New Directions in the Acquisition of Romance Languages

New Directions in the Acquisition of Romance Languages: Selected Proceedings of The Romance Turn V

Edited by

João Costa, Alexandra Fiéis, Maria João Freitas, Maria Lobo and Ana Lúcia Santos

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PREFACE

The conference *The Romance Turn* brings together researchers working on the acquisition of Romance languages every two years. Although this initiative is still recent, it has become a reference event for scholars in the field.

This volume publishes the selected proceedings of the fifth edition of this conference, which took place in Lisbon, in 2012, under the organization of the research centers of the two universities of Lisbon, Centro de Linguística da Universidade Nova de Lisboa (CLUNL) and Centro de Linguística da Universidade de Lisboa (CLUL).

The volume contains 15 of the talks presented and two keynote addresses by Letícia Sicuro Correa and by Ivan Rose.

The papers included in this volume not only share an interest for Romance languages, allowing for a close comparison between related languages, but mostly reflect current research on language acquisition. This is attested by the inclusion of papers not only on L1 acquisition, but also on the comparison between situations of acquisition in different settings: L2, bilingualism and cases of language impairment.

A look at the topics studied in the papers published in the volume reveals the role of processing constraints in language development as a major topic of research. Other topics present in the contributions to this volume include the interplay between the development of syntactic and semantic constraints or the role of features in the explanation of children's performance.

João Costa, Alexandra Fiéis, Maria João Freitas,
Maria Lobo and Ana Lúcia Santos

PLENARY PRESENTATIONS

INTERFACE INFORMATION AND COMPUTATIONAL COST: AN INTEGRATED PROCEDURAL APPROACH TO LANGUAGE ACQUISITION WITH SOME IMPLICATIONS FOR SLI

LETÍCIA M. SICURO CORRÊA

Introduction

Language acquisition has been one of the most attractive research topics for more than fifty years. Any child can, in principle, naturally acquire any human language. What makes this achievement viable? How does the process take place? What happens when language becomes impaired? These are the main questions guiding the traditional research on first language acquisition and the more recent research on Specific Language Impairment (SLI). The pursuit of their answers is intended to contribute to an understanding of what is unique to the human mind. Additionally, it may provide a theoretically sound basis for possible interventions in atypical language development.

Generative linguistics has formulated and focused on the first of these questions, aiming to provide a theory of language knowledge. Psycholinguistic approaches to language acquisition have focused on the second one, with the aim of providing a procedural account of the language acquisition process from an information processing point of view. Linguists, psycholinguists, developmental psychologists, and neuroscientists have been increasingly motivated to provide an explanation for SLI—a syndrome that is apparently restricted to the domain of language, insofar as children have typical development, as far as non-verbal cognition is concerned, and no physical handicaps (such as hearing problems) that could explain their impaired linguistic performance (cf. Leonard, 1989).

In principle, linguistic and psycholinguistic research would be expected to be complementary and eventually converge into an integrated theory of language knowledge, processing, and acquisition. Such a theory

would be expected to guide the research on SLI by predicting possible outcomes due to difficulties in the process of grammar identification and/or in the conduction of real-time processing. Inclusion criteria could then be formulated, thereby making it possible for the co-existence of SLI with other syndromes to be considered.

This is not, however, the picture that has been obtained so far. In fact, the linguistic and the psycholinguistic research has traditionally run, to a large extent, in parallel. Consequently, the linguistic research on language acquisition may fail to take into account processing factors as determinants of language development, and the psycholinguistic research may resent the absence of a theory of language.

Generative linguistics has presented the problem of language acquisition as children's identification of the grammar of a particular language, on the basis of a subset of the sentences generated by it. The rationalist (biolinguistic) perspective has oriented the linguistic theorizing. The working hypothesis was that the properties shared by natural language grammars do not need to be learned. In this view, language is part of the biological program that defines the human species and develops (as an *organ* of the mind) in a predefined way, once children are inserted into a linguistic environment. The main concern of mainstream generative linguistics was then to provide a theory of the initial state of language (Universal Grammar; UG), which would constrain the form that human grammars can assume, thereby facilitating the child's task of identifying a particular grammar (Chomsky, 1965). The linguistic research under this working hypothesis has converged to the Principles and Parameters (P&P) conception of UG (Chomsky, 1981), which states that languages abide by universal principles with a finite array of options, accounting for language diversity. The task of the child is to set the parameters that account for language variability on the basis of evidence provided by the linguistic input. A branch of this theory is devoted to investigating the process of language acquisition by providing linguistic descriptions of the state of children's grammar in the course of linguistic development and hypotheses to account for the changes of state, in light of the current linguistic formalism and hypotheses (cf. Goodluck, 1991; Guasti, 2002).

In the context of the psycholinguistic research on language acquisition (in which there is some overlap with Developmental Psychology), the process of grammar identification or language learning has been approached from different standpoints in the spectrum, ranging from rationalist/idealist positions to the most empiricist ones (cf. Ambridge & Lieven, 2011; Gleitman & Wanner, 1982; Hirsh-Pasek & Gollinkoff, 1996; Jusczyk, 1993; MacWhinney, 1987; Tomasello, 2003). The idea that

there must be constraints on language learning is not a matter of controversy. Assumptions vary, nevertheless, regarding the initial state of the acquisition process and the weight ascribed to cognitive or language-external factors in shaping the form of human languages. The fact that language universals and UG principles have been presented as "knowledge" has given rise to some resistance to generative theory in the developmental psychology/psycholinguistic field.

