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AN ARGUMENT FOR DPS AS *PHASE*S IN AN INTEGRATED MODEL OF ON-LINE COMPUTATION: THE IMMEDIATE MAPPING OF COMPLEX DPS WITH RELATIVE CLAUSES

Marina R. A. Augusto[1]
Letícia M. Sicuro Correa[2]
Renê Forster[3]

marinaaug@uerj.br
lscorrea@puc-rio.br
rene.forster@gmail.com

ABSTRACT: A formal characterization of DPs as *phases* (Chomsky, 2002) in the integrated model of on-line computation (MINC) (Correa & Augusto, 2007; 2011) is provided. The proposal of DPs as *phases*, which are spelled-out dynamically, in the context of on-line computation, accounts for the incremental mapping of DPs onto referents. Incrementality in sentence processing is characterized and psycholinguistic evidence for the immediate mapping of DPs onto referents is presented. In particular, results of an eye-tracking experiment are reported, in which the comprehension of restrictive RCs was investigated with adult speakers of Portuguese. It is argued that incorporation of the concept of *phase* in sentence processing models is a means of reconciling the immediate mapping of DPs onto referents with an autonomous parser.
KEYWORDS: syntactic computation; minimalism; DP as *phase*; relative clause processing.

INTRODUCTION

The integrated model of on-line computation (henceforth, MINC – *Modelo Integrado de Computação on-line*) (Correa & Augusto, 2007; 2011) has been proposed as an attempt to incorporate a minimalist derivation (Chomsky, 1995; 2000; 2007) into processing models, in so far as some convergence had been observed in the conception of syntactic derivation in the Minimalist Program (MP) and psycholinguistic models of sentence processing (Correa, 2002;

[1] Universidade do Estado do Rio de Janeiro – UERJ.
[2] Pontifícia Universidade Católica do Rio de Janeiro – PUC-Rio.
[3] Pontifícia Universidade Católica do Rio de Janeiro – PUC-Rio.

2006). Some adjustments would, nevertheless, be required in order for syntactic computation, as conceived of in an I-language model, to be characterized as an on-line process (Correa, 2005; 2008).

This paper aims at providing a formal solution for the incorporation of *phases* (Chomsky, 2000) as processing units in MINC. This concept seems to be compatible with the incremental nature of on-line computation. Moreover, assuming DPs as *phases* would enable the model to account for the immediate mapping of DPs onto referents as the sentence is analyzed (Correa, 2008). The formal characterization of *phases* in a bottom-up derivation is, nevertheless, incompatible with the left-to-right analysis of sentences in real time processing. Being so, a formal solution for incorporating *phases* in MINC is required. In this context, Relative Clause (RC) processing provides a particularly interesting case for the characterization of DPs as *phases*.

This paper starts with the characterization of *phase* in linguistic theory. The psycholinguistic literature on the incremental processing is addressed and the results of an eye-tracking comprehension experiment obtained with adult-speakers of Portuguese are briefly presented in so far as they provide additional evidence for the immediate mapping of DPs onto referents in the comprehension of restrictive RCs (Forster et al., 2010a; 2010b). These results are then interpreted in the light of MINC, with DPs as *phases*.

1. THE CONCEPT OF *PHASE*

The concept of *phases* is introduced in Chomsky (2000). They constitute domains that enable syntactic derivation to proceed in incremental chunks. Each *phase* is built from a specific lexical sub-array and feeds interface levels dynamically, that is, they are transferred to the interfaces and their content becomes available for operations in the interface levels (PF and LF). Computational cost reduction is one of the main arguments usually put forward for the adoption of *phase*s. For the identification of suitable candidates to constitute *phase*s, Chomsky (2000) has argued for domains presenting "full argument structure" or "propositional content". CPs and vPs stood up immediately, although DPs have been seriously taken under consideration as well (Svenonius, 2004; Hiraiwa, 2005).

