

★ REVIEWS ★

At the Interface of (Bio)linguistics, Language Processing, and Neuropsychology

Sanz, Montserrat, Itziar Laka & Michael K. Tanenhaus (eds.). 2013. *Language Down the Garden Path: The Cognitive and Biological Basis for Linguistic Structures*. Oxford: Oxford University Press.

by Diego Gabriel Krivochen

This book, part of the Oxford Studies in Biolinguistic series, presents a state-of-the-art overview of the field, more specifically, on psycho- and neurolinguistics and their relation to models of syntax, semantics, and morpho-phonology, while advancing its limits with cutting-edge research. A distinctive feature of the piece is the strong presence of interdisciplinary work and the internal coherence of the volume, integrating computational science, cognitive science, neurology and psycholinguistics, as well as syntax, semantics, and morpho-phonology; an integration that is most welcomed as it triggers debate and productive revisiting of the machinery assumed within all aforementioned sub-disciplines of linguistics. The volume is organized around the notion of garden path sentences, relative clauses, and their relations at the processing level; this includes major problems of natural language processing and the relations between syntax, semantics, and morpho-phonology from a more general point of view as well.

The editors have chosen to open the book with a reprinted article by Thomas Bever, from 1970 (which becomes a recurrent *motif* to which the contributors refer once and again as a departing point, thus giving structural and thematic unity and coherence to the book as a whole), a *locus classicus* for the psycholinguistic and neurocognitive approaches to ambiguity resolution, parsing (sentence perception, at the moment) strategies, and so-called 'garden path sentences' (GPS), the best known example being *The horse raced past the barn fell*, even if, as Tanenhaus claims in the Afterword, none of those is the prime theme of the work (but it is mostly about the relation between language and general cognitive strategies, an early plea for holism). The opening seems appropriate, since it provides the reader with an overall perspective on the studies of *language* as a concept analogous to those of "species or organ, as they are used in biological science" (p. 2). The article makes a case of distinguishing *language* as a mental/biological entity from *language* as a behavior; but, crucially, language structure and development are not to be isolated from the development of other cognitive capacities. Choosing this particular article is a statement in itself: Perceptual mechanisms, cognitive structures (including counting and number approximation, visual patterns and 2-D/3-D illusions), and linguistic structures (grammatical role assignment, abstraction of a structural pattern like 'active' or



morphological/syntactic 'passive'), trying to abstract common cognitive routines (taking the term from computational science) and statistically valid parsing strategies (where one of the most important features of the article rely), are analyzed in their interactions and complexity, without limiting the scope to narrow linguistic mechanisms (cf. Hauser, Chomsky & Fitch 2002 and their narrow concept of 'syntax'), but adopting a holistic approach to cognition. The properties of perceptual systems affect language acquisition and, therefore, adult grammar. The other way around, once the neurophysiological substratum of perceptual/behavioral systems is found, the question to be asked is how that substratum organizes and computes information provided by perceptual systems, via different kind of 'strategies' involved in acquisition and maturation of mental organs. Such a perspective, I think, should be taken into account more often in current biolinguistic studies, particularly given the very active role the relations between language, cognition, and brain have in Bever's piece (and throughout the volume).

The perspective put forth by Bever is reinforced and actualized in Chapter 1, by Montserrat Sanz, Itziar Laka & Michael Tanenhaus. Of particular interest is the claim that, if some structures do not appear, it is due to the fact that they might not be learnable (p. 81), which sets a strong empirical challenge to be addressed in upcoming years (apart from the attention it has received since Bever's foundational piece). The historical perspective adopted in this chapter (relating Bever's research with previous experiments by Piaget on development and learning) is essential not only for non-linguists who might be venturing into the field from a Biolinguistic stance, but also for scholars working within the field, as the chapter helps situating historically, justifying methodologically, and demystifying some pervasive claims in the field. Developmental psychology, as well as cognitive science, is revealed as a foundational stone for linguistic theories of acquisition, and more recently language processing research, essentially focused on the computational and neurophysiological nature of parsing. Some of Bever's strategies are summarized and discussed, and a partial classificatory typology is established. Within the limits of a book article, the piece provides a well-informed and wide historical scenario, including the aspects of past research that have had major impact on current research (including, but not limited to—and here lies one of the major contributions of the book in terms of wide potential readership—the Minimalist Program advanced over the past 20 years by Noam Chomsky and related scholars).

The book often looks back at itself and provides the reader with means to contextualize some specific papers (as is the case of chapters 8 and 12 with respect to the syntax–semantics interface), and the inclusion of opposing views is more than welcomed: For example, chapters 18 and 19 offer different interpretations of neurocognitive evidence regarding the existence of a set of uniquely linguistic elements (a 'Faculty of Language in the Narrow Sense' or FLN, in terms of Hauser, Chomsky & Fitch 2002), ranging from a defense of FLN to the claim that FL does not contain unique elements that cannot be found in other cognitive domains. This self-referential nature, and the pervasive interconnectivity between chapters is best explicated by a useful (although a bit confusing at first sight) diagram, which makes connections between chapters explicit, in terms of

themes and methodologies (p. 109). To the best of my knowledge, this is a rare feature in this kind of contributions to linguistic investigations, and I think the focus on such features should be encouraged regardless the personal opinion the reader might have with respect to the theory or theories entertained in each contribution.

Gerry Altmann builds on Bever's contributions in his 1970 paper in Chapter 2, while doing a review of the development of psycholinguistics from 1980 to this day. Empirically, his focus is set on the interpretation of GPS like (1), mentioned above:

(1) The horse raced past the barn fell.

The parsing that takes [the horse raced past the barn] as the matrix clause is misleading, as the introduction of a finite V [fell] at the end of the sentence requires a complete change of perspective when assigning a structural representation to (1). The chapter describes with clarity the evolution of thinking about garden path and structural ambiguity resolution (of the 'flying planes...' kind), from focus on the process itself to research on the cognitive procedures *before* parsing. Bever's contribution is taken as a departing point to discuss a number of approaches that emerged during the late '70s, and during the '80s and '90s, including the author's own research vinculating syntactic and semantic processing (as opposed to Bever's dissociative view, p. 115) via linking rules. Interesting perspectives blurring the distinction between syntactic and semantic processing, as well as competence and performance, are introduced; although references might seem a bit outdated if the reader wants to follow up to the chapter. The discussion about connectionist networks and their mainly statistical approach to meaning (based on Elman's work) in section 2.3 is clear and concise, but only one recent reference addressing the issue (Altmann & Mirkovic 2009) is mentioned, which I think is somehow anticlimactic. (The same actually occurs in subsequent sections: Relatively recent references are almost always limited to the author's own works, the only exception being the reference to a special issue of *Trends in Cognitive Science* from 2010.) This chapter is eminently descriptive/explicative (briefly introducing ideas and authors, and summarizing effectively three decades of psycholinguistic research while acknowledging the impact Bever's work had on computational linguistics and neural network research), and does not engage on independent argumentation or raise new questions: Its place in the book seems to me to be well chosen (as an introductory chapter), but it might disappoint the reader looking for original research.