In the non-empiricist or least empiricist view, even though innateness is not a major issue, the extent to which the constraints on human languages and on grammar identification are language or species specific is an empirical question (cf. Bever, 1970; Jusczyk, 1997; Mehler, Christophe, & Ramus, 2000; Slobin & Bever, 1982). In the most empiricist veins, the possibility of a general learning algorithm to account for language learning saw a renewed interest in the '80s, as connectionist modeling was incorporated in psycholinguistic research (Elman et al., 1996; Plunkett, 1998; Rumelhart & McClelland, 1986). More recently, brain studies have been conducted with the aim of unveiling a progressive wiring up for language, which might be taken to contradict the idea of a rich initial state (Plunkett, 2007). In general, then, the question of domain specificity has been a sticking point when linguistic and psycholinguistic approaches to language acquisition are compared.

The research on SLI reflects these parallel lines of research. The linguistic research is motivated by the fact that this syndrome is apparently restricted to the language domain. The language acquisition process, viewed as distinct from other learning processes, is impaired, giving rise to a defective grammar, and the possibility of selective impairment within the grammar has been considered (Clahsen, 1999; Friedmann & Novogrodsky, 2008; Hamann, Penner, & Lindner, 1998; Mastropavlou & Tsimpli, 2011; Rice, Wexler, & Cleave, 1995). In other fields, a number of factors external to language have been considered to account for SLI symptoms (Bishop, 2006; Gathercole & Baddeley, 1990; Leonard, 1998; Montgomery, 1995; Tallal, Stark, & Mellits, 1985). In the neuroscience context, in particular, the domain specificity of SLI has been called into question, given the abnormal development of brain structures apparently involved in language and in different cognitive or motor skills (Ullman & Pierpont, 2005).

It is argued here that the Minimalist Program (Chomsky, 1995 onwards) contributes to clarify what can be meant by domain specificity as far as language is concerned, thereby enabling an integrated theory of language knowledge, processing, and acquisition to be envisaged. According to the Strong Minimalist Thesis (SMT), language is an optimal

solution to the mapping of sound and meaning, given the constraints set by the sensorimotor and the conceptual/intentional systems (Chomsky, 2000; 2005). UG principles are subsumed under the Principle of Full Interpretation (FI) at the interface levels between language and the so-called performance systems (Chomsky, 1995). SMT imposes, therefore, not only that the pre-minimalist analyses are reviewed, but that some of the questions orienting the linguistic research on language acquisition are reframed. It also predicts theoretical developments towards a closer relationship between the psycholinguistic research and the Chomskyan enterprise than the one that has been maintained since the abandonment of the Derivational Theory of Complexity in the late '60s (cf. Fodor, Bever & Garrett, 1974).

This chapter is organized as follows. In the first section, the linguistic and psycholinguistic approaches to language acquisition are briefly presented with the aim of contrasting their perspectives, methodologies, and concerns, and putting forward the view that in spite of their differences, there are signs that these lines of research may eventually converge. In Section 2, the minimalist turn is characterized, and a model of on-line computation is briefly outlined, which is intended to mediate the relationship between a formal model of language and models of language processing and acquisition. In Section 3, a procedural approach to language acquisition grounded on minimalist assumptions is sketched, including reference to experimental results pertaining to the acquisition of Portuguese. In Section 4, SLI is considered in light of this integrated approach. The last section presents the final remarks.

1. Linguistic and psycholinguistic approaches to language acquisition

1.1. The linguistic research on language acquisition

The linguistic research on language acquisition has been conducted with the aim of contributing to the development of a theory of language by characterizing and accounting for the changes of the internal language in the course of development, given the current theory of its initial state (UG) (cf. Avram, 2003). Early spontaneous language production data are predominantly used. Comprehension and grammaticality judgment experiments are also conducted as a means of evaluating the extent to which children's performance is in accordance with UG constraints.

A great deal of the empirical linguistic research on language acquisition in the pre-minimalist era has been concerned with providing evidence for

children's structure-dependent hypotheses with regard to language and for their reliance on UG principles when producing, analyzing, and interpreting linguistic utterances (Crain, 1991). This sort of evidence was intended to demonstrate that children have innate knowledge of the principles underlying the possible human grammars. The extent to which UG principles are fully available from the start, as proposed by the continuity hypothesis, or undergo maturation gave rise to intense debate in the '90s (cf. Atkinson, 1998). Much of this debate reached, nevertheless, a stalemate, in so far as the continuity hypothesis is not falsifiable. Children's performance not in consonance with the predictions derived from it could be explained by grammar external factors (such as processing demands and pragmatic knowledge), thereby enabling the hypothesis to be maintained (cf. Chien & Wexler, 1990; Weissenborn, Goodluck, & Roeper, 1992).

The early availability of functional categories has also been a matter of controversy in the context of the language acquisition research (cf. Hyams, 1996 and references therein; Radford, 1990). For some, the absence or optional use of functional items in early language production provides a basis for the proposal of an essentially lexical early grammar, in which semantic (thematic) relations account for word combinations (cf. Radford, 1990). Alternatively, functional heads are considered to be underspecified in early language. Apart from their role in defining syntactic domains, these categories represent information pertaining to pragmatics that may take time to be fully represented in children's lexicon (such as information pertaining to reference to entities (in D), to the time of an event in relation to the to the time of discourse (in T), and so on). This being the case, from a syntactic viewpoint, functional categories are fully available in early language, and the development of a pragmatic system accounts for the optionality of functional items in children's use of language (Hyams, 1996). This proposal is compatible with the results of the psycholinguistic research in early speech processing in which functional items play a major role (cf. Section 3) and with the on-line model outlined in Section 2.1., in which the fact that functional categories represent intentional information has implications for the grammatical encoding of sentences.

