily learnt. See Gavarro and Zhu's article in this volume, which bring evidence from Chinese that functional categories are available at very early stages of language acquisition.

Furthermore, several studies in first language acquisition indicate that functional morphemes are more difficult to produce and process than lexical morphemes (Brown & Fraser 1963; Brown 1973; Wanner & Gleitman 1982; Guilfoyle & Noonan 1988; Lebeaux 1988; Gerken, Landau, & Remez 1990; Radford 1990). Word priming experiments indicate that while lexical categories prime homophone and semantically related expressions, this does not seem to be the case for functional expressions (Shillcock and Bard 1993). Experiments show that normal subjects take longer to reject nonwords based on lexical expressions than those based on functional expressions, e.g., *thinage* vs. *thanage* (Bradley 1978, Matthei and Kean 1989). Processing delays and disorder in children's natural production studies provide evidence for a bifurcation of linguistic categories into lexical and functional.

Theoretical and experimental works in language acquisition suggest however that children's difficulty with complex structures is not due to the absence of structure dependent principles. For example,

Di Sciullo and Aguero (2008) argue that the Delay of Principle B effect, observed in English but not in Romance languages, does not undermine the availability of structure dependent principles in language acquisition. Friedman, Belletti & Rizzi (2009) tie the difficulty that children show in object relatives during early stages of language acquisition to Relativized Minimality and intervention effects. They reported that young Hebrew-speaking children avoided intervention structures in production by producing subject relatives instead of object relatives. Friedmann, Yachini and Szterman (2015) report that the production of subject and object relatives in 175 Hebrew-speaking children and adolescents with Syntactic Specific Language Impairment (SySLI) and 87 controls, the SySLI group avoided intervention significantly more than the control group.

Functional categories and features are part of human's genetic endowment for language. The fact that they are apparently defective in early language acquisition indicates that other constraints are at stake, as discussed for example in Wexler (1990) and related works. Wexler (1998, 2003) focuses on the fact that English children at the age of 3 years optionally produce expressions with infinitives instead of tensed verbs, e.g., *He walk* and *He walks* in the same recording session. Wexler (1998) attributes the Optional Infinite Stage in language development to a developmental principle, the Unique Checking Constraint (UCC). According to the UCC, the genetic system development has the property that more than one checking of the same unvalued feature is dis-preferred at young ages. In the VP domain, AGREEMENT and Tense cannot be both checked, given UCC, and thus one is eliminated giving rise to the Optional Infinitive Stage. Furthermore, Rice, Wexler and Redmond (1999) demonstrated that the Optional Infinitive Stage persists for a longer period of time in children with SLI and also in a subgroup of children with Autism Spectrum Disorder (ASD), as in Roberts, Rice & Tager-Flusberg (2004). These results suggest that cognitive development constraints affect functional feature checking/valuation.

Other experimental studies point to the developmental path in the comprehension and in the production of functional categories. For example, Children begin with conjunction before argument structure (Lebeaux 2000, Yang and Roeper 2011). Studies in the production of recursive PP structures by children show a difference with adult behaviour (Roeper 2010, 2011; Pérez-Leroux et al. 2012). Children use different strategies in the production of multiple PP structures.

The acquisition data suggests that coordination is a basic functional structure in language. The elementary form of recursion is used instead of a more complex prepositional form. Children interpret recursive PP structures as conjunctions (19). Roeper and Oseki (2018) differentiate three kinds of recursion in children's acquisition path: direct unstructured recursion (DUR), direct structured recursion (DSR), and indirect structured recursion (IR). With DUR, illustrated below in (20a), the permutations of the PPs are possible, with changes in semantic interpretation, (20a) vs. (20b). Both DSR and IR are semantically compositional and syntactically hierarchical, and differ from direct unstructured recursion, as the example in (20c) illustrates.

- (19) a. The house near the tree near the river.
 b. #The house near the tree and the river.
- (20) a. Put an apple [in the house][in the kitchen][in the cabinet]
 b. #Put an apple in the cabinet in the kitchen in the house.
 c. *What did John put an apple in the cabinet in the kitchen in
 <what>?