Chapter 3, by Maryellen McDonald, also stems from Bever's considerations about garden path sentences, but confronting them with sentences like (2):

(2) The boy that the girl likes hit the man.

Both GPS and sentences with relative clauses containing an overt C [that], like (2), have been addressed from psycholinguistic points of view. However, and this is one of McDonald's points, seldom have they been discussed in a single piece, contrastively and comparatively. Like Lin in chapter 4, McDonald rejects

the proposal that GPS and complex, but unambiguous, sentences are processed under different assumptions: The goal is to bridge the division of the field of sentence comprehension by unifying those two apparently different kinds of processes. McDonald sheds light over Bever's initial assumptions regarding a constraint-based system of ambiguity resolution, and relativizes the equation noun + verb = subject + verb by including not only syntactic patterns into account, but also lexical information and extra-linguistic resources (e.g., speaker identity, visual environment, etc.; p. 132). It is relevant to point out that the constraint-based approach has not been applied to relative clause interpretation (at least not widely), since they are traditionally believed to be unambiguous, and constraint-based systems have usually been associated to ambiguous sentences. Work in relative clause processing, summarized in chapter 4, has mostly appealed to a two-stage system, in which syntactic processing precedes semantic effects. Chapter 3 has as its goal to apply Bever's general ideas, expressed through a constraint-based model, to object relative clauses (i.e., relative clauses in which the *wh*-operator is the object of the embedded V). The exposition takes into account computational limitations in human minds, as well as factors such as memory limitations and interference, when rejecting purely structural accounts (i.e., accounts based primarily on independent syntactic processing) in favor of a constraint-based system as a model for general comprehension, which implies a simpler and more coherent theory. The argument requires development of research of ambiguity within relative clauses, which is provided in a complete and clear subsection (pp. 135ff.), providing recent and relevant references to the interested reader. The discussion of the author's own work towards integration of both phenomena (GPS and relative clause processing), as announced, takes into account the animacy feature of the relative clause's antecedent as an important cue for interpretation, thus resorting to lexical/semantic factors as well as structural information (e.g., the antecedent is coindexed with the object of the relative clause). To complete the chapter, a discussion of *production* models is provided, with which the offered perspective is even wider, even if production is addressed almost exclusively from a statistical perspective which takes into account tendencies regarding animate and inanimate antecedents. The references in this section are mostly the authors', and the paper concludes almost surprisingly, with section 3.5. A conclusion section, summarizing the highlights of the piece, would have been welcomed. However, it does advance some lines of current and future research.

Chapter 4, by Chien-Jer Charles Lin, is intimately related to chapter 3, as it deals with relative clause processing. However, unlike chapter 3, it draws heavily on Chomskyan generative grammar, which leads to claims of the kind "they [relative clauses] demonstrate three critical formal properties of human language: recursivity, the existence of empty categories (e.g., traces), and constraints on dependencies related to those categories" (p. 142). These are problematic claims, insofar as no independent evidence is provided, nor are alternative accounts discussed. For example, there is a debate about the role of recursive procedures in natural language (which are obviously not the same as recursive functions as defined by Gödel 1931 [1986]) which the author overlooks; the same happens with the existence of empty categories in the sense of Chomsky (1981), namely

wh-trace, NP-trace, *pro*/PRO, which require a strong burden of independent proof (as it is possible to conceive internally coherent frameworks without the need to resort to traces/copies) and has been challenged from more than one front (e.g., Culicover & Jackendoff 2005). This is not to say that the author's arguments are to be rejected; it just means that the argumentation does not take into account alternative frameworks and is in this way limited. The discussion on relative clause processing relies crucially on the interpretation of *gaps*, and the establishment of *filler-gaps* dependencies. Notice that the notion of *gap* as presented by Mainstream Generative Grammar requires, as Culicover & Jackendoff (2005: 16) put it, 'hidden levels of syntax', related by means of structure mapping operations. In my opinion, no sufficient *independent* evidence is provided in this piece to accept that conclusion. The author proposes parallel syntactic and thematic (semantic) processing strategies (the latter comprising 'templates' which are activated automatically, in relation to Bever's N + V = Subject + V procedure), but does not specify whether thematic information can be used by the syntactic parser and vice versa (cf. chapter 3), which is, I think, a gap in the argument. Moreover, both representations must match (p. 144), but no details are provided with respect to how exactly this process takes place. Multiple recent references are provided, and, should the reader accept the initial assumptions, the discussion is internally coherent and consistent. My objection to the structure and content of this chapter stems precisely from the lack of justification for those initial assumptions, too strong to be taken for granted. Empirically, this chapter provides comparative evidence from English and Chinese, a most welcomed strategy, and processing asymmetries in production and comprehension of relative clauses are justified with this comparative evidence. Unfortunately, no future prospects are provided, and there is no independent conclusion section.

The next chapter focuses on English data, and relates to chapters 3 and 4 insofar as its object of inquiry is the processing asymmetries of subject and object relative clauses, and complexity issues related to this processing. While not committing themselves to any particular theory of syntax (unlike the previous chapter), a substantial amount of literature is provided by the authors Edward Gibson, Harry Tily & Evelina Fedorenko in each point of the discussion, and cross-linguistic studies are also mentioned (although, as clearly stated in the chapter title, concrete cross-linguistic data is not discussed). The chapter is organized in three main parts, corresponding to three main theories about complexity issues arising in the processing of extraction effects: Section 5.2 is devoted to *reanalysis theories*, according to which an incorrect parsing (e.g., interpreting [raced] as the main V in (1), with [the horse] as its subject, following the N+V = Subject +V procedure) is to be somehow repaired (although no details is provided about how this is performed, even within the discussion section 5.5); section 5.2 discusses *experience-/surprisal-based theories*, according to which interpretation is a statistical function of previous experience with similar input (e.g., more frequent words are easier to process), both at the word-level and the phrasal level. This section presents more discussion, and brief reports of different tendencies within the general approach, something that would have been desirable for reanalysis theories as well. Finally, *memory-based theories* take into account *working memory* capacity, and predict more complexity in ORC proces-

sing because they imply both more *storage cost* (maintaining a dependency active, as would be a relative operator and its associate base position) and more *retrieval cost* (retrieving word-meaning from LTM, for instance). Once again, a concise discussion about alternatives is provided, and in the last two sections the reader can find recent relevant references. Section 5.5 summarizes the predictions each group of theories would make, and provides evidence for each. The discussion is extremely neat and very well organized, the arguments can be followed with no difficulty, and for each empirical problem a substantial load of references is available. Section 5.6 problematizes the predictions made by each theory, with the interesting and thought provoking claim that no theory by itself can explain all considered phenomena; followed by section 5.7 in which two experiments including the relevant data, considering as a variable the possibility that a single NP can fulfill or not several grammatical functions with respect to the verbs, are carefully reported (including participants, methods, and results) and discussed from each viewpoint, spelling-out the predictions each theory makes applied to the experiment in question. The permanent discussion between theories and the specific predictions they make in different cases (with particular focus on variants of memory-based and experience-based theories) is one of the highlights of the chapter, and is very welcomed as a methodology for the presentation and contextualization of both the frameworks and the data. In the conclusion, prospects for the application of retrieval-based theories (a subtype of memory-based theories) to languages with different basic word order than English (SVO), like Japanese, Korean, or Chinese are presented, and constitute a further challenge for the retrieval-based framework the authors mostly support, while always arguing convincingly and with various sources in favor of mixed approaches and not relying on a single mechanism to explain such a complex phenomenon as RC interpretation.