Within the P&P framework, the developmental process whereby parameters are set gives rise to a number of questions (cf. Avram, 2003). Which value is ascribed first, given general learnability principles (e.g., the subset principle) (Manzini & Wexler, 1987; Wexler & Manzini, 1987), the possibility of default values, and the implications of resetting them (Hyams, 1986; 1992; Platzack, 1996) are among the main questions addressed.

As for the role of input in the process, the linguistic data provide children "cues" for the setting of parameters (Fodor, 1998; Lightfoot, 1994, 1999). These cues are conceived of in terms of abstract structures resulting from at least a minimum parsing. There has not been a consensus, however, with regard to the structural domain required for the cues to be identified—simple sentences, as proposed by the degree-0 learnability theory (Lightfoot, 1994) or embedded structures (Gibson & Wexler, 1994; Roeper & Weissenborn, 1990).

The notion of parameter setting in language acquisition has progressively departed from the switchboard metaphor whereby it became popularized (Chomsky, 1986), in so far as it has been difficult to identify the interconnected grammatical phenomena originally presumed. Different forms of conceiving UG parameters have been considered (cf. Snyder & Lillo-Martin, 2011) without the cascade effect necessarily being predicted (cf. Fodor, 1998, 2009). The very notion of parameter has become, nevertheless, a matter of controversy in the minimalist context (cf. Boeckx, 2010).

In sum, the pre-minimalist linguistic approach to language acquisition focused on empirical evidence for UG principles and on questions pertaining to the setting of parameters. In the MP context, the interplay between economy conditions and legibility at the interface levels has started to be considered, particularly with regard to WH-pronoun extraction (cf. Gavruseva & Thornton, 2001; Roeper, 2008; Soares, 2003). Minimality (cf. Rizzi, 2004), as a factor ultimately pertaining to computational cost, has been claimed to affect the path of linguistic development (Costa, Grillo, & Lobo, 2012; Friedman, Belletti, & Rizzi, 2009). The experimental methodology, which characterizes psycholinguistic investigations, is now being increasingly used in the linguistic approaches to language acquisition. There are, therefore, some signs of an integrated theory of language knowledge, processing, and acquisition on the (still remote) horizon.

1.2. The psycholinguistic approach

The psycholinguist research on language acquisition focuses how children extract grammatically relevant information from the linguistic; children's early processing abilities; the factors that may account for the common course of development across languages; and the demands that may affect processing cost in the course of linguistic development. The segmentation the flow of speech in a sequence of lexical items, the delimitation of sentence constituents, and the representation of categories in the lexicon

are matters of particular concern (cf. Bloom, 1993; Gleitman & Wanner, 1982; Jusczyk, 1993; MacWhinney, 1987). This research is mostly conducted on an experimental basis, and ingenious techniques have been devised to detect infants' analysis of linguistic material, even before they combine their first words.

The conception of language as a system of rules, as presented by early generative linguistics, has been widely assumed. "Basic linguistic capacities" and "definitional universals" concerning the form and function of languages, shared by human beings, have been incorporated in the seminal psycholinguistic research on language acquisition (Bever, 1970; Slobin, 1973). These would include the communicative functions that linguistic utterances can perform, the fundamental semantic relations they express, and the formal means (in the sense of perceptible by the senses) of expressing them, under the assumption that word combinations are structure-dependent.

The debate over the extent to which such basic capacities or universals are innate or partially acquired on the basis of experience was put temporarily aside in the early investigations. Operating principles of language learning were then proposed, which presupposed a number of linguistic concepts (e.g., word, morpheme, phonological form) and early speech segmentation abilities (e.g., "Pay attention to the ends of words," "Pay attention to the order of words and morphemes," "The phonological forms of the words can be systematically modified") (Slobin, 1973). The predictions derived from them, which relate to the path of development, have been verified and refined on the basis of cross-language data (Slobin, 1985).

The question of domain specificity has been a contentious issue when linguistic and psycholinguistic approaches to language acquisition are contrasted, even when basic assumptions concerning the biological foundations of language are shared. The idea of a *language organ* and concepts such as *language universals*, *language acquisition device*, and *UG principles*, whereby language has been presented as a specific domain in the context of generative linguistics, seem to have been taken to imply that processes and resources external to language do not play a role in language processing and acquisition or in the ultimate form of human languages. The following quotations illustrate this point.

> As clear example of a formal universal that reflects general cognitive structures, consider Chomsky's proposal that it is a formal linguistic universal that [...] "proper names must designate objects meeting a condition of spatiotemporal contiguity, and that the same is true of other names designating objects" (Chomsky, 1965, p. 29). Surely one could

> argue that the same principle applies to the visual apprehension of objects, independent of their name. (Bever, 1970, footnote 14)

> The basic learning issue remains – is there a special learning device for language, or it is the outcome of the combination of a general hypothesis testing model, in combination with a large symbolic capacity and special tuning to access particular linguistic architectures that provide consistent cognitive representations of languages? (Bever, 1992 p. 230)

> Today, it is difficult to find impartial scientists who think that the linguistic competence is equally shared by humans and animals. We were less outright, however, when trying to identify the locus of the postulated language organ. We closed our presentation showing that infants display behaviors that are remarkably well suited to acquire language. These behaviors can already be exposed in neonates during their first contacts with speech. We are not, however, claiming that those behaviors are unique to humans. We only claim that it is only humans who enact them and derive language as a consequence. (Mehler, Christophe, & Ramus, 2000, p. 15)

Thus, the concept of *innately guided learning,* stemming from ethology (Gould & Marler, 1987; Marler, 1991), more than the concept of UG is closer to the view of innateness expressed in the psycholinguistic research (Jusczyk & Bertoncini, 1998). Though compatible with domain specificity in general, and with the P&P framework in particular, assuming *innately guided learning* does not require immediate commitment with a particular model of UG. This concept is also accepted in empiricist approaches (Plunket, 1997), in so far as this form of learning does not eliminate the possibility of infants making use of domain-general procedures in the analysis of linguistic input.