Maia et al. designed EEG experiments to compare DUR (coordination) and IR (embedding) and found that embedding is costlier to process than coordination in terms of both latency and amplitude. They conclude that DSR is a stepping-stone in the acquisition path whereby a non-semantically restricted interpretation is projected before a restricted interpretation. If IR has tighter syntax-semantic mapping and is preferred with no violation of the anti-identify condition, children will ultimately reject the DSR. See Lage et al.'s article in this volume, reporting results from eye tracking experiments indicating that the presence of overt P heads facilitate the development of simpler to more complex recursive structures.

Psycholinguistic and fMRI studies in aphasic breakdown point to possible cognitive and biological underpinnings of functional categories and their projection. fMRI studies also point to a specific area of the brain affected by language disabilities such as aphasia. Agrammatic aphasia (Broca's aphasia) is characterized by impaired access to grammatical knowledge, including functional categories. Semantic processing seems to be intact, while syntactic operations including displacement in the CP layer are disrupted, see Grodzinsky (2000), Penke (2015) and the references therein. Hinzen and Schro-

eder's article, in this volume, point to the fact that what we know about major neurodevelopmental, neuropsychiatric, and neurodegenerative disorders, including autism spectrum conditions, schizophrenia and some dementias, have repercussions on the functional edge of the DP layer. This also highlights the role of functional layers in the language-thought connection, discussed from a different perspective in Arsenijević's article, in this volume.

Summarizing, results from theoretical and experimental research indicate that functional categories and their projections play a role in language acquisition and disabilities, as well as on the mapping of conceptual structure. Here again, several questions remain open for further inquiries.

4. Introduction to Contributors' Articles

We have quickly overflowed formal approaches to functional categories in Generative Grammar as well as some theoretical and experimental results on language acquisition and neurodiversity which speak to the questions set at the beginning of this Introduction: What are functional categories, how and why are they part of the grammar, and what is their incidence in language variation, acquisition, and neurodiversity. The papers assembled in this volume address some of these questions in more detail and provide innovative hypotheses leading to a better understanding of these elements in grammar.

Novel approaches to functional material

In "Playful Speculations and how Language might Be and Why there is Functional Material" Boban Arsenijević addresses the question of why there are functional material, features, categories, and projections in a model of grammar where the source of hierarchical structure is a specific algorithm of knowledge retrieval and update. Arsenijević develops the view that functional material is primary in the mapping of language to conceptual structure. Specifically, he argues that functional material corresponds to the elements of knowledge representation, which have priority on retrieval and have a special role in the mapping algorithm due to their universality and/or high frequency of occurrences. Roberta D'Alessandro and Marc Oos-

tendrop's contribution, "Language Variation and Functional Heads: Magnetic Grammar" outline a model of grammar where features are primitives in both syntax and phonology and are subject to forces of attraction and repulsion. They illustrate the consequences of their hypothesis for the explanation of different phonological, syntactic patterns, and morphosyntactic paradigms. In "The place of Linear Order in the Language Faculty". Richard Kayne considers Berwick and Chomsky's (2016) hypothesis that Merge is unordered and the linearization of linguistic constituents is set in the morphophonological component. He proposes that while the linearization of syntactic constituents is set at the sensorimotor interface, a more local notion of precedence holds in syntactic derivation. He argues that "immediate precedence" is part of syntax, while keeping precedence as part of externalization. He also suggests a possible explanation of why this would be the case, given shared properties of syntax and phonology as well as the relations between language and music.

These contributions provide insights on the role of functional categories, their features and projections in the grammar, and explore the hypothesis that functional material is primary: in the mapping of language to conceptual structure in the case of Boban Arsenijević's contribution; that formal features are primitives in syntax and phonology and are subject to the same forces in the case of D'Alessandro and Oostendrop's article; and by arguing that immediate precedence between constituents is derived in syntax, while precedence between constituents is part of externalization in the case of Richard Kane's contribution.

Alternative analyses of variation

In "Alternatives to No Nominative Case in Spanish," Ricardo Etxepare and Ángel J. Gallego's contribution provides alternative strategies for licensing subjects in languages such as Spanish. The analysis relies on ϕ -features valuation and has consequences for the properties of C, the functional category responsible for nominative Case assignment. Their proposal also leads to a broader approach to parametric variation connecting typologically different languages. In "Island Effects Under Recomplementation," Alba Cerrudo and Ángel J. Gallego discuss the derivation of recomplementation in Spanish, where a second complementizer "que" prevents wh-movement

from the embedded clause. Departing from cartographic approaches to island effect, they put forward a derivational explanation. In particular, Cerrudo and Gallego argue that recomplementation and non-recomplementation structures do not differ in the spell-out of a functional projection. They argue instead that recomplementation involves C movement to V, which creates a new complement position immediately following a topic that turns the embedded clause into a specifier (a non-complement). If correct, this entails that island effects under recomplementation are an instance of CED effects.