Chapter 6 is built upon the concept of *psycholinguistic chain* (P-chain), which relates production, prediction (error), and (consequent) acquisition in a novel form, with modifications presented in the chapter. The first approximation to the P-chain would be as follows (p. 175):

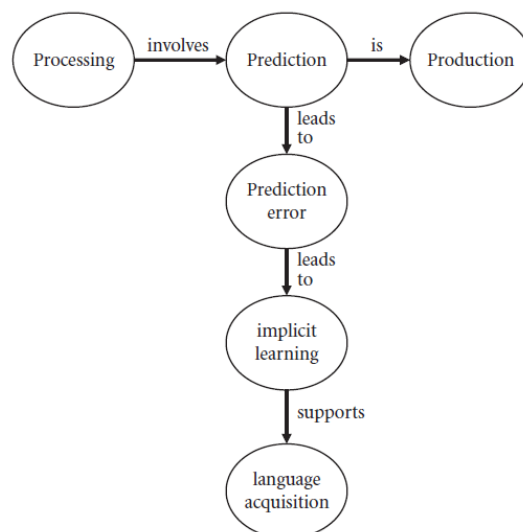


Figure 1: *Psycholinguistic chain*

The authors (Gary Dell & Audrey Kittredge) argue their way through the P-chain in a clear and concise manner, providing theoretical and experimental support for their claims, and relating language with other cognitive capacities (e.g., eye-tracking), as well as stressing the mutual relation between processing and production, as well as implicit learning and prediction (as loops in the chain), making the model more dynamic and powerful. Section 6.2 is devoted to full explication and argumentation of the claims involved in the P-chain framework, dedicating particular subsections to each of the 'links' so that the reader can have a general idea of what the framework is about, and how it impacts on empirical research. The framework is contextualized historically (in relation to previous theories) as well as epistemologically (in relation to contemporary alternatives), which is a great help for readers with a limited background on psycholinguistics and its development. The chapter presents a most interesting view of acquisition, in which partial errors in structural/lexical prediction lead to changes in the linguistic system (a perspective that is perfectly compatible with recent advances in complexity theory and language as a complex system), resulting in the readjustment of the system (acquisition). Overtly independent of syntactic frameworks like Generative Grammar, the article assumes the existence of "an 'innate' architecture that has the ability to learn sequences and to represent meaning" (p. 179), which, exposed to input (sentences, their meaning being inferred from the context), corrects activation weights in neural networks and the system thus acquires a structure *and* its meaning, based on a 'trial and error' basis. While objectionable (particularly from the viewpoints of formal syntax and semantics, as the computational/neurocognitive nature of syntactic structure is not made explicit), the framework is a dynamic attempt to coherently relate three essential processes in language use, external or not. It is to be noticed that the case study presented by the authors involves phonotactic learning, which does not have the articulated structure that is currently theorized for syntactic representations or semantic structures. It should be a challenge (and a desirable and exciting development) for the P-chain theory presented here to try to accommodate the RRCC data presented in previous chapters and the acquisition of discontinuous Operator-Variable syntactic dependencies, to give some examples.

Chapter 7 gets back to Bever's article as a foundational stone for many issues of present relevance for psycholinguistics. David Townsend focuses on four claims deeply related to Bever's paper (in fact, reformulations of Bever's strategies) and provides theoretical and empirical support for them (p. 184):

- Comprehenders form linguistic structures.
- Linguistic elements project structure.
- Common representations interact.
- Grammar checks the adequacy of projected structures.

Given the strength of some of those claims and/or the theoretical and empirical consequences they have, it would have been nice to define some key concepts, like 'structure formation' or 'projection', of crucial relevance in current theoretical linguistics, particularly within generative grammar (from which the author takes concepts, like 'traces' in p. 191).

The author compares and confronts the program advanced by Bever with previous theories (e.g., Derivational Theory of Complexity), providing evidence in favor of the former. Each of the claims above is expanded on in its own section, which also features Bever's original interpretative strategies for reference and clarification. Garden path effects are compared with other kinds of parsing ambiguities (e.g., homonymy), and argument alternations (e.g., *The dancer tripped John/The dancer tripped*), which also affect the assignment of a structural description to a certain string. The author introduces concepts about verb semantics (like 'bounded verbs') and the requirements they establish for co-occurring arguments which are not formalized or made totally explicit, however, the argumentation can be followed without problems. Section 7.4 clarifies the somehow obscure *sentential* 'common representations interact', by making a case for the interaction of syntax and semantics, and how comprehension makes use of structural and semantic information simultaneously, while comparing and contrasting competing theories with experimental basis (although little independent evidence is mentioned at this point). Section 7.5 explores the means by which grammar and meaning interact via patterns that provide provisory semantic representations to be refined in real time, although no clear definition of what 'grammar' comprises is given (sometimes it seems to be used as a synonym of 'syntax', but that is not clarified). The section is carefully argued, and extends on the mechanisms via which comprehenders anticipate meaning and structure in terms of conceptual and/or linguistic representations.

Chapter 8, by Robert Berwick, is more narrowly linguistically oriented. Taking as a 'cornerstone' of Bever's seminal article to highlight Chomsky's (1986) distinction between *knowledge of language* and *use of that knowledge*, the author attempts to provide a synthesis between internalist and externalist models of language. External modeling is identified with statistical methods in corpus linguistics (and part of computational linguistics as well, including insights from information theory), having as its aim to be able to predict the next element to appear in a string, in turn assuming a certain model of comprehension based on memory-retrieval, as we saw above. Internal modeling (which the author identifies with Chomskyan generative linguistics, which is a perspective I find quite limited, given the amount and quality of alternative formal internalist approaches), on the contrary, focuses on simplicity at the time of formulating generalizations about the mentally represented knowledge a speaker has in its mind-brain. The author proceeds to discuss formal grammars in section 8.4, assuming that the subset relations expressed in the so-called Chomsky hierarchy hold (but see Krivochen 2014 for a critique of such a claim both theoretically and empirically grounded). The argument expands on that made in Chomsky (1957) about the inadequacy of Markov models to account for linguistic structure, as they are based on linear relations (a claim which has to be, at best, relativized to portions of natural language grammars, as I show in Krivochen 2014), which is useful for the reader more familiar with neurolinguistic literature than with the foundational texts of generative transformational grammar, but adds little if anything to the discussion about the adequacy of certain formal grammars to generate structural descriptions for natural languages or particular segments of them. A main concern of the author seems to be to establish a comparison pro-