The role of statistical analysis in infants' speech processing has been particularly explored, regardless of the theoretical assumptions that might be guiding the research (Aslin, Saffran, & Newport, 1998; Kuhl, 2004). Infants have been shown to be innately guided to detect stress patterns (Jusczyk, Cutler, & Redantz, 1993), to be sensitive to speech sound frequency, to identify phonotactic sequences (Werker et al., 2002), to tune their speech perception to those phonetic distinctions that correspond to phonological contrasts in the language(s) they are exposed to, and to recognize the distribution of recurrent elements, which can be organized in major (closed and open) categories (cf. Jusczyk, 1993; Morgan & Demuth, 1996).

Statistical analysis by itself does not, however, suffice even for word segmentation in child-directed speech (Johnson & Jusczyk, 2001; Yang,

2002). A syntax-phonology interface would have to be assumed in order for the internal structure of linguistic utterances to be, to some extent, available to perceptual systems.

The phonological bootstrapping hypothesis assumes such an interface (cf. Morgan & Demuth, 1996). It has been demonstrated, in the context of learnability research, that the number of possible grammars to be considered, given sequences of lexical items, is considerably reduced if information pertaining to bracketing is provided (Morgan, 1986). Prosodic patterns corresponding to units of a prosodic hierarchy would enable chunks to be segmented. Prosodic units facilitate the delimitation of word boundaries and possible syntactic units, in which distributional analysis can be carried out. The way infants perceive and analyze speech data can, therefore, be instrumental for syntactic analysis and grammar identification. They would be innately guided to detect "cues" for speech segmentation and grammar identification in the linguistic input, such as the phonetic and prosodic properties of functional elements (Shi & Lapage, 2008; Shi, Morgan, & Allopennna, 1998; Shi, Werker, & Cutler, 2006; Shi, Werker, & Morgan, 1999). Domain-general early statistical analysis can, therefore, be reconciled with pattern identification in a specific domain once such innate guidance is assumed.

There is, nevertheless, a missing link in the procedure that goes from distributional analysis on the basis of phonetically expressed patterns to the parsing of sequences of lexical items in hierarchical structures. That is, the phonological bootstrapping account does not make sufficiently clear how syntactic computation starts (Corrêa, 2009). This point can be clarified once the concept of interface with performance systems and the Principle of FI are incorporated in a procedural model of language acquisition.

2. The minimalist turn

The *minimalist turn,* as it is characterized here, may not be perceived as such within linguistic quarters, where the continuity of the generative enterprise, as a coherent theoretical endeavor, has been stressed (Chomsky, 2005a, 2005b, 2007). From the point of view of those concerned with bringing together linguistic theory and a theory of language processing and acquisition, however, the Minimalist Program (MP) represents a major turning point.

For the first time, constraints on the form of human language are overtly considered to reflect interface impositions, i.e., impositions stemming from language-external systems (the whole cognitive and

physical apparatus involved in language processing).[1] Even if the logical problem of language acquisition had been, in a sense, solved by the P&P conception of UG, MP makes it clear that accounting for language acquisition (and for language itself) requires going beyond this level of explanation, by providing a principled explanation of UG principles. In this context, an explanation is regarded as principled if it can be reduced to the so-called bare output conditions (properties of the interface systems and considerations concerning computational efficiency) (Chomsky, 2005b). The following quotation makes it clear that the linguistic inquiry into the nature of language goes in the direction of clarifying the question of domain specificity, thereby converging to the concerns that have been guiding psycholinguistic research (cf. Section 1.2).

> For computational systems such as language, we naturally hope to discover concepts of computational efficiency that carry us beyond explanatory adequacy, and to investigate how these relate to principles of a more general character that may hold in other domains and for other organisms, and may have deeper explanations. (Chomsky, 2005, p. 2)

The P&P framework had made the primary linguistic data look less opaque than they appeared to be in the standard theory (Chomsky, 1965), as these data were considered to provide children very precise information for parameters to be set. The research strategy put forward in the GB lectures (Chomsky, 1981) gave rise, however, to a highly complex descriptive apparatus.[2] The possibility of incorporating a generative model of language into a theory of language processing in an explicit manner was far from reach.

MP simplified the architecture and the mode of operation of language. The only representational levels that remain are the interface levels, and there is a single universal computational system with a small set of operations (*faculty of language in the narrow sense*). These operations apply iteratively/recursively to the items of a parameterized lexicon in the construction of syntactic objects and, in the track of earlier developments (Borer, 1984), all information that is relevant for syntactic computation is represented in the formal features of the functional categories of the lexicon.

The fundamental relationship between the lexicon of natural languages and broad cognition is captured by the concept of *faculty of language in the broad sense*, which also encompasses the working memory system and all of the apparatus that imposes constraints on the mode of operation of language (Hauser, Chomsky, & Fitch, 2002).

Formal features (FF) are the key features of language, and their role in linguistic computation becomes more explicit once the grammar becomes lexicalized. They encode intentional, conceptual/classificatory distinctions that are grammatically relevant to human beings and/or to a particular linguistic community, as well as information pertaining to case and to the linear order of grammatical constituents in a given language, which is crucial to the parser. They behave, nevertheless, as symbols (i.e., non-meaningful entities, as in a Turing machine) in the syntactic computation. FFs therefore enable syntactic objects to encode intentional/conceptual and logical relations that become legible at the phonetic (PF) and semantic (LF) interfaces.