The articles by Ricardo Etxepare and Ángel Gallego and Alba Cerrudo and Angel Gallelo provide alternative derivational analyses of linguistic phenomena related to functional categories, namely, Nominative Case assignment in Ricardo Etxepare and Ángel J. Gallego, and re-complementation in Spanish, and have consequences for the understanding of parameters of variation.

(As)symmetry of functional projections

The DP hypothesis, argued for in several works, including Szabolsci (1983, 1989), Fukui and Speas (1986) and Abney (1987), has been challenged in different works, including Bruening (2009), and Bruening, Dinh and Kim (2018). In “The DP Hypothesis and (AS)Symmetries between DP and CP,” Richard Larson evaluates Bruening’s (2009) and Bruening, Dinh and Kim’s (2018) arguments against the DP hypothesis and shows that they are not convincing. Larson points to the fact that the putative DP/CP asymmetry is not well-founded under current analyses of features and agreement, which allow both DP and CP to be viewed in similar terms. Anna Maria Di Sciullo’s contribution “DP and PP in Locative Pro-forms” provides derivations of locative Pro-forms in Italian and in Abruzzese based on simplest Merge and principles of efficient computation. She argues that the micro variation in the externalization of the preposition is reduced to a difference in feature specification of prepositions, given independently needed Principles of efficient computation. Di Sciullo’s contribution brings support to the projections of DP and PP in locative pro-forms in Italian and Abruzzese notwithstanding the variation in the externalization of the preposition which is not externalized in Italian. The analysis relates to the diachronic development from Latin to Italian, and provides support to the view that functional

features are part of an explanatory theory of language and variation.

Both Richard Larson and Anna Maria Di Sciullo's contributions provide evidence for extended projections in the nominal and the sentential domain. Larson provides new arguments based on features and agreement in favour of the DP/CP symmetry. Di Sciullo argues that DP and PP are both projected in the derivation of locative pro-forms in Italian and Abruzzese locative determiners.

Functional categories in language acquisition and neurodiversity

Anna Gavarro and Jingtao Zhu's article on "Functional Categories in Very Early Acquisition" presents some new results on feature setting in 17 month-old children exposed to Mandarin Chinese using the preferential looking paradigm. The infants' gazing behaviour indicates that they can understand the canonical SVO and the non-canonical SOV *ba* resultative constructions. These results indicate that the functional projections responsible for the resultative *ba* construction are available well before children reach the two-word stage. In "Eye Tracking Children's Processing of Three Types of Recursive Computations Using PPs in Brazilian Portuguese," Aleria Lage, Anielá Improta França, Mayara de Sá Pinto, Nathacia Lucena Ribeiro, and Sarayane Miranda do Carmo Silva Costa report the results of eye tracking experiments, indicating that the processing of functional heads is part of the acquisition path going from unstructured to structured recursive PP structures. They investigate the stages and the computational costs of children's (mean age 5.5 years) computation of direct unstructured, direct structured and indirect recursion. The results indicate that while coordination (direct unstructured recursion) is easier to process than embedding (direct structured and indirect recursion), the latter is facilitated with overt prepositional heads. Wolfram Hinzen and Kristen Schroeder's contribution on "Functional Categories and Neurodiversity" discuss the language-thought connection through the lens of the lexical-functional dimensions of specific language profiles in major mental disorders. They point to the fact that autism spectrum conditions have linguistic repercussions on the upper functional layers of the noun phrase, affecting the configuration of definiteness, deixis, and Person. The fact that such functional layers are also affected in schizophrenia

and some dementias, also points to the relation between functional structure and specific cognitive functions affected in these disorders.

Results on the role of functional categories in early language acquisition are reported in Anna Gavaro and Jingtao Zhu's article, on the comprehension of recursive functional structure in language acquisition in Aleria Lage et al.'s contribution, and on the mapping of functional to conceptual structure in neurodiversity in the case of Wolfram Hinzen and Kristen Schroeder's article.

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