From a formal perspective, *phases* have been shown to provide cyclic domains, due to the adoption of PIC (Phase Impenetrability Condition) and p(eripheral)-feature (or generalized EPP). PIC has been formulated considering that three distinguishing elements would constitute a *phase*: its head, its complement (the sister of the *phase* head) and its edge

(the specifier domain). Considering the bottom-up mode of operation, the derivation of a simple declarative sentence would instantiate a derivation in which the first *phase* node to be reached would be the vP. Once it is built, its complement, that is, the VP is spelled out, being sent to the interfaces. The derivation proceeds up to the next phase, the CP. The TP, its complement, is thus shipped to the interfaces and a final spell-out applies to the whole tree (Hornstein, Nunes & Grohmann, 2005):

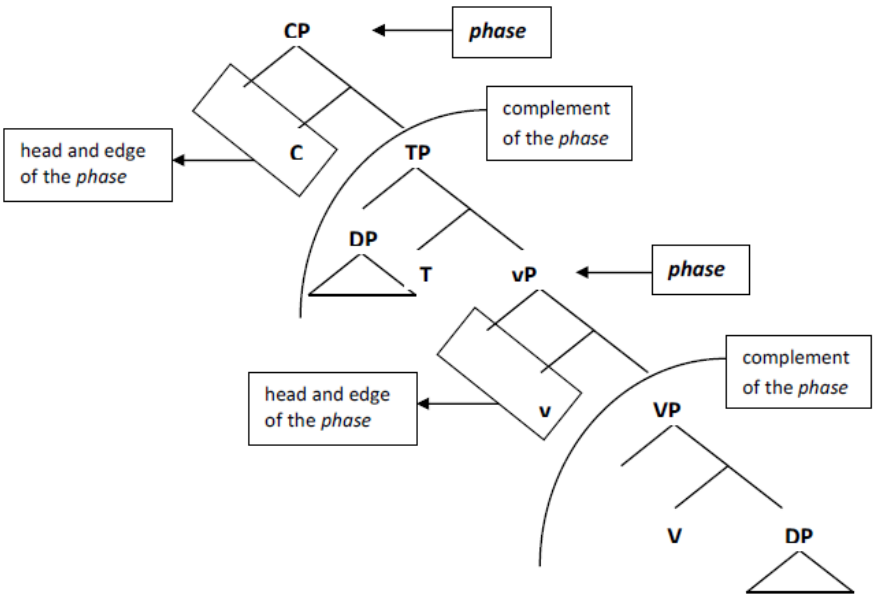

Figure 1: Phases and corresponding spelled-out material

PIC is the condition responsible for stipulating that the sister of a *phase* head is transferred to the interfaces and becomes inaccessible for further syntactic computation. Complementarily, it states that the head and the edge are accessible for the establishment of possible relations to material outside the *phase*. The dynamical shipping of material to the interfaces would allow the derivation to be inspected for convergence at distinct derivational steps as the computation unfolds, which contributes for computational complexity reduction. As it has been conceived of, however, PIC would prevent any extraction of complements, which is contrary to facts. In order to circumvent the restrictions imposed by PIC, Chomsky (2000) assumes that each *phase* may be endowed with an extra EPP feature, serving as an escape hatch for extraction. From this perspective, *phase*s have been suspiciously evaluated as "reincarnations of bounding nodes and barriers" (Boeckx, 2008:52).

Despite of the numerous criticisms against *phase*s (Epstein & Seely, 2002; Legate, 2003; Boeckx & Grohmann, 2007), this concept is useful for an explicit relation to be

established between a formal model of language and an on-line model of syntactic computation. The concept of the dynamical feeding of the interfaces appears to incorporate the idea of incremental processing, which has been explored in processing models, not easily reconcilable with the idea of an autonomous parsing, much more akin to minimalist assumptions (Kempen & Hoenkamp, 1987; Altmann & Kamide, 1