FI guarantees that only information that can be legible by performance systems is available at the interface levels. Consequently, all information that is necessary for sentence parsing, interpretation, and language acquisition is available at these levels. Originally proposed as a means of guaranteeing the well-formedness of linguistic expressions (Chomsky, 1986), FI can now be viewed as guaranteeing the *processability* of the linguistic expressions generated by possible human grammars.[3] In particular, the principles preventing unnecessary operations from being executed (such as Greed, Procrastination, and Last Resort) (cf. Hornstein, 2001) brought to the fore the economy concerns that became central in the MP.

Another difference introduced by MP is its option for a derivational model of grammar, in contrast with the representational models of the ’80s. Although possibly equivalent in strictly formal terms, representational and derivational models have seemly different implications for a model intended to account for grammatical knowledge.[4] A derivational model captures the dynamics of the implementation of a computational algorithm, making it appealing to recover the idea of an algorithmic model of speaker/hearer incorporating a generative grammar (Miller & Chomsky, 1963). Unlike early derivational models (Chomsky, 1957, 1965), though, minimalist derivations depart from a (sub)array of bare lexical items. A grammatical derivation or syntactic computation so conceived enables a parallel to be, to some extent, established between the computational procedure for generating linguistic expressions and the on-line (real time) computation required in the actual production and comprehension of sentences.

The initial array/subarray of lexical items in a grammatical derivation can be compared with the set of items retrieved from the mental lexicon for grammatical encoding in actual sentence production, and with the items recognized for the parsing of sentences in language comprehension.

Partially built phrase-markers are progressively transferred to the interfaces as *phases* (Chomsky, 2001, 2005), which resembles the incremental or partially incremental character of on-line sentence production and comprehension (cf. Ferreira & Swets, 2002).

A minimalist derivation comes closer, therefore, to the ideal of an algorithmic model of speaker-hearer (Miller & Chomsky, 1963) than its predecessors did. A model of on-line computation is, in any case, required in order to mediate the relationship between a theory of language knowledge and psycholinguistic models of language processing and acquisition.

In sum, FI, the option for a derivational model, and the concept of *phase* facilitate the envisagement of a theory that integrates language knowledge, processing, and acquisition. As for domain specificity, this issue seems to have been to a large extent diluted or clarified, given the concept of faculty of language in the broad sense and the role of external systems in providing a principle explanation of the principles that constrain the form of possible human languages.[5]

2.1. On-line computation from a minimalist perspective

This section outlines the basic features of an on-line model of linguistic computation (in progress) intended to mediate models of language and language processing and acquisition. These features are as follows: non-arbitrary constitution of the array (subarray) wherefrom the syntactic computation starts; bidirectionality (top-down and bottom up); left-to-right incrementality; discourse-driven internal merge (cf. Corrêa & Augusto, 2007, 2011; Augusto, Corrêa, & Forster, 2012).

A model of on-line computation deals with the small set of derivations that abide by FI. Hence, unlike a grammatical derivation in a formal model of language knowledge (henceforth, virtual derivation), the array (subarray) of items retrieved from the mental lexicon has an intention/propositional attitude behind it.

Minimalist virtual derivations are bottom up. On-line computation cannot be so, because sentences are planned top-down, with a given illocutionary force, and analyzed from left-to-right in prosodic chunks. A bi-direction (top-down/bottom-up) model of on-line computation has then been conceived, which takes into account the feature composition of lexical items (Corrêa, 2005, 2008; Corrêa & Augusto, 2007, 2011). Functional items are essentially constituted of formal features codifying in language information pertaining to intentionality (illocutionary force, point of view, definiteness, tense, aspect, mood, etc.). Lexical elements s-select

the complements they subcategorize for, which is compatible with a bottom-up derivation. The selection of a functional element in on-line computation enables top-down skeletons stemming from the sentence planning to be generated (from C, D), where bottom-up generated NPs and VPs (in parallel derivational spaces) will be assembled. In sentence comprehension, once illocutionary force can be detected and functional items recognized, underspecified functional skeletons can be derived to be filled in by NPs and VPs, from left-to-right (cf. Corrêa & Augusto, 2011 for illustration). The concept of *phase*, once adapted to left-to-right processing, is particularly suitable for characterizing the incrementally of sentence processing (cf. Augusto, Corrêa, & Forster, 2012).

The distinction between functional and lexical categories and its implication for on-line computation are relevant for a procedural account of language acquisition insofar as the early parsing can be conducted with underspecified functional nodes, and underspecified functional skeletons can account for optionality in the use of morphological forms in early language production.

In a model of on-line computation, only discourse-driven internal merge needs to be implemented. Internal merge intended to put hierarchical and linear positions in correspondence does not need to be computed on-line, once word-order parameters are set.[6] A and A' movement are implemented in actual sentence production for the sake of economy in discourse processing (as in passives), ostensive focus (as in clefting, interrogative sentences), integration of information (as in restrictive relative clauses), lessening the burden of heavy constituents in working memory (as in extraposition), and so forth. The displacement of constituents from their canonical position is, in principle, costly, and the overall cost can differ in production versus comprehension. Striking a balance between discourse needs and computational cost would characterize the optimal use of language.

In sum, a model of on-line computation that mediates language knowledge, processing, and acquisition basically involves universal computational operations, at least a minimal lexicon with functional and lexical categories, and knowledge of word order patterns. The possibility of constituent displacement is represented in the properties of formal features once interface cues concerning discourse-driven internal merge can be detected at the interfaces and the resulting long-distance relationships can be processed.