cedure for grammars, understood as sets of (generative + transformational) rules, which favors phrase structure grammars (a claim traceable back to Chomsky's early writings). The author points to an apparent tension between statistical methods and linguistic description, given by the fact that constituency tests do not always coincide with statistical preferences (p. 201), such that, for instance, the syntactic constituents [VP walk [PP on ice]] are differently chunked when it comes to statistical prediction, and the P [on] is more likely to appear with [walk] than [walk on] is to appear with [ice]. The proposed solution is highly theory-dependent, and consists on substituting a standard phrase structure grammar with Bare Phrase Structure (BPS), in which there are no labels (for details, see Chomsky 1995). However conceptually appealing the proposal might seem, there are to the best of my knowledge no neurocognitive accounts that support such theory, what is more, performance compatible models (e.g., Sag & Wasow 2011) provide more explicit accounts of the apparent tension between knowledge and use than the alternative proposed here, strictly tied to the Minimalist Program. Weakening the conditions for predictive models is not, in my opinion, an advisable methodological step. The announced synthesis consists on taking BPS as higher-level instructions that generate particular instructions (knowledge put to use), appealing to the (digital) computer analogy, and acknowledging the combination of different information sources (a recurrent motif throughout the volume). In spite of the multiple theoretical biases we find here when it comes to internalist linguistics, the argumentation is clean and neat, and the reader who is not familiar with the field of formal grammars will find a nice introduction to some old but still relevant arguments.

Connected with the linguistic concerns of chapter 8, Chapter 9 also introduces the discussion of Center-Embedded Clauses (CEC) within the framework of Chomsky's version of the Minimalist Program. Janet Fodor links Bever's strategies (which are not language-specific) to the (methodological) desire to minimize the specificity of the Language Faculty and allocate as many properties of language as possible in other cognitive systems, so-called 'external systems'. CEC present discontinuous dependency patterns like (3):

- (3) The dog the cat the fox was chasing was scratching was yelping.
(Bever 1970: 334)

Fodor presents recursion and movement (transformational rules) as two *facts* about human language, for the second time in the volume (cf. chapter 4), thus restricting her theoretical framework (and the syntactic representations she uses) to Minimalism (without acknowledging much discussion about the nature and properties of recursion, including problems concerning its very definition). She describes CECs as particularly difficult to parse while not presenting differences with other kinds of clauses in terms of multiple embedding or movement rules. In opposition to previous accounts based on structural subadjacency, Fodor reformulates Bever's *Strategy J*, regarding the relative roles of NPs in NP, NP, ..., V configurations and the assignment of grammatical functions within their respective clauses. She holds the threshold of two levels of embedding as providing particular processing problems, while deriving it from the syntax-prosody

interface. Her account relates the assignment of structural descriptions to units based on the prosodic contour of local units, in turn relying on the idea of local phonological cycles and the necessity to wipe the working memory clean of structure as soon as possible, several times during a derivation. Fodor provides cross-linguistic variation patterns of RC attachment preferences, based on derivational chunks ('packages', similar in spirit to Chomskyan *phases* but psycholinguistically supported) and the difficulty of the parser 'looking into' an already finished package, which is subjected to interpretation as a unit. The packaging mechanism would not be directly derived from memory issues, but from prosodic patterns (which are present even in silent read, the so-called 'Implicit Prosody Hypothesis'), thus cross-linguistic variation can be accounted for without the need to suggest different speakers of different languages have different working memory capacities. The article has important consequences for the theory of phases and syntactic locality in general, although a discussion of the implications this theory has for semantic cycles would be necessary in order to implement the model within a wider program. The author integrates phonological and lexical information, but it is not clear whether the packaging occurs on the meaning side as well as on the sound side, an interesting challenge for the theory presented here to address. The prosodic interface and inner structure of intonational phrases are however described with great detail, and even if a one-sided (i.e., taking into account only the sound interface) explanation of the phenomena involved does not seem plausible to me, the evidence is carefully presented and the arguments follow from the initial claims with no gaps, should one accept the path taken by Fodor. The author herself provides a discussion of non-prosodic explanations in section 9.5, focused on syntactic accounts mainly worried about structural distance between dependent constituents for memory reasons (which do not coincide with the "distances that matter for prosodic parsing", p. 228), and giving arguments in favor of the superiority of the prosodic account in terms of predictions. In relation to the previous chapter, a mention of Markov models for phonological structure would have been a nice link (as there is a mention of 'flattening' structure at the syntax-phonology interface, p. 217), but it is a task left for the reader to undertake.

Chapter 10 takes the reader back to neurocognitive issues, drifting away from generative linguistics. Brian McElree & Lisbeth Dyer focus on the role of working memory in deriving linguistic expressions in real time (a topic explicitly left aside in generative grammar), and how linguistic processing is limited by non-language-specific constraints on the amount of structure that can be processed at any given time. The authors, advancing Bever's (1970) inquiries on the role of memory representations during comprehension, its nature, and the factors determining the success or failure of memory-involving processes; provide a much needed gap-filling, since there has been surprisingly little research on working memory and its relation to real-time language processing, particularly when facing long-distance dependencies between constituents. The authors review previous theories, problematizing tricky notions like 'processing complexity' (which are taken for granted in many narrow-syntactic works) and critically evaluating their impact on different accounts of memory-limitations approaches to comprehension, impairments (e.g., as result of brain injuries), and reduced

processing capacities, providing the reader with a fair amount of relevant bibliography on each section. The very notion of working memory as opposed to a retrieval-only Long Term Memory (LTM) is challenged, insofar as empirical evidence has not been conclusive enough to postulate two separate systems, and a more dynamic system is argued for, in which WM does not have a fixed capacity (cf. Miller's 'plus-minus seven units'), and information retrieval does not seem to be privileged or faster for elements predicted to be in the WM with respect to elements predicted to be in LTM. Therefore, a fixed approach to WM is inadequate, the authors claim, and a dynamic real-time approach is necessary to account for comprehension phenomena. Section 10.3 is devoted to information retrieval in language comprehension, comparing predictions about the respective roles of WM and LTM with exemplified experiments (only essential details and general discussion). Retrieval models are relevant insofar as cue-driven retrieval can account for both rapid access to information as well as failure to pick the relevant piece of data out (importantly, this is not limited to language, but applies to "any complex cognitive skill", p. 238), if the cue does not point towards the required information with enough specificity, what is called 'retrieval interference', there being the possibility of overlapping between cues. This model can provide the flexibility that fixed WM accounts lack, and the authors carefully argue their point. The claims about memory and retrieval possibilities are adequately exemplified, with clear cases and a concise account of each, without adhering to any particular grammatical formalism (which is a positive note, insofar as the reader can translate the results to the framework of his preference). The reader is lead through the discussion gently, with numerous and recent bibliographical sources.

