Minimalist perspectives for psycholinguistic research*

Perspectivas minimalistas en la investigación psicolingüística

Perspectivas minimalistas na pesquisa psicolingüística

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Abstract

A particular approach to the study of psycholinguistic processes is presented, which is based on a minimalist conception of language. A procedural model of language acquisition is sketched, which reconciles infants speech processing and the idea of innately guided learning with a minimalist view of the initial state of language acquisition in an account of the bootstrapping problem. Language acquisition is viewed as proceeding with the progressive specification of formal features of the functional categories of the lexicon. The possibility of a minimalist derivation to be incorporated in a sentence production and/or comprehension model is discussed. Possible sources of language impairment, as manifested in SLI (Specific Language Impairment) syndrome, are considered in the light of this integrative approach. Reference is made to experimental work carried out in Brazilian Portuguese, with some extension to European Portuguese and River-Plate Spanish.

Keywords: language processing, language acquisition, minimalism, Specific Language Impairment (SLI), Brazilian Portuguese.

Resumen

Se presenta una aproximación particular al estudio de los procesos psicolingüísticos, la cual está basada en una aproximación minimalista del lenguaje. Se esboza un modelo procedimental de la adquisición del lenguaje, el cual reconcilia el procesamiento del habla en los niños, y la idea del aprendizaje innatamente guiado, con una visión minimalista del estado inicial de la adquisición del lenguaje en una explicación del problema del arranque. La adquisición del lenguaje es vista como procedente con la especificación progresiva de los rasgos formales de las categorías funcionales del léxico. Se discute la posibilidad de que una derivación minimalista sea incorporada en un modelo de producción y/o comprensión de frases. Se consideran posibles fuentes de impedimentos del lenguaje, como los manifestados en el síndrome TEL (Trastorno Específico del Lenguaje), a la luz de esta aproximación integrativa. Se hace referencia al trabajo experimental llevado a cabo en portugués brasileño, con alguna extensión al portugués europeo y al español del Río de la Plata.

Palabras clave: procesamiento linguístico, adquisición del lenguaje, minimalismo, Trastorno Específico del Lenguaje (TEL), portugués brasileño.

Resumo

Apresenta-se uma abordagem particular para o estudo de processos psicolinguísticos, que tem por base uma concepção minimalista de língua. Um modelo procedimental da aquisição da linguagem é esboçado, no qual se conciliam, no tratamento do problema do desencadeamento da sintaxe, o processamento da fala por in-

fantes aliado à ideia de aprendizagem guiada por fatores inatos, com uma visão minimalista do estado inicial da aquisição da linguagem. A aquisição da linguagem é concebida como a progressiva especificação dos traços formais das categorias funcionais do léxico. Discute-se a possibilidade de incorporação de uma derivação minimalista em modelos de produção/compreensão de sentenças. Possíveis fontes de problemas de linguagem, tais como os manifestos no quadro do DEL (Défict Específico da Linguagem), são consideradas à luz dessa abordagem integrada. Remete-se a resultados obtidos em experimentos conduzidos em Português Brasileiro, alguns dos quais replicados em Português Europeu e Espanhol Rioplatense..

Palavras chave: processamento linguístico, aquisição da linguagem, minimalismo, Déficit Específico da Linguagem (DEL), Português Brasileiro.

Introduction

Psycholinguistic research is concerned with providing a functional account of the mental processes by means of which language processing is carried out in both the production and the comprehension of linguistic utterances. It interacts with a theory of language in so far as linguistic theory, particularly in the generative vein, is concerned with providing a formal account of the knowledge of language that enables the speaker/hearer to carry out such linguistic processes. Psycholinguistics and linguistic theory are also bound to interact in the construction of a theory of language acquisition, in so far as a formal model of language knowledge must present those proprieties that make any human language learnable by human beings, and psycholinguistic approaches to language acquisition are aimed at characterizing how such a state of knowledge is achieved. The relationship between psycholinguistic research and linguistic theory has been, however, far from smooth.

Generative linguistics had a fundamental role in the constitution of Psycholinguistics as a research field in the XX century 60´s, under the information processing approach of Cognitive Psychology. In this context, the Derivational Theory of Complexity (DTC) was an early attempt to explore the

possibility of integrating hypotheses derived from a formal grammar with experimental research on language processing. However, once this attempt proved misconceived, chomskyan linguistics and psycholinguistic research have developed quite apart (cf. Fodor, Bever & Garett, 1974; Altmann, 2006). Divergences concerning the domain specificity of linguistic processes, the extent to which the initial state of the language acquisition process is linguistically informed and the intricacies of the formalism developed for grammar, in order to reconcile universal properties of human languages with cross-language differences, may explain this fact. In the 90´s, however, the Minimalist Program of generative linguistics (Chomsky, 1995) brought to bear a conception of language which, in our view, facilitates the establishment of a more fruitful dialogue with Psycholinguistics than the one that has been maintained in the last decades.

This paper is not intended to provide a historical review of the relationship between these areas (see Kess, 1992), neither to compare and relate current approaches to psycholinguistic processes that depart from a generative/minimalist perspective (see Phillips, 1996). Rather, it is intended to present a particular research program under development, in which language processing, acquisition and impairment (SLI in particular) are approached in the light of minimalist assumptions (Correa, 2002; 2005; 2006; 2008). This research has been conducted with data from children and adults whose first language is Brazilian Portuguese, mainly. Some data from children acquiring European Portuguese and Plata-River Spanish have also been obtained.