3. Towards an integrated procedural theory of language acquisition

There is evidence that infants are sensitive to prosody even before birth (Lecanuet, 1998). This sensitivity would not, however, be useful for parsing and grammar identification if humans were not equipped in such a way that language systems, with a syntax/phonology interface, could be created (by social groups) and identified (in social interaction). By the same token, infants are able to identify patterns and to conduct statistical analyses on the basis of information provided by speech sounds (Kuhl, 2004). This ability can be taken as an instance of a domain-general procedure that is useful for language acquisition. Early statistical abilities would not, however, contribute to grammar identification if infants were not directed to the grammatically relevant information in the speech stream (cf. Yang, 2002).

In light of linguistic theory, the formal features of functional items represent, in the lexicon, the grammatically relevant information to be identified in the course of language acquisition. According to minimalist assumptions, all information that is required for sentence parsing and grammar identification is available at the interfaces. Language-specific, grammatically relevant intentional, conceptual, and logical distinctions are expressed in word order patterns, inflectional morphology, or even intonation. Infants are able to identify these patterns. There is, therefore, a close relationship between the patterns that can be identified in speech input and the representation of formal features. These systematic patterns can be taken as grammatically relevant information that is legible at the phonetic interface (PF). In order for infants' early statistical abilities to converge into grammar identification, they must therefore be innately guided to represent speech patterns as interface information, i.e., as information relevant to parsing and grammar identification.

Infants are sensitive to the phonetic properties of functional items in the first days of life (Shi, Werker, & Morgan, 1999). Functional items are closed class elements that are small in number, with a typical phonetic pattern and a regular distribution. They are instrumental to the delimitation of lexical categories and crucial to early parsing (Höhle & Weissenborn, 2000). By the 10^{th} month of life, infants distinguish functional items in the flow of speech (Shady, 1996; Shady, Gerken, & Jusczyk, 1995; Shafer, Shucard, Shucard, & Gerken, 1998). At the beginning of the second year of life (10–14 months), they can distinguish the morphophonological pattern of functional elements in general, and determiners and verbal affixes in particular (Bagetti & Corrêa, 2010; Blenn, Seidl, & Höhle, 2002; Morgan,

Shi, & Allopena, 1996; Name, 2002) and process Determiner-Noun merge (Höhle & Weissenborn, 2000). Word order patterns and the directionality of head-complement relations are also incorporated as linguistic knowledge in the first year of life (Christophe et al., 2003; Weissenborn et al., 1998).

The distinction between closed and open classes and the representation of basic word order patterns can be taken as the fundamental distinctions to be represented in terms of formal features in the lexicon. A minimal lexicon would include a basic categorical feature—the one distinguishing closed and open classes, and a feature pertaining to order (possibly OCC, formerly the EPP feature (Chomsky, 2001)). Insofar as these features are crucial for the establishment of locality relations in early parsing, and the computational system operates based on formal features, their representation can be enough to bootstrap the operations of the computational system. Once initialized, syntactic computation would become instrumental for the setting of parameters or specification of the properties of the formal features of functional items (cf. Corrêa, 2009).

Innately guided learning in light of minimalist assumption means that (i) infants perceive speech sounds as interface information; (ii) distinctive patterns in closed class items are taken to correspond to the different values a given formal feature may assume; (iii) inflectional morphology is taken to be the expression of feature matching and valuation (*Agree*) in local domains; [7] (iv) the values of the formal features are interpreted in terms of categorical, conceptual/intentional distinctions; and (v) linguistic utterances are taken as speech acts referring to entities and events.

The language computational system operates basically by means of *Merge* (external and internal) and *Agree*, which enable interpretable and uninterpretable formal features of the same kind to be paired and the latter to be valued by the former. Once this system is initialized, it can be assumed that this operation can be implemented and becomes instrumental to the progressive specification of formal features.

The identification of the gender feature in Portuguese and the ascription of intrinsic gender to novel nouns by 22-month-old children illustrate this point. Children recognize morphophonological variation in closed class determiners. This variation signals a morphological grammatical distinction to be represented as a formal feature with different values (corresponding to different categories, not necessarily specified). Determiners and nouns are parsed as a constituent, with D being the head. The value ascribed to the critical (gender) feature in D, on the basis of inflectional morphology, is projected to the highest node and ascribed to the noun under the presumption that inflectional morphology reflects

agreement. Hence, the gender value signaled in the D morphology will define for children the (gender) class to which a particular noun belongs. Once intrinsic gender is assigned, it becomes interpretable in the noun. Thus, before children can establish a possible correlation between noun endings in Portuguese and gender (*-a* feminine; *-o* masculine), an analogy that gives rise to errors, they ascribe to novel nouns the gender class informed by the determiner morphology under the presumption of determiner-noun agreement (cf. Corrêa, Augusto, & Castro, 2011; Corrêa & Name, 2003).

Marked morphology can be viewed as interface information signaling to the child a particular categorical contrast (male class, female class; unitary class / class with more than one element) to be inferred on the basis of the presumption that linguistic utterances can be related to events in the world. By the age of two, marked (optional) gender, (optional) number and person seem to be differentially represented by children acquiring Portuguese (possibly in terms of Gen, Num, and Person functional categories) (cf. Corrêa, 2009). The full specification of formal features requires, therefore, that an initial underspecified categorical representation is enriched on the basis of information pertaining to the semantic interface and reference.

Once syntactic computation becomes instrumental for the progressive specification of formal features, the developmental course can be predicted to be a function of legibility at the interfaces and computational cost.