The next chapter, by Ina Bornkessel-Schlesewsky & Mathias Schlewsky, touches on a crucial point for both grammatical theories (including syntax, semantics, and morpho-phonology) and neurocognitive approaches to language: the role and identity of universals. The authors begin with an overview of the concept, and the (relative) dissociation between linguistic universals and cognitive universals (already drawn by Bever), as well as the present difficulty of finding real universals, particularly after the tremendous growth of typological studies, which often force theoreticians to relativize universals into tendencies. The authors' goal is to combine neurocognitive research with linguistic typology, in so-called 'neurotypology', a most interesting aim and certainly welcomed gap filling in (non-UG-driven) research on universals. The enterprise is based on a dynamic approach to the relations between language, brain organization, and (general principles of) cognition. Specific linguistic characteristics would be given by a direct relation between properties of the brain and properties of language, without mediation by cognition. The authors discuss a number of related proposals which address topics underlying the aforementioned tripartite relation in section 11.2; and address the issue of inter-linguistic variation in section 11.3, providing evidence of different neurological responses to form-meaning conflicts in different languages, supported with a good deal of references and brief, but effective, experiment reporting. This section makes a point of qualitative inter-linguistic variation from a neurological point of view, which the authors attempt to derive within a framework based on Bever's strategies, particularly the NP-V-

NP pattern as *actor–process–undergoer*, and the properties of a given language in terms of cognitive categorization and decision-making. The notion of ‘cue’, which has already appeared in the volume, is of key relevance here, as languages seem to rely of different cues when assigning semantic roles to arguments in a syntactic construal (p. 247). In spite of differences, it seems that the cognitive system prefers prototypical actors and actor-initial argument orders, in order to identify roles as quickly and effectively as possible, a conclusion supported by inter-linguistic electrophysiological studies involving languages belonging to different families (Germanic, Altaic, Romance) and typologies (accusative vs. ergative languages). Asymmetries between actors and undergoers (patients–themes in theta-theoretical terms) are also attested, always providing neurophysiological evidence (which considerably strengthens the argument), which the authors interpret as a ‘competence’ for the actor role (p. 249), depending on the prototypicality (animate, human, definite, nominative/absolute) of the competing arguments, a competence which does not arise for other argument roles. This competition, the authors claim, is a plausible universal of linguistic processing (which is not to be confused with a proper linguistic universal of the kind advocated for in UG-based proposals or even Greenberg-type universals). The authors introduce the category of ‘neural attractor’ for the actor role, insofar as it is that role which triggers the competence between arguments in processing. Moreover, this competence could be modeled by means of attractor networks, which is in itself an exciting empirical challenge for the neurotypological enterprise (and its collaboration with related disciplines, particularly mathematical modeling of complex systems) in future years.

Chapter 12 focuses on the syntax-semantics interface (arguably, a topic also present in chapter 11, taking into account its concern for role assignment in processing), and the respective takes of formal syntax (assuming the Minimalist Program, in detriment of alternatives which are not even mentioned) and psycholinguistics. Montserrat Sanz provides a useful *racconto* of the takes on thematic structure from GB to Minimalism, and problematizes the mapping between semantic construal (in which notions like ‘event’ are core) and syntactic construal (which works with formal, semantic, and phonological features, in the theory assumed by the author). Sanz claims that linguistics deals with competence, whereas psycholinguistics deals with performance, a claim that leads to justifying Chomsky’s seminal distinction. However, the distinction has blurred in several occasions, and unifying theories have been proposed (some in this very same volume, but see also Sag & Wasow 2011 for an alternative outside transformational generative grammar), whose discussion would have been welcomed. The author’s take on the syntax-semantics interface is heavily influenced by the strong role features play in the Minimalist program, and parsing is also tackled from this stance. This perspective, while not extent of problems (particularly given the difficulty of assigning neurocognitive reality to formal features, which are at the very core of Minimalism), is novel and therefore welcomed; and whereas the concept the author has about what constitutes the syntax-semantics interface can be discussed, it is a pushing-forward development of the initial Minimalist desire to explain properties of language in terms of output conditions established by the C-I and S-M interface systems. Moreover, it critically discusses

both exclusively syntactic and exclusively semantic attempts at explaining the parsing difficulties of GPS, which strengthens the interface approach to linguistic phenomena. Assuming the Minimalist Program (Chomsky 1995 *et seq.*), then, the article is not only reader-friendly and well-grounded, but also provocative (at least for the most orthodox takes on the role of the interfaces in parsing). The author is very careful in including multiple factors into account (e.g., Aktionsart, lexical syntax/semantics, verb typology, etc.) when arguing in favor of a particular take on GPS processing, and provides relevant references for each factor. Considering these variables, Sanz argues that there is a gradient of difficulty for GPS processing, which is more easily accounted for assuming aspects of lexical semantics and compositional properties of the Verb Phrase and the event it denotes (including Aktionsart) than ignoring those factors. The discussion turns highly technical when the author considers the possibility of including an Event Phrase as a functional projection in the syntactic construal, whose interpretable features are read off at the semantic component. The author claims that thematic roles are *parsing necessities*, not grammatical necessities (*contra* those approaches within Minimalism, like Hornstein 2003, that consider theta roles as features to be checked *before* the derivation reaches the interfaces): This claim has potentially interesting consequences not only at the empirical level, but also when considering the ‘design’ problem for the Faculty of Language (for those approaches that assume such a notion). Within the theoretical limits imposed by the Minimalist Program, Sanz makes a valuable contribution, and advances the ground in relevant and little explored aspects of the (lexicon-)syntax-semantics interface(s).

Massimo Piattelli-Palmarini tackles the issue of Platonistic vs. Cartesian approaches to language, which has been the topic of recent debate (see, e.g., Watumull 2013 for an attempt of unification, and Behme 2014 or Krivochen 2013 for a critical view and extended discussion). The main issue is whether linguistic objects can be abstract and biological or not, and the ontology of derivations and the generative system in each case. Piattelli-Palmarini makes an assessment of the role of abstraction in linguistic theory, clearly aligned with the Chomskyan view that there is no ‘knowledge of language’, as ‘language’ itself is the knowledge a speaker has in its mind-brain, UG and the grammar of a particular language (p. 264). The article is clear and well-organized, although key notions are left undefined (as in most of the papers constituting the realist-conceptualist debate), ‘abstract object’ being perhaps the most important. The author argues his point with empirical evidence regarding so-called ‘conservativity’, a set-theoretical property according to which $A \cap B = (A \cap B) \cap A$. This is particularly revealing of the framework he assumes, since the Minimalist generative operation Merge forms *sets* (Shieber’s 1986 Unification also works with sets, but the resulting object is not characterized as identical to either of the terms involved in the operation, but as the union of the feature matrices involved). This property is said to hold for determiners (a linguistic label) *in all natural languages* (references are provided for this claim, but only few examples outside English are analyzed), however, the examples actually involve existential and universal quantifiers and their logical properties, p. 266 (regardless their materialization, namely morpho-phonological form, this is an important distinction). Piattelli-Palmarini compares English determiner ‘the’ and its properties with imaginary determiners for which