As far as language acquisition is concerned, a procedural model of language acquisition has been conceived of, in the light of the phonological bootstrapping hypothesis (Morgan & Demuth, 1996; Christophe et al., 2003). According to this model, the identification of prosodic and distributional patterns during the first year of life converges to the creation of a minimal lexicon with a minimal number of categories distinguished by underspecified formal features. These features would enable a universal computational system to operate in the parsing of linguistic utterances and the very ability to conduct a basic parsing would promote

the progressive specification of the formal features of the lexicon, given the assumption that as soon as naming starts to be recognized, children take linguistic utterances to refer to entities and events (Corrêa, 2009).

As for processing, an on-line model of linguistic computation has been characterized in the light of a minimalist derivation. Unlike a linguistic derivation, which can be thought of as a virtual possibility for a sentence to be built in a particular language, on-line computation is part of the actual linguistic processing in real time. In this case, the problem that language specific word ordering presents to a linguistic derivation aimed at characterizing how universal grammatical relations (which admit different forms of expression in terms of word ordering) are expressed in a particular language, is assumed to have been solved in the process of language acquisition (when parameters pertaining to word order are set). That is, as soon as the child identifies the particular word order patterns of his/her language, there is no need for the mapping between structural and linear positions to be computed every time a sentence is produced and analyzed. Consequently, a number of operations that are required in a linguistic derivation (head-movement, subject-movement, for instance) do not have to be characterized when on-line computation is considered (Correa, 2005). Moreover, linguistic computation is inserted into the process of sentence production and comprehension in such a way that it can be identified with the process of grammatical encoding in production and with parsing in comprehension (Corrêa & Augusto, 2007; Corrêa, 2008). This model enables processing cost to be characterized and possible errors to be predicted in both planned and unplanned production tasks (Correa et al, 2008; Correa, Augusto & Marcilese, 2009).

This approach to language acquisition and processing gives rise to hypotheses concerning different manifestations of SLI (Specific Language Impairment) (Corrêa & Augusto, 2011a), some of which have been guiding more applied research (Correa & Augusto, 2011b).

In this paper, these research lines are introduced. In the next section, the minimalist conception of language is briefly presented. In section three, an account to the bootstrapping problem of language acquisition is provided in terms of a feature based model of language acquisition, and reference is made to some of the experimental results obtained so far. Section 4 presents problems to be dealt with by an on-line model of linguistic computation that incorporates minimalist operations. Section 5 *synthesizes* some of the hypotheses aimed to account for the diversity of the SLI syndrome formulated in the light of this integrated approach to language processing and acquisition. The final remarks are in section 6.

Minimalist assumptions

The Minimalist Program (MP) provides major guidelines for the study of internal language (henceforth, language) (Chomsky, 1995; 2005; 2007). On the one hand, this program can be taken as a means of carrying on the language research along the lines of the so called Principles and Parameters approach (Chomsky, 1981) in a formally simpler way. On the other, it represents a major break in the generative research in so far as a principled explanation to the grammatical principles ascribed to the initial state of language acquisition (Universal Grammar, UG) is searched for. For the first time, in this sort of linguistic theorizing, processability comes clearly into play. From a minimalist perspective, UG principles would guarantee the processability of the linguistic expressions any human grammar generates. It is for this reason that the minimalist conception of language can be attractive to psycholinguistic research.

According to MP, language is constituted of a universal computational system (UCS) and a lexicon, which is fully specified in the course of language acquisition. The elements of the lexicon are composed of semantic, phonological and formal features. Semantic features enable language to interact with conceptual and intentional systems, in the expression of meaning and in the encoding of reference. Phonological features enable the elements from the lexicon to assume a form that can be converted into speech sounds or other physical means of expression (such as the gestures of sign languages). Formal features are the only features

that are accessible to the computational system. They convey information that enables lexical items to be structurally related in the computation of a linguistic expression and represent in the lexicon conceptual distinctions taken to be grammatically relevant in a particular language (such as gender, number, tense, aspect distinctions). They can be viewed as equivalent to the information provided by lemmas in psycholinguistic models of lexical access (Levelt, 1989; Levelt, Roelofs & Meyer, 1999).

The elements of the lexicon can be distributed into lexical and functional categories. The former includes open class elements such as nouns (Ns), adjective (Adjs) and verbs (Vs) and possibly a few prepositions (Ps) that select their complements on the basis of their lexical content (eg. in, on, under). Functional categories represent in the grammar distinctions pertaining to definiteness, tense, aspect, mood, illocutionary force, among others. The number and the properties of functional categories is a matter of linguistic research. Their elements take the form of closed class elements (eg. determiners, affixes, connectives) and, from a syntactic point of view, they define the major syntactic domains such as C (complementizer) – the sentence domain; D (determiner) the nominal domain, assumed to be headed by a determiner, and T (tense), which can define a verbal domain. All language specific information is considered to be represented as properties of the formal features of the functional categories of the lexicon. That is, these properties define what is systematically expressed in language specific morphology and word order. Hence, this is the information that children must identify in the process of language acquisition.

UCS has a few operations: Select, which selects elements from a lexical array; Merge, which combines a lexical item with another one from the array, giving rise to a tree-structure (dominated by a projection of the element taken to be the head), or combines a element from the array with an partially formed tree-structure; Agree, which relates elements sharing formal features of a certain type, in a syntactic domain, a process that may give rise to agreement patterns in the inflectional morphology of different languages; and Move, which promotes

the dislocation of constituents either to be placed in their canonical linear order or to be removed from a canonical position as a means of satisfying specific discourse requirements (such as passive sentences, focused structures, WH questions and relative clauses) when sentences are actually produced.

The result of the syntactic computation is a hierarchical structure, a syntactic tree, whose terminal elements form a sequence of lexical items ready to be spelled-out. Spelling out is the conversion of this abstract sequence into a linguistic expression, constituted of a phonetic ("sound") and a logical ("meaning") form. The phonetic representation can be converted into speech sounds and the logical one represents meaning relations between the syntactically related lexical items. The phonetic and the logical forms constitute, therefore, interface levels between language and the so-called performance systems (sensory-motor/conceptual-intentional). It can be noticed that a minimalist conception of grammatical derivation has some resemblance with models of sentence production in which sentence formulation departs from lexical access, and involves grammatical encoding giving rise to a representation to be morphophonologically encoded, in order to be eventually articulated (Levelt, 1989; 1995)

The reason why this conception of language facilitates a closer dialogue between chomskyan linguistics and psycholinguistics goes beyond, however, similarities with regard to the sequential processes characterized in a grammar and in a processing model. In the MP, the form of the human languages is viewed to be constrained by the impositions of the interface levels. That is, there is a principled explanation for the sort of formal principles that are claimed to underlie the form of the grammars of the human languages, for the parameters that define those aspects of the grammars that can vary across languages, and for the values these parameters can assume. The principles and parameters ascribed to the initial state of language acquisition (UG) are, in the MP, subsumed under the Principle of Full Interpretation at the interfaces (FI), and language independent economy criteria would also play a role in constraining grammars. Due to these constraints, all information that is re-

levant for language processing (parsing) and acquisition is visible at the interfaces between (internal) language and the so-called performance systems. This information must be visible in word order, morphophonological and prosodic patterns (a language internal syntax/phonology interface being assumed), and in syntactic relations that can be semantically interpreted in a compositional basis (a language internal syntax/semantic interface being assumed). In other words, grammatical information is expressed in the systematic patterns the human processing apparatus is capable of perceiving and analyzing.

Given this framework, a procedural model of language acquisition must characterize how children identify grammatically relevant information while processing the speech sound in order to enable on-line syntactic computation to start.

Getting syntactic computation started

A major problem for a learning theory in general and for a theory of language acquisition in particular is the bootstrapping problem. As far as the acquisition of a language is concerned, the bootstrapping problem concerns how the child gets started in the process of identifying the grammar underlying the linguistic material he/she is able to perceive, in order to be able to parse and to formulate sentences according to it.

The phonological bootstrapping hypothesis departs from the assumption that the internal structure of linguistic utterances is, to some extent, perceptually accessible to children, once prosodic units are delimited, phonotactic patterns are recognized and the distribution of recurrent elements is detected in the analysis of the speech sound (Morgan & Demuth, 1996; Gerken, 2001). This hypothesis assumes a syntax-phonology interface, which makes syntactic information in some way accessible to perceptual systems. Speech processing by infants would be innately guided to the recognition of patterns that play a fundamental role in the early parsing and grammar identification (Jusczyck & Bertoncini, 1988). Innately guided learning, inherited from Ethology, is learning by instinct, that is, animals, in general, are biologically programmed

to attend to specific cues of the environment or of the material they perceive (Gould & Marler, 1987). This concept is compatible with the idea of UG expressed in MP.

A major finding in infants' speech processing research concerns their sensitivity to the phonological pattern of functional elements by the end of the first year of life. At about 10 months of age, infants are sensitive to phonetic alterations in functional elements as suggested by both their listening preferences, when listening to normal and modified prose passages, and the corresponding brain responses (ERPs – event related potentials) (Shady, Gerken & Jusczyk, 1995; Shady, 1996; Shaffer et. al, 1998). There is also evidence that, by the age of twelve months, babies acquiring German recognize monosyllabic nouns previously presented preceded by a determiner, when these nouns/syllables are presented preceded by a different determiner. Babies do not recognize, however, the same syllable, when presented as part of a disyllabic word (Höhle & Weissenborn, 2000). This kind of result suggests that elements from the set of determiners and their linear position have been identified, which may indicate that parsing has started to be carried out.

The recognition of determiners in prose passages without previous familiarization has been detected in Brazilian Portuguese in the listening preferences of 14 month olds (Name, 2002; Name & Correa, 2003). Sensitivity to these elements may, nevertheless, be achieved earlier since by 10 months of age, infants acquiring this language have been shown to be sensitive to the pattern of verbal affixes (Bagetti, 2009; Bagetti & Correa, 2010).

This sort of evidence suggests that although functional elements are not produced by children in their early production, children are sensitive to them prior to producing one-word utterances and may rely on them in the analysis of the incoming linguistic material. Some preliminary results supporting an early parsing were obtained from Brazilian 18 month olds preferential looking, when presented to homophonous words in different syntactic contexts (Olha! o pinto na mesa [Look! The chick on the table] and Olha! Eu pinto a mesa [Look! I paint the table] (Bagetti, 2009; Bagetti & Correa, 2011).

The phonological bootstrapping hypothesis points to the relevance of prosodic and distributional cues for the recognition of these elements. There is, however, a conceptual gap in the explanation for the starting of syntactic processing conveyed by this hypothesis. Why should recognized patterns be instrumental to parsing?

The solution to the bootstrapping problem appears to require a universal computational system and formal features in a minimal lexicon. Assuming a faculty of language that guides first language learning, the distinction between closed and open classes of lexical items would enable the creation of a minimal lexicon with two underspecified classes – closed/functional and open/lexical classes. The representation of these classes would constitute a minimal lexicon with a single (categorical) formal feature. The formal representation of linear ordering that can be derived from the early sensitivity to rhythmic patterns (Nespor, Guasti & Christophe, 1996; Christophe et al., 2003) would also be formally represented and these features would enable syntactic computation to get started.

Recall that all information that is relevant to grammar identification is made visible at the interfaces between language and processing systems and that such an information can be provided by word order patterns and inflectional morphology. Morphemes are closed class elements that usually appear in a marked form. Marked (as opposed to unmarked) forms can be detected as variations in the form of closed class elements. For instance, the presence/absence of the feminine morpheme –a and the plural morpheme –s in Portuguese and Spanish determiners expresses grammatically relevant distinctions. An innately guided process would take this sort of alternation as indication that it conveys grammatically relevant information. The conceptual or language internal distinctions expressed by the marked forms would be searched for by children as language acquisition proceeds.

According to a semantic bootstrapping hypothesis, along the lines of the early work by Macnamara (1977), children would assume that linguistic utterances are meaningful and that they are about entities and events. Under this assumption, the sort of conceptual distinctions that are grammatically

relevant in a particular language, such as number, person, tense, for instance, would be bootstrapped. Semantic bootstrapping would then account for a moment in the language acquisition process that presupposes that parsing has already started. That is, the universal computational system would have to have been initialized once formal features were represented on the basis of prosodic and distributional patterns.

Both children acquiring Brazilian Portuguese (BP) and children acquiring European Portuguese (EP) extract number information from the marked morphology of the determiner under the assumption that novel nouns name novel entities, that DPs (determiner phrases) are used to refer to one or more tokens of an object type, and that there is agreement within the DP (Corrêa, Augusto & Ferrari-Neto, 2005; Castro & Ferrari-Neto, 2007; Ferrari-Neto, 2008; Correa, Augusto & Castro, 2011). In experiments conducted in both of these varieties of Portuguese, children participated in a picture-identification task in which they should choose, amongst four pictures, the one that matched a phrase (DP) with a pseudo-noun, in object position (Eg. Mostra X to Dedé [Show X to Dedé]). When presented to plural phrases such as os dabos, there was a tendency for children to choose the picture presenting multiple invented objects/characters. This tendency was not observed when the phrase contained an unmarked determiner followed by a pseudo noun with an –s ending like o dabos. Differences between BP and EP could be detected in the way children dealt with phrases like os dabo, in which only the determiner is inflected. This sort of phrase is widely used in non-standard BP whereas it is ungrammatical in EP. No significant difference was obtained in the number of Brazilian children's correct responses to the standard (os dabos) and to the non-standard (os dabo) plural DPs. This difference was significant in the results of the Portuguese children. These is, nevertheless, evidence that even Portuguese children extract information regarding plurality from the determiner since there were more plural responses to phrases in which only the determiner was inflected (os dabo) than to those in which only the noun could be inflected (o dabos). Since number inflection in the

determiner results from agreement within the DP, there is evidence that parsing is taking place.

Although the formal features expressed as inflectional affixes at the interface levels tend to convey grammatically relevant conceptual distinctions, they can be taken as grammatical classifiers, deprived of conceptual content. This is the case of intrinsic gender in Romance languages. Unlike optional gender, which is ascribed to a nominal root as a function of the sex of the referent of the DP (menino/menin-a (Portuguese); niño/niñ-a (Spanish), intrinsic gender classifies nouns in noun classes – masculine and feminine nouns –, regardless of natural gender. Hence, an animate noun such as (criança [child]) in Portuguese is feminine and consequently requires feminine determiners, adjectives and predicative phrases, regardless of whether the child at stake is a boy or girl. Inanimate nouns illustrate more clearly the classifier function of gender since the ascription of an inanimate noun to a gender class can only be arbitrary. In this case, the identification of the gender of the noun on the basis of the gender of agreeing element presupposes the parsing of the DP.

In a series of experiments conducted with Brazilian children (Correa & Name, 2003), Brazilian and Portuguese children (Correa, Augusto & Castro, 2010) and Argentinean children (Dotti et al., to appear), three and four year olds listened to short stories in which an invented object or character was presented by a DP with a pseudo noun. The same noun form was presented preceded by a masculine or by a feminine determiner. The noun ending was either typically masculine (the thematic vowel –o), typically feminine (the thematic vowel –a or the gender morpheme –a), or neutral with regard to typical gender (the thematic vowel –e). It was verified that even the youngest children predominantly ascribe inanimate and animate novel nouns (pseudo nouns) to a gender class based on the gender of the determiner, when required to refer to the recently introduced object or character. This point can be made clearer with the experimental material presented in the Figure 1.

The experimenter says:

Olha! Aqui tem **um dabo/um daba/uma dabo/uma daba/um dabe/uma dabe** *e aquitem um peixe.*

[Look, there is **a dabo** here and there is a fish here)

(*a dabo*: DP (indefinite determiner phrase) with a pseudo-noun in different conditions, varying as a function of the gender of the determiner (masc;/fem) and noun-endings combinations *(-o, -a, -e)*)

O/A dabo/a/e *e o peixe estão jogando bola na praia. Olha o peixe! Olha* **o/a dabo/a/e***!*

[The fish and **the (masc/fem) dabo/a/e** are playing at the beach. Look at the fish! Look at **the** (masc/fem) **dabo/a/e**!]

Ih, o que aconteceu? Quem pegou a bola?

[Hey,what happened? Who has catched the ball?]

-- The child has to refer the recently introduced character. Articles in full DPs, demonstrative pronouns, 3rd person pronouns reveal the gender class ascription of the novel noun by the child. The number of responses in which the correct gender is maintained is the dependent variable.

Figure 1. Material to induce to production of a referring expression or pronoun in which the gender ascribed to a novel noun can be identified.

Source: This illustration is adapted from Corrêa, Augusto & Castro, 2010.

Even though children can be affected by the co-relational pattern that holds between the gender expressed in the determiner and noun-endings in the language, even the youngest children rely more on the most reliable gender information, namely, the determiner. Not only responses based on the gender of the determiner predominate but errors in the determiner/noun-ending mismatch condition tended to result from alterations in the noun-ending in order for the gender matching to be reestablished, or for the noun to be neutral with regard to gender possible correlations. In the case of animate novel nouns, feminine gender tends to raise expectancies concerning the nature of the noun-ending. In this case, the unmatched condition becomes more difficulty since the noun-ending is expected to be the gender inflection morpheme –a, which can be semantically interpreted.

In sum, this sort of results is compatible with children's being attentive to morphophonological alterations in closed class items. Their reliance on the information provided by the determiner in classifying nouns according to gender is indicative that parsing is instrumental to the identification of the possible values (masculine and feminine) grammatical gender can assume in the language. Moreover, children's being affected by feminine gender when nouns are animate indicates that, by the age of two, they have already perceived intrinsic gender as a noun classifier and optional gender as a semantically interpretable feature. Spontaneous production data present occasional erroneous gender ascription and self-corrections on the basis of phonological/semantic patterns (Figueira, 2003). These occasional events, though suggesting that children are sensitive to these patterns and try to identify a logical principle for gender classification, do not indicate that they can acquire gender by relying on them. On the contrary, once the computational system starts operating in parsing, morphophonological patterns are taken to result from agreement.

The model of early language acquisition just sketched reconciles infant's speech processing data, which is compatible with the view that the early identification of recurrent patterns plays a role in language acquisition (a process that may be conducted by general statistical principles), with a minimalist conception of UG. Children would be innately guided to represent as grammatically relevant what is perceived as systematic information at the phonetic interface. The distinction between closed and open class would be enough for the constitution of a minimal lexical. The presence of formal features in an underspecified lexicon would initialize UCS. Once syntactic operations can be used in the early parsing and morphophonological variations within closed class elements are taken to express grammatical distinctions, the progressive specification of formal features can be started, under the assumption that linguistic utterances have form and meaning and that they can be related to entities and events.

This sort of procedure can be applied to other grammatical distinctions. The cost of acquisition would be determined by how consistent morphophonological information is, how subtle the conceptual/intentional distinctions conveyed are, and how demanding the parsing is, of the structures in which this information occurs. Studies pertaining to the acquisition of definiteness and genericity (Augusto & Correa, 2008; Correa, Augusto & Andrade Silva, 2008), aspect (Lima-Rodrigues, 2007) and mood (Longchamps, 2009; Longchamps and Correa, 2010) and cross-language comparison concerning the visibility of interface information in Spanish and Portuguese (Marcilese, 2007; Marcilese, Correa & Augusto, 2008) provide empirical data compatible with this view.

On-line computation in sentence formulation and parsing

Syntactic computation can be viewed as the process whereby lexical items are combined into syntactic structures either in the grammatical encoding of a message, or in the parsing of sentence. In psycholinguistic research, the processes pertaining to the grammatical encoding in sentence production are the least specified (cf. Ferreira & Slevic, 2007). The opposite occurs for parsing, in so far as a number of models have been proposed to account for it, some of which grounded in linguistic theory (cf. Townsend & Bever, 2002; Crocker, Pickering and Clifton, 2000). There is, nevertheless, poor cha-

racterization of the procedures whereby the parser would be informed by the grammar.

A model of on-line computation couched in linguistic assumptions may facilitate the grammar-parser or grammar-formulator relation to be characterized. In fact, the universal computational system operating upon the formal features of the lexicon has been equated with the operations carried out in actual syntactic processing in the so-called PiG (Parser is Grammar) model (Phillips, 1996). The fact that the DTC had failed, more than indicating the impossibility of this equation, would indicate the empirical inadequacy of that particular model. There are however, a number of problems to be sorted out, when syntactic computation conceived of on a virtual basis (in a formal model of language, not to be actually implemented in real time) is considered in terms of on-line procedures.

One of the problems is in the fact that linguistic derivations are carried out bottom-up, which means that the most deeply embedded clauses are computed earlier than a main clause. This assumption is difficult to be reconciled with the incrementality of on-line processing. Right-branching structures, such as complement sentences and relative clauses as object modifiers, may not be fully planned while the main clause is being produced, as a bottom-up sentence formulator, along the lines of the syntactic derivation would entail. Some evidence can be presented in this regard.

In a study carried out with adult speakers of Brazilian Portuguese (Corrêa, Augusto & Marcilese, 2009; to appear), the participants were elicited to produce restrictive relative clauses in planned and in unplanned conditions. They were presented to two identical pictures of either a boy or a girl in a computer screen and asked to read aloud a written preamble corresponding to a clause having the one of the two pictures as the referent of an object DP (Cf. Figure 2). Since the pictures were identical, the participant would be compelled to generate a modifier based on extra-picture information in order to distinguish the target. The distinguishing critical information was provided (in written form) either in advance (before the preamble was presented) or on-line (5 sec after the preamble was presented), i.e. as the object of the sentence started to be pro-

duced, roughly. It was assumed that when that information is provided in advance, the sentence can be fully planned and its production has relatively low demand. By contrast, when the distinguishing information is provided on-line, the restrictive RC has to be formulated as its head noun is produced. It was hypothesized that the unplanned condition imposes considerable demands in so far as it exacerbates the incremental character of on-line production. This condition should, then, give rise to cost minimizing strategies. Two types of strategies were considered, the production of passive subject RCs instead of a direct object (DO) RC, as a means of minimizing the computational cost of an intervening DP in subject position (Friedmann, Belletti & Rizzi, 2008) (Eg. … a menina que foi assustada pelo palhaço …vs. a menina que o palhaço assustou [the girl that was frightened by the clown … the girl who the clown has frighted], and the production of resumptive pronouns, which have been characterized as a last resort strategy in the production of Indirect object (IO) relative clauses, when preposition stranding is not allowed (Shlonsky, 1992; Hornstein, 2001) (Eg. … a menina que o palhaço falou com ela…[… the girl who the clown has talked with her]), as shown to be produced by children and adults speakers´ of Portuguese (Miranda, 2008; Corrêa et al., 2008). The results presented a greater number of standard responses in the planned condition than in the unplanned one ($F(1,37)=6.31$ p =.01 (by subject); $F(1,10) = 36.44$ p<.0001 (by item) and a significant interaction between task (planned and unplanned) and type of RC was also obtained. In the low demand task (planned condition), there was a greater number of standard responses to IO Relatives than to DO relatives, since passive subject relatives compete with the standard strategy regardless of the task demands (since DO RCs are high demanding). In the high demand task (unplanned condition), on the contrary, the number of standard responses was higher in DO than in the IO RCs. The results also showed a significantly greater number of resumptive pronouns in the unplanned conditions when IO RCs with lexical and functional prepositions and genitive RCs were considered $F(1,38)=5.4$ p <.03 (by subject); $F(1,10) = 17.98$ p<.01 (by item) and the occurrence of resumptive pronouns was

greater in IO RCs than in the Genitive ones. These latter, though the most demanding ones, did not give rise to this sort of strategy. The tendency was for the speakers to substitute the relative pronoun cujo/a by the person underspecified que and to omit the PP (cujo pai [whose father] by que o pai (dele elliptical) [that the father (of him elliptical)]. A model of on-line computation which can account for such results cannot, therefore, depart from the assumption that the most deeply embedded structure is computed first in a bottom-up manner when sentence production is concerned.

Two solutions have been considered in order for a model of on-line computation to reconcile directionality with incrementality in processing: making directionally a function of the sort of information that a node codifies; and incorporating the notion of parallel derivational spaces (Uriagereka, 1999) in the model. Unlike the initial array of lexical items in a linguistic derivation (which can be conceived of as created at random), the lexical array whereupon on-line computation started stems from a search for linguistic means of expressing the speaker's intention and a message, given the linguistic knowledge stored in the mental lexicon. Being so, it can be argued that functional items codify information pertaining to the speaker's intentions, i.e., information concerning the illocutionary force of the utterance and the speaker's point of view concerning reference to entities and events, which can be located in time, for instance.

Elements from lexical categories, by their turn, provide information regarding the argument structure that needs to be syntactically encoded, given the message conceived of by the speaker. In Corrêa (2005a; 2005b), the idea was put forward that functional elements (determiners, complementizers, tense, aspect, etc.) interact with intentional systems in the Mental Lexicon, whereas elements of lexical categories (N, V, Adj) interact with conceptual systems. More recently, the idea has been explored that intentional systems include a Theory of Relevance (possibly a module of a Theory of Mind), which interacts with these functional elements, affecting the way reference is encoded (Longchamps & Correa, 2011). This differential source of information would give rise to top-down and bottom-up derivations, respectively, and this sort of distinction has been formally expressed in Correa & Augusto, 2006; 2007; 2011. Figures 3 and 4 characterize this distinction.
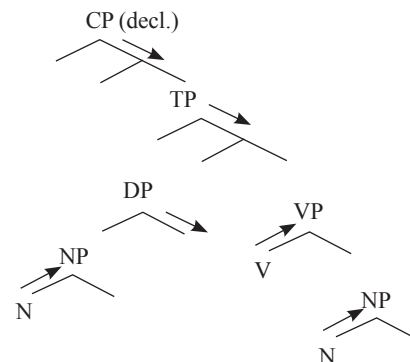

Figure 3. Top down and botton-up derivation in parallel derivational spaces.

Critical distinguishing information:

O palhaco assustou esta menina
[*The clow has frightened this girl*]

Preamble: O treinador chamou para o ginásio ...
[The coach called into the gymnasium ...]