Interface legibility can be considered in relation to the so-called TAM (Tense, Aspect, and Mood) complex in the verbal morphology of Romance languages, which, in the case of Brazilian Portuguese (BP), has some inconsistency (particularly regarding the subjunctive mood). Even though children acquiring BP start expressing the distinction between realis/irrealis mood by 24 months, by contrasting finite/non-finite verbal forms, it is only by the age of seven that mood distinctions (indicative – realis / subjunctive – irrealis) start to be consistently interpreted on the basis of the standard morphology (Longchamps & Corrêa, 2010). Distinctions pertaining to definite and generic reference are also subtle in this language and take a relatively long time to be established (Augusto & Corrêa, 2005). Intentional distinctions pertaining to the grammar-pragmatic interface, such as the unicity/totality of reference implied by the [+definite] definiteness feature of D (e.g., *Maria comeu a maçã* 'Mary ate the apple' → There was only one apple; *Maria comeu as maçãs* 'Mary ate the apples' → Mary ate all apples available), which rely on information provided by the semantic interface, seem to be among the most difficult ones to achieve (Longchamps, in prep).

Computational cost can be characterized in terms of the number and type of functional nodes, the degree of specification of formal features, and the demands imposed by A and A-bar movement operations, which give rise to long-distance dependencies (Correa & Augusto, 2011; Jakubowicz, 2003). In this case, interface information not only provides data pertaining to the properties of formal features but it enables processing strategies to be created, which can minimize processing cost.

High computational cost is, in principle, counterproductive in an information processing system. Additional cost in on-line syntactic computation can, nevertheless, be justified insofar as it can satisfy discourse demands and contribute to the encoding of explicit reference to entities and events. In light of MP, a cost-benefit ratio balance would be expected in each particular grammar with regard to the amount of intentional/conceptual distinctions that are represented as formal features of functional categories, the number of functional nodes that admit recursion, and the syntactic positions that allow movement.

In languages with direct passives, i.e., passives that involve A-movement, WH-movement, and recursion in syntactic positions other than the subject (cf. Keean & Comrie, 1977), language acquisition becomes somewhat constrained by the development of the processing abilities required in the establishment of long-distance dependencies. In the acquisition of passives, children have to recognize Aux + Participial (+ by phrase) as interface information concerning the possibility of A-movement (i.e., the specification of a possible functional projection Voice-P (cf. Lima Júnior, & Augusto, this volume)). They must be able to cope with a processing window in which these elements can be related. In the acquisition of WH-movement (in interrogatives and relatives), children have to recognize WH-movement as a possibility in the language and the positions that admit a recursive sentential modifier (signaled by the presence of the relative pronoun/marker *que* in Portuguese). Feature specification in this case requires that children are able to relate the moved element with an empty position.

Additionally, in order for children to be able to rely on this knowledge in different processing conditions, interface information must prompt the use of strategies that minimize the effect of computational cost, thereby enabling long-distance dependencies to be processed in time. This ability can take longer to be established in the course of linguistic development than the representation of the properties of the relevant formal features. In the comprehension of passives, children have to develop a processing strategy that refrains the immediate ascription of an actor/experiencer role to the first [+animate] DP (cf. Townsend & Bever, 2002), in order to avoid

reanalysis (cf. Rodrigues & Marcilese, this volume). Less demanding conditions (with [-animate]) would enable the grammatical information pertaining to passives to be identified. In the acquisition of relative clauses, the recursive nodes are identified early. Two-year-olds acquiring Portuguese are sensitive to the presence of the relative pronoun as an interface cue for recursion. They repeat and act out the main clause, thereby ignoring the information in a center-embedded relative clause. Four-year-olds do not have major difficulties in the comprehension of either center-embedded or right-branching subject relative clauses, though they tend to skip the information in center-embedded object relative clauses (Corrêa, 1995a). Coping with long-distance dependencies is then particularly hard.

The asymmetry between subject and object relative clauses is well documented across languages in both children and adults (cf. Costa, Lobo, & Silva, 2011) and is also attested in neurodata (King & Kutas, 1995). The comprehension of object relative clauses is, nevertheless, particularly difficult, when the intervening subject is structurally similar to the moved constituent, possibility due to shared features (Friedmann, Belletti, & Rizzi, 2009; Ribeiro & Corrêa, this volume and references therein). Given that UG principles express impositions of the performance systems, overcoming the extension of this principle to the syntactic structures not blocked by it may require developing strategies that minimize the effect of interference in the processing of long-distance dependencies.

The processing of object relative requires holding the head noun active in working memory, while a subject-verb relationship is processed in the relative clause, and recovering it to fill in the object gap, where its thematic role is ascribed (cf. Corrêa, 1995b). Holding the head noun free from interference in working memory is likely to require reliance on mnemonic rehearsal (Baddeley, 1992). Prompting this sort of strategy appears to be particularly difficult, insofar as it goes in the opposite direction of the parsing strategies used by adults, which account for the subject/object unbalance in their performance (Clifton & Frazier, 1989; Frazier & Flores d'Arcais, 1989; Pritchett, 1992).

In sum, an integrated procedural approach to language acquisition makes it clear that language-specific innate guidance toward the recognition and interpretation of formal features is required in order for linguistic computation to be implemented. Assuming that language is a specific domain of the mind does not, however, entail that all the processes and resources involved in language processing and acquisition are exclusively human and language-specific.[8]

Interface legibility and computational cost can be taken as the determinants of linguistic development. Dealing with interface cues and minimizing computational cost can be constrained by developmental processes external to language.

4. Interpreting SLI data in light of the integrated approach

An integrated procedural approach to language acquisition enables different possible sources for SLI symptoms to be located in the course of language acquisition. The conception of on-line computation in the context of sentence production and comprehension also makes it possible for SLI symptoms to be considered in relation to specific processing demands.