the property of 'conservativity' does not hold, and claims that non-conservative determiners would invert the logical properties of the word class as a two-place predicate. In my opinion, there is a mix between linguistic and logical properties of determiners (a trend traceable back to Russell 1905), which makes the discussion a bit hard to follow if one distinguishes logics from (formal) grammars of natural languages. It is also not clear whether the property arises at the semantic interface or is relevant in the so-called 'narrow syntax', although the second option is hinted at—insofar as feature checking considerations are mentioned, but the exact *locus* of conservativity relevance is not formulated explicitly: The mention of 'syntactico-semantic structures' (p. 268) does not clarify the matter, as 'semantic structures' is left undefined. After the consideration of the examples, and discussion from a Minimalist stance, section 13.3 dwells with the status of this 'universal', and goes back to the initially mentioned debate between realism and conceptualism: The author's hypothesis is that the universal follows from a property of the Language Faculty, even if the motivation for this property is "outside the domain of linguistics" (p. 270), which is at least an anticlimactic claim: Why should it be outside the boundaries of linguistic inquiry, particularly considering the 'biolinguistic enterprise'? Sections 13.4 and 13.5 (the latter, a conclusion) focus on the properties of 'abstraction' as a cognitive operation, but the exact nature of 'abstract objects', central to the realist-conceptualist debate, is never clarified. Nor is the highly problematic notion of 'virtual conceptual necessity', introduced at the very end (p. 271). The article is reader-friendly, particularly for those who are familiar with the assumptions and axioms of the Minimalist program, but is very likely to leave other readers asking questions about the overt and covert assumptions that guide and underlie the argumentation.

Chapter 14 follows on the topic of determiners and their role in the core syntax, but from an *empirical* stance, which is most welcomed. Methodologically, Virginia Valian chooses to begin by justifying her selection of determiners as the object of study, which is a rare and welcomed feature in innateness-related studies. Moreover, the author (briefly) addresses the issue of what is innate and what is learned/acquired, again a point in favor of the methodology followed in this article. The author's concern to make her assumptions fully explicit before entering data discussion (limited by space reasons) is ostensive and clarifying. The study includes careful analysis of determiner acquisition timing: Experiments, rather than being fully explained including methods, participants, and results followed by discussion, are directly discussed, even though relevant results are incorporated in tables. Empirical predictions stemming from the claim that schematic representations of determiners are innate are spelled out, and they involve continuity on the developmental trajectory (p. 276). Evidence in favor of a continuity approach is provided, including the crucial notion of *underspecification* and its role in acquiring the relevant elements; as well as *equivalence classes* (how the class of 'determiners' is abstracted from the data, and, conversely, how elements in speech stream are assigned a class). After discussing what the author hypothesizes to be innate, and providing experimental evidence in favor of her hypothesis; she proceeds to discuss what is left to be learnt in section 14.5. Three factors are identified here: prosodic templates, knowledge of specific lexical items, and controlled processing including several sources of information.

These factors are succinctly explained, and it would have helped the reader to have a separate conclusion summarizing the main points of the piece, as well as including future prospects and empirical challenges. The article is nevertheless a valuable piece, as it relies on experimental data to make assertions, and predictions are clearly spelled out, which makes them falsifiable and thus scientifically interesting.

In Chapter 15, Simona Mancini, Nicola Molinaro & Manuel Carreiras analyze the concept of morphological *agreement*, from the perspective of the Minimalist program, in which feature agreement triggers operations like Move and even, in some versions of the theory, Merge (e.g., Wurmbrand 2014). Despite considering features (of the kind [*value*, *Dimension*], as in [*Past Tense*]) “the basic building blocks of a derivation” (p. 282) as in orthodox versions of Minimalism (a claim shared with models like HPSG and LFG) but an assumption that has not remained unchallenged (e.g., by Cognitive Grammar, Construction Grammar, and the like), the authors provide a novel perspective over so-called ϕ -features, a bundle including *person*, *number*, and *gender*, from a psycholinguistic stance. The thesis is that, since there are differences in the processing of each kind of information, those features should not be treated as a single unit. The authors distinguish between morphosyntactic information conveyed by a feature (ϕ -value) and the semantic-pragmatic information concerning the *denotatum* (σ -value). That is an interesting distinction insofar as ϕ -features are traditionally thought to be uninterpretable by LF, and the notion of σ -value makes a point of the semantic relevance of those features, at the cost of introducing yet another distinction in a theory that is already quite far from ‘minimalist’. The discussion is clear, and examples are clarifying, particularly given the fact that new notions are introduced, like σ -value or ‘interpretative anchor’ of a feature (its σ -value). Theoretically, there is a further complication represented by matching operations between both sets of values, but if the enterprise pays off empirically, the complication will have been justified. The article does not present so detailed an analysis that we can be certain of this, but it is a challenge to be addressed in future research. However, section 15.3 tests the validity of the approach against psycholinguistic evidence, including ERP patterns for some of the Spanish examples cited, which reinforces the point, as well as analyses of N–A and V–N agreement patterns, including acceptable morphological mismatches and their subsequent explanation in terms of the model presented here, both theoretically and via psycholinguistic evidence in processing. It is not clear that the data cannot be accounted for via different agreement patterns, as the alternative is not considered (which opens the door for future simplifications of the theory), but the level of descriptive adequacy is reached, and, should one adhere to feature-driven operations in the syntax, so is explanatory adequacy. A point in favor of the article is that there are comparisons drawn between what would be expected in mainstream models of comprehension (involving ϕ -features as a single bundle) and the ‘anchor’ model presented in the article, which helps situating the proposal within the field, in relation to alternatives. The dissociation between ϕ - and σ -values allow the authors to explain qualitatively different patterns in neurocognitive studies between person mismatches and number mismatches, which advances the ground with respect to orthodox agreement research. The

notion of σ -values and anchors could have been developed further, and future prospects for the theory could as well have been given, but the perspective of the piece is overall interesting and novel within Minimalist assumptions.

Colin Phillips, in Chapter 16, revisits Bever's parsing model, in which an initial hypothesis about meaning is the result of a 'quick and dirty parsing', to be later on replaced by the definitive representation of the linguistic expression's meaning. The article critically reviews the relation between mental grammars and parsing, as well as the psychological reality of grammatical representations, and the historical relations between generative transformational grammars and psycholinguistics, focusing on the problems the transformational component brought about for psycholinguistics given the uncertain psychological status of transformational rules. Early empirical research seemed to support the general view about a generative component, but the conclusions were at best elusive when considering transformations (e.g., the impossibility of 'reversing' a transformation). The historical review is helpful for the reader, insofar as it presents hypotheses and experiments carried out in the early days of generative linguistics in a concise and clear manner, as well as the theoretical and empirical challenges the data imposed to transformational models. The author also addresses the difficulties presented by the Derivational Theory of Complexity, and the necessity to critically revisit the basic ideas the DTC presented and are nowadays still in use. Phillips considers, as empirical points the incremental character of linguistic parsing, which is incompatible with Standard Theory's rewriting rules (based on L-grammars), and the problems posited by sentences which had apparently undergone a transformation, whose interpretation required additional stipulations in the psycholinguistic side in order to comply with the model of the grammar. Section 16.4 is focused on discussing Bever's 'double interpretation' model and plausibility-based strategies, suggesting that comprehenders build fully-fledged representations for sentences (p. 306), a claim that is not incompatible with probabilistic heuristics. Phillips' discussion includes numerous references to experiments succinctly described, as well as bibliographical references which are of much use for the reader to have direct access to primary sources of the cases reported. It is to be highlighted that potential objections and counter-arguments (often related to Bever's account and similar purposes) are considered and properly addressed by Phillips, which makes the point stronger and also leads the reader gently into the conclusions. The article makes a point of the necessity of looking for more than one way to account for processing phenomena, suggesting alternatives and considering (within reasonable space limits) the theoretical and empirical implications of each possibility (section 16.7 and the revision of Townsend & Bever's 'analysis by synthesis' is a fine example of this tendency). While acknowledging the importance of Bever's research for the interaction between grammar and psycholinguistics, Phillips presents a critical panorama and points towards several possibilities for future prospects.

Edward Stabler analyzes the relation between language and cognition from a computational perspective in Chapter 17. The author problematizes accounting for linguistic variation, the lack of consensus upon basic theoretical notions (both major issues in current formal linguistics), and the identification of psychological processes involved in linguistic parsing in section 17.1, which helps situating the

problematic interplay of computational linguistics and psycholinguistics in context. Section 17.2 presents some basic notions about which there is, apparently, more consensus than often acknowledged, although oversimplifying some issues: While Joshi's (1985) claim that natural languages are mildly context-sensitive is indeed widely accepted (p. 318), it is also to be noticed that there has been research on the Markov nature of morphophonology from the 80's onwards, as well as higher-level, Turing computable models for linguistic theory (see, e.g., Watumull 2012). Therefore, his subset relations between formal grammars, centered on Minimalist Grammars as defined by Stabler (1997) and Michaelis (2001) leaves aside many important and relevant issues both computational (e.g., the alternative models that have been developed beyond Minimalist Grammars, including Unification-based grammars, to give but one example) and empirical (their descriptive/explanatory adequacy). The author centers his attention on Context-Sensitive Minimalist Grammars (CSMG), including a transformational component (as he formalizes the notion of movement in a Minimalist tree, p. 321). All theoretical biases notwithstanding, Stabler attempts to unify formalisms in order to address fundamental issues arising in various versions of the Minimalist Program (like the existence of traces and multidominance alternatives, and the computational nature of Merge, as well as learning methods). Section 17.3 proceeds to briefly discuss the relation between CSMG and psycholinguistic research, departing from Bever's work, and including automata theory. Stabler argues in favor of the existence of computational universals, which he opposes to 'concrete universals', an interesting distinction particularly considering the content of chapters 11 and 13; it might be interesting for the reader to see if the 'conservativity' property Piattelli-Palmarini proposes as a universal holds, and how if so, in a CSMG. Unfortunately, the distinction is not developed to its full extent, no examples are provided (this holds all throughout the article), and the chapter ends quite abruptly. It does, however, provide some future challenges to be addressed from a computational perspective for linguistics and psycholinguistics.

Chapter 18, by Luciano Fadiga & Alessandro D'Ausilio, focuses on the relation between 'action' (so-called 'motor system', although it is clarified that more than a single area of the brain) and language, digging into the problem of how several processes are temporarily organized, and how 'actions' obey an end, related to the issue of problem-solving. The issue is relevant for language insofar as there are common characteristics found in problem-solving and language structure, like recursivity (with due distinctions between nested structures and strict sequentiality, the latter of which is problematic), which is not technically defined, but in this paper seems to be synonymous with 'hierarchy' (even though it is not the case that all definitions of recursive functions would be compatible with this approach, particularly given the fact that we can have hierarchy without recursion, in a non-trivial sense, if recursion comprehends [X...[X...]] structures and we operate only with hierarchy without center embedding, appealing to monotonic applications of a generative function). This relevance is somehow difficult to see in the first sections of the chapter, devoted almost entirely to the motor systems, their functioning, and comparison with other systems (like the visual system). The properties of neural networks on which the motor systems depend are also explained, with references where applicable. Only

in section 18.3, devoted to Broca's area, can the reader begin to establish a relation with human language, given the key importance of this area in language processing, and in section 18.4 the relevance of the previous discussion is spelled out. It would have helped the reader if this relevance had at least been hinted at in the introduction, or a small summary of the content of each subsection had been provided, so that the reader can prepare to grasp the major points of each section and connect them all in 18.4. Discussion in this section is mainly speculative (e.g., regarding the common origin of language semantics and syntax and the motor systems, a claim that the authors themselves recognize not verifiable), and to some extent also vague. After what seems too long an introduction, more concrete connections with observable aspects of language behavior or careful consideration of language structure would have been expected. However, the only key concept linking both domains, hierarchy, is not technically and unambiguously defined, which seriously undermines the discussion, particularly for formal and computational linguists.

The issue of modular vs. holistic models of the mind is the object of Chapter 19, by Josef Grodzinsky, who makes an introductory history of the debate (going back to Broca's 1861 influential paper in favor of localization, and the holistic reactions it generated), easy to follow and full of relevant references for the interested reader. Within the context of this debate, Bever's position is identified with a form of holism, as he attempted to derive linguistic generalizations from more general cognitive principles. Grodzinsky, on the other hand, stems from Fodor's work on modularity in order to establish four clear delimitation criteria, which are used to discuss literature holding the claim that language is *not* modular, exemplified by the so-called 'mirror neuron theory', and exactly why and how it is insufficient to account for a number of theoretical and empirical problems. As it is essential for the following argument, the case for modular models of the mind is presented in a very neat and clear way, and all throughout the chapter, several perspectives are discussed (neurocognitive, computational, psycholinguistic, and syntactic) and illustrated by means of reported experiments (focusing on different interpretations of the set of data obtained by Fazio et. al.) and, where relevant, concrete linguistic examples (involving relative clauses and quantifier scope, which is an interesting link with the content of chapters 3, 4, and 5). The author considers several possible counterexamples to the modular theory seriously and in detail, which is a feature to highlight in this article. Neurocognitive evidence is focused on the specific—modular—role of Broca's area in language, and whereas its role can be subsumed to more general cognitive principles or not: Experiment report is once again crucial and it is carried out with the utmost care. The author concludes that Broca aphasia is not directly connected to deficits in sequencing, embedding, or action theory (cf. chapter 18), and even considers (although very firefly) cross-linguistic evidence. A clear perspective of what the Broca's area does and does not do emerges clearly by the end of the chapter, and, despite the reader's own position, the discussion is logically consistent and carefully presented, deserving close scrutiny.

Chapter 20 addresses language acquisition, reporting studies with neonates and very young infants. Jacques Mehler builds on Bever's work on cognitive strategies, and suggests that language learning (along with other human-specific

cognitive abilities) should be studied before comparing capacities shared with other species. The paper is devoted to discussing breakthroughs in language acquisition research, from Bever's seminal work to current studies on the relation between frequency and abstraction of word order patterns in pre-lexical infants (thus making it a useful reference piece). Discussion in this chapter is centered on phonology, both segmental and suprasegmental, and how it affected theoretical accounts of acquisition from a psycholinguistic point of view; limited space is devoted to lexical learning, but it is taken advantage of: Several proposals are discussed, including pros and cons of each. Other crucial aspects of language, like hierarchy, are mentioned but only in connection to the phonology/prosody aspects, for instance, a neurocognitive differentiation between audios of regular sentences and backward sentences which suggests structure sensitivity. All aspects are related when necessary, for instance, when considering prosody a cue for lexical comprehension or rhythm as a determining factor for distinguishing different languages even at pre-lexical stages; such relations are clarifying and provide unity to the piece. The last part of the article (section 20.5) is devoted to the role of memory (recalling events) and its relation to language acquisition timing, which apparently makes the former more articulate: Language, it is hypothesized, structures event recalling. The section soon enters again the realm of phonology and the status of phonological representations (including syllabic sensitivity) in the brain of neonates. Relevant references are provided when necessary, covering four decades of research, and the discussion is neat and reader-friendly.

Phonology and the syntax-phonology interface is (also) the subject of Chapter 21, by Ewan Dunbar, Brian Dillon & William Idsardi. They focus on the phonological points made in Bever's contribution and Bayesian probabilistic models of parsimony in phonological description. Bayesian approaches are particularly favorable to Bever's 'analysis by synthesis', insofar as they determine that in order to assess the probability of a hypothesis, some prior probability is specified, which is then updated given new data, while allowing reasoning under uncertainty (as they are not limited by Boolean binary operators). For non-specialists, it would have been useful that the authors explained what a Bayesian probabilistic model is, and, at least briefly, summarize its major points, particularly given the fact that the whole chapter revolves around mathematical tools offered by those models and their use in phonological analyses. In my opinion, a couple of sentences in p. 361 are just not enough to fully understand the forthcoming arguments (even though section 2.3.1 is devoted to probability in linguistics, the basic notions of Bayesian probability are not clearly spelled out). Section 21.2 is devoted to concrete problems of Kalaallisut phonology, addressed from a Bayesian perspective on section 21.3, which also includes more general considerations about the pertinence of Bayesian reasoning in linguistics. The authors tackle the issue of acquisition research as one of looking for an optimal grammatical model with respect to primary linguistic data, but the notion of 'optimality' is not defined or formalized. The article assumes a good deal of mathematical knowledge from the reader, but it does provide clarifications for the formulae employed, even though some notions (e.g., 'stochastic model'), with which some readers might not be familiar, are not explained. This, nevertheless, does not

undermine the article's overall intelligibility. When discussing learning algorithms and Bayesian inference (e.g. pp. 368ff.), the authors provide the formula(e) in question, which is a very positive feature of this piece, as it entails complete explication of the mathematical tools assumed in this particular framework. Probabilistic models are here compared to their possibility to account for a certain corpus given so-called *Bayes decision rule*, in tune with early generative conceptions of linguistic theory as providing a *decision procedure for grammars* (Chomsky 1957: 52). Despite the highly theoretical character of the piece, and the proliferation of mathematical formulae (sometimes in detriment of concrete examples), the connection to the main topic is never lost, and the application of the mathematical framework to phonetics and phonology (and procedures to decide between models of acquisition, understood as inference from primary linguistic data) is always stressed.

The final research piece is, quite appropriately, an article by Thomas Bever, who updates and advances considerations made in the initial piece, 43 years later. Bever relates his early claims with the subsequent development of the biolinguistic program (said to have emerged in 1974), and reviews a series of later researched points that stress the relation between language and general cognitive and neurological systems. It is worth mentioning those points here, as the reader will see they are recurrent topics throughout the book (once again, giving it rarely found internal coherence and unity):

- (A) Statistical and categorial processes interact, so that initial 'draft' representations of meaning are built, to be replaced with definitive representations (cf. chapter 16).
- (B) Sentences mix serial and hierarchical processes (i.e., linearity vs. embedding), and derivations include null terminals (i.e., empty categories).
- (C) Language has modular basis (something apparently 'logically necessary', p. 389), and syntax is computationally unique.
- (D) The neurological basis of language also differ from other skills, perhaps being related to lateralization.
- (E) There are some skills involved in language that have parallels in non-humans, but there remains a core linguistic uniqueness that is only human.
- (F) There are no external sources of linguistic universals (e.g., physical laws).

The reader might agree or not (I consider, for instance, that the presentation of arguments against the view that universals might be given by physical laws contains *non sequitur* arguments, and that the possibility is not seriously considered), but it is true that the article advances on the introductory chapter, and in doing so also provides a historical account of what has happened in between. Quite appropriately, Bever presents in section 22.8 two challenges for the future, related to the problems of the 'poverty of stimulus' (in both acquisition and real-time comprehension, very much following the line of the 'analysis by synthesis' approach), and the role of genetic variation (including familiar antecedents) in the neurological representation of language. The article follows a neat *past-present-future* pattern which makes it a structurally coherent piece, and includes a good number of references for each period, including brief discussion of current experiments which will surely be reported in forthcoming publications.

The book closes with an Afterword, by Michael Tanenhaus, focused on the impact of Bever's 1970 article, and its offspring: all the debate it generated and all the alternative visions of language and cognition it stimulated, some compatible with Bever's formulation, some contrary to it. The Afterword summarizes in a very clear manner key points of Bever's legacy, including its impact on Chomsky-an generative grammar (unfortunately, without mentioning any alternative framework, e.g., Sag & Wasow 2011) and wider aspects of linguistic inquiry, often not directly connected with Bever's ideas, but stemming from the 1970 paper in one way or another. As a way to project the volume to the future, the Afterword features some of the contributors' impressions about the research paths that could arise, flourish, revive, or fall in the future.

The volume is overall a very valuable contribution to the fields of neuro-linguistics, psycholinguistics, theoretical and experimental linguistics, and the broader scientific inquiry about the mutual relations between language, cognition, and brain, and has the potential to become a classic on the topics. The variety of views there expressed, and the focus on interdisciplinary work make this book a very important tool for scholars related to any of the aforementioned disciplines, or curious about how we got here with respect to learning, processing, using, and analyzing language. The structure of the book, in terms of internal coherence, dynamic organization, and multiple recurrent *motifs*, is in itself a welcomed change with respect to other volumes on the topic. Structure and content thus combine to make an excellent state-of-the-art volume, featuring some of the most prominent figures on their respective fields, and trying to advance the field with cutting-edge research as well as valuable and useful historical accounts of the development of psycho and neurolinguistics.

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