Figure 2. Example of test material to elicit the production of a restrictive RC.

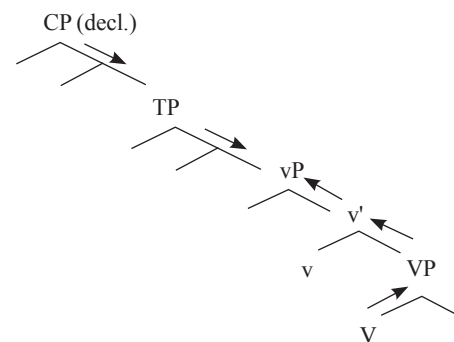Source: Corrêa, Augusto & Marcilese, 2009; to appear.

Figure 4. Lexical tree meets functional tree.

Source of Figures 3 & 4: adapted from Corrêa & Augusto (2011a).

A major problem for an on-line model is to account for the two sorts of movement operations involved in a linguistic derivation: those required for the linear positioning of constituents in a language specific canonical order and those required for the satisfaction of discourse demands. As mentioned above, there are a number of operations that would not need to be carried out on line, once word order parameters had been set. Consequently, sentences would be derived in a particular word ordering. Constituent displacement from the position it can be semantically interpreted would be carried out only as a function of particular discourse demands. It would explain the processing cost of passives, focused structures, WH questions and relative clauses in contrast with structures in the canonical word order.

In the on-line model under development, a particular solution has been provided in order to enable the immediate linear positioning of a subject constituent (in a SVO language) while guaranteeing that information concerning thematic requirements is provided without computational cost. Discourse driven movement is, by contrast, characterized in such a way that additional computational cost can be predicted. The formal solution to this problem that has been envisaged so far is the on-line generation of copies of the moved constitutes in their original places. Whereas in costless movement there would be synchronized placement of the moved constituent and its copy, in the case of discourse driven movement, the sequential placement of the moved constituent and its copy would characterize an operation requiring more processing time (Figure 5 presents the derivation of a relative clause, which can illustrate this point). Conceiving of simultaneous copies can account for the immediate mapping of constituents in a particular canonical order in production, while guaranteeing that thematic assignment can be done, without necessarily incorporating lexicalized structures (Joshi & Rambow, 2003) in the grammar or heuristic procedures (Townsend & Bever, 2002) in comprehension.

Given this conception, the computational operations (Select, Merge and Move) would take place in on-line computation in a particular order, as a function of the processing mode at stake. Production may require the initial selection of functional elements in order for a basic functional skeleton to be constructed with underspecified lexical complements while intentional information is incorporated in the derivation. Comprehension, in its turn, is likely to require selection (via recognition) and left to right merging for the sentence parsing. The bottom-up recognition of functional elements may, in any case, promote the top-down derivation of functional skeletons to be filled in from left-to-right by DPs and VPs. Different processing conditions in each mode of processing may, nevertheless, require a particular derivational procedure. In Correa, Augusto & Marcilese (2009; to appear), for instance, the low demanding and the high demanding processing conditions characterized above were related
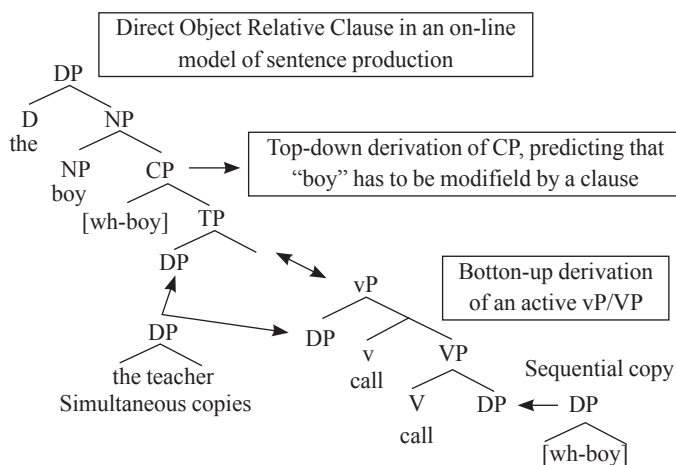

Figure 5. On line derivation of a relative clause.

to two types of analyses of RCs. The fully planned low demand condition, in which the speaker knew the distinguishing property, was considered to be more compatible with the Head Raising Analysis (HRA) (Kayne 1994) in which the RC is a complement of the determiner. The speaker knows that there is more than one possible referent of a certain kind in a given context and plans to distinguish a particular one by means of a referential expression – a DP containing a noun modifier, which may be a RC. In this case, the head noun is moved to the left-most position from an argument position within the RC. The unplanned condition, which requires the on-line planning of the RC, can be more properly captured by The Matching Analysis (MA) (Citko 2001; Sauerland 2003). In this case, the speaker notices that an unmodified DP is insufficient for the identification of the intended referent in a given context, while computing the syntactic encoding of a referential expression. So, a modifier must be introduced in the computation in an incremental fashion. In MA, the RC is an adjunct to the NP, and the head noun, outside the RC, is co-related with the moved element, bound by an operator. A more detailed characterization of these procedures in the context of the on-line model has been proposed (Correa, Augusto & Marcilese, 2009; to appear).

Impairment in language acquisition and processing

SLI has a variety of manifestations and there are a number of competing hypotheses to account for them (cf. Leonard, 1995; Jakubowicz, 2006). A single account does not, however, appear to cover optional omission of inflections, optional subject and auxiliary omission, performance improvement as perceptual cues are enhanced, selective impairments, difficulty in the comprehension of the most costly structures, use of minimal cost production strategies, even if symptoms are restricted to the so-called syntactic SLI (Friedmann & Novogrodsky, 2008).

According to the procedural model of language acquisition sketched here, some of them may derive from problems in the very process of language acquisition, particularly in the early processing of interface information that gives rise to the represen-

tation of the formal features of functional categories in the lexicon. Others may stem from difficulties in the conduction of on-line computation, even though the relevant formal features are represented in the lexicon. Underspecification of the formal features of lexical categories and computational cost would then be the source of a variety of manifestations of SLI (Correa & Augusto, 2011).

Difficulties in the process of grammar identification would be expected to cause developmental delay, in so far as the initialization of the computational system on the basis of PF information may require more experience and/or more time for the relevant resources to mature. After such an initialization, impairment may result from difficulties in the recognition of morphophonological variation within closed class elements as informative of the particular properties of formal features. In this case, the progressive specification of these features would take longer than in normal language acquisition. And it is even possible that such a specification may not be fully achieved. In this case, language problems would persist in adulthood.

Low sensitivity to the cues that can be extracted from interface information may require their visibility to be specially enhanced as a means of promoting improvement in performance (Leonard, 1998; Tallal et al., 1985, 1996). There are, however, SLI manifestations that are unaffected by such facilitative measures, as suggested by differential abilities in the processing of perceptually similar items (Jakubowicz et al., 1998). These are more likely to stem from problems in the representation of morphophonological distinctions as morphosyntactic ones.

Difficulties stemming from the underspecification of formal features are expected to be manifested in both production and comprehension tasks. There may be, however, problems restricted to the retrieval of information pertaining to formal features in on-line production. These would explain impairment restricted to production, such as the optional use of morphological marks of agreement when agreement mismatch can be detected in comprehension (Jakubowicz & Roulet, 2008). The fact that functional categories are viewed as interacting with intentional systems and their role in the structuring of major syntactic domains predict that deter-

miners, tense markers, as well as the conduction of discourse driven operations would be particularly affected. As for the later, they are expected to be more affected the more costly they are.

Coping with the processing of computationally costly structures has been pointed out as one of the most impaired linguistic abilities in SLI (Jakubowicz, 2004; van de Lely, 2005), though there is not consensus on a metric of computational cost. According to the model of on-line computation considered above, discourse driven operations depend on access to a particular feature requiring sequential copies. Keeping a copy while syntactic relations are established would account for additional processing demands (Correa & Augusto, 2011a).

There are a number of findings indicating that the comprehension of passives, WH interrogatives and relative clauses are particularly costly and that interference of a subject constituent adds demands to object constructions (Friedmann et al., 2009). The use of subject passives as a means of minimizing the cost of the production of these sentences that has been observed in adults´ production regardless of the task demand, as described above, is a strategy that may not be immediately available to impaired children. In a elicited production task, language impaired children were asked to say who they would like to be, given two characters previously presented as the referent of an object DP (Eg. The doctor inoculated this boy with an injection; the nurse inoculated that boy with drops on his tongue. Which boy would you like to be?). Both truncated sentences and simplified sentences promoting meaning change were considerably frequent. It is interesting to notice, however, that after a pilot-intervention procedure, focusing on passives and relative clauses, more adult-like cost minimizing strategies could be observed (Correa & Augusto, 2011b; c). In the same study, it was also noticed that language impaired children tend to avoid full subject DPs in the production of WH-N interrogative sentences (Que boné seu filho quer? [Which cap does your son want?]). Cost minimizing strategies include the use of an anaphoric pronoun (he) or even WH in situ (Seu filho quer que boné?[Your son wants which cap?]) Language impaired children not only rely on these options but make use of a pragmatically inadequate

deitic (2nd person) pronoun (instead of a full DP or a 3rd person pronoun) apparently to avoid the sort of production cost, as predicted by the on-line model (Corrêa, Augusto & Bagetti, 2011).

In sum, an integrated approach to language processing and acquisition couched in a theory of language in which the principled explanation for the initial state of language acquisition relies on the properties of the processing apparatus appears to provide a fruitful basis for language impairment to be investigated. This point is extensively developed in Correa & Augusto (2011).

Final remarks

This paper has presented a research program on language processing, acquisition and impairment which explores the possibility of psycholinguistic research to incorporate the view of language expressed in the MP of generative linguistics, while maintaining its identity as a theoretical domain of its own. The results obtained so far suggest that an account for the bootstrapping problem of language acquisition can be provided by reconciling infant's speech processing research with a minimalist concept of UG. These results also support the view that the progressive specification of the formal features of functional categories in the lexicon relies on the early parsing of linguistic utterances by children, under the presumption of agreement between elements within a syntactic domain, and that linguistic utterances are about entities and events. Some solutions have been proposed in order for an on-line model of linguistic computation, conceived of in the light of a minimalist derivation, to be incorporated into processing models of sentence production and comprehension, though there is a lot to be done in order for such a model be directly tested. In a more applied vein, approaching SLI in the light of such integrated theories enables different manifestations of SLI to be accounted for in a principled basis. This program is incipient and its development is clearly beyond the possibilities of a single research group. The reason for presenting it, in such a comprehensive and general form, is to advance some ideas that can be explored (and caused into question) from different directions.

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