In Corrêa and Augusto (2011), four possible sources of SLI symptoms were located: (i) in the identification of the specific properties of formal features that provide instructions to the computational system; (ii) in the access to these features for either grammatical encoding in production or for sentence parsing in comprehension; (iii) in the actual implementation of syntactic computation; (iv) in post-syntactic processes pertaining either to morphophonological encoding in production or to semantic interpretation in comprehension. A severity scale was proposed that was inversely correlated with this ordering.

Making these points more explicit here, it can be argued that (i) would result from impairment in the genetic program guiding language learning (or in the neurological means of executing it). Difficulty in recognizing interface information pertaining to formal features at PF would make it difficult for them to be represented on the basis of the systematic patterns that can be identified in speech sounds. This sort of impairment would give rise to delayed acquisition, possibly resulting in defective representations of one or more functional categories. This prediction is compatible with the data of event-related potentials (ERPs), revealing that function words elicit left-lateralized negativity in typically developing children and bilateral/right-lateralized negativity in children with impairments in syntax (Neville et al., 1993). Reliance on atypical language learning procedures would then be expected, with an outcome similar to the one obtained in language learning beyond the critical or sensitive period (cf. Newport, Bavelier, & Neville, 2005). In this regard, it has been observed that some SLI children and adults use explicit "rules" for compensating impaired syntactic computation (Paradis & Gopink, 1994; Ullman & Gopnik, 1999) and a high proportion of lexicalized phrases (Thordardottir & Weismer, 2002).

The model of language acquisition sketched here relies on syntactic computation on the basis of underspecified features as a means of achieving their full specification. The implementation of Agree is considered to be instrumental for the value of a formal feature, identified in an agreeing element, to be given to the item where it can be interpreted. Failing to take morphological information pertaining to agreement as interface information concerning the values that a formal feature can assume is likely to make children dependent on inductive learning and on analogies based on the phonological forms. Evidence in this regard can be obtained from language impaired children acquiring Portuguese as far as gender is concerned (Silveira, 2002, 2011).

The legibility of the interface information and processing cost can also affect the language acquisition process and give rise to delayed or defective grammatical representations if the source of the impairment is on the external systems that integrate the faculty of language in the broad sense. The presence of genetic impairment would enable these possibilities to be distinguished. Hence, there are grounds for the different accounts of SLI to be reconciled.

Corrêa and Augusto's (2011) possible sources of SLI symptoms (items ii-iv above) can be grouped as impairment in the process of on-line syntactic computation, regardless of how defective the grammar is. Considering that grammatical information in represented in the lexicon, the retrieval of this sort of information in sentence production and/or in sentence comprehension can be impaired, giving rise to omission and erratic (optional) use of functional elements. Failing to retrieve information pertaining to formal features would give rise to defective functional skeletons in on-line computation. Insofar as functional elements codify information pertaining to the grammar-pragmatics interface, it is, in principle, possible that there are selective manifestations at this interface (Longchamps & Corrêa, 2012; Longchamps, in prep), which may also be situated within the spectrum of autism (Tager-Flusberg, 2000).

The model of on-line computation makes it clear that SLI symptoms can stem from difficulties in the very implementation of grammatical encoding in sentence production or in the process of sentence parsing in comprehension (no matter how specified formal features are in the lexicon). Difficulties in relying on interface information as a means of prompting strategies that can optimize the processing of long-distance dependencies may promote the ascription of the agent/experiencer role to the [+animate] subject of passive sentences, even though the category Voice is specified in the lexicon. By the same token, failure in activating rehearsal as soon as a WH-element is recognized in order to keep

"verbatim" information active in working memory in the most demanding processing conditions may prevent object relative clauses from being successfully comprehended.

If SLI symptoms stem from children's difficulty in taking into account interface information as cues to syntactic processing in comprehension tasks (exclusively dependent on them), they may be shared with Attention Deficit Hyperactivity Disorder (ADHD) (Im-Bolter & Cohen, 2007) in attention-demanding tasks. It would also be expected that in low-demanding discourse conditions, performance would improve in both cases (cf. Ribeiro & Corrêa, this volume). If SLI symptoms involve impairment in the use of rehearsal strategies, then these manifestations are expected to concentrate on the most costly structures and object RCs are likely to be exclusively affected. It can be observed, in this regard, that SLI and working memory deficits are strongly related (Gathercole & Baddeley, 1990; Montgomery, 1995), though there are children with spared working memory who are vulnerable to feature interference effects in the comprehension of object relative clauses (Corrêa & Trugo, to appear).

The model of on-line computation also includes the post-syntactic recovery of morphological forms in sentence production (Corrêa & Augusto, 2011). In this regard, there is evidence that some SLI children may detect agreement mismatch in spite of making optional use of the agreement morphology (Jakubowicz & Roulet, 2007). Contrasting the production and comprehension of gender agreement and the ascription of gender to novel nouns may contribute to a differential diagnosis with regard to the possible cause of SLI symptoms in Romance languages.

In sum, a procedural approach to language acquisition and a model of on-line computation grounded on minimalist assumptions help to account for the heterogeneity of SLI symptoms and to reconcile apparently conflicting accounts. As for domain specificity, this question requires distinguishing the roles of the external systems and the genetic "program" for language. The role of language external systems in shaping the form of human grammars, in affecting the extraction of grammatically relevant information from the linguistic input, and in the very performance of on-line computation makes it clear that the resources and processes pertaining to the domain of language (i.e., language processing and acquisition) may be shared across domains. Comorbidity with a common cause can then be expected (as suggested by Ullman & Pierpont's (2005) data) if shared brain resources are impaired. Impairment in the genetic program that enables syntactic computation to be carried out is, nevertheless, likely to rely on resources specific to the language domain. In this case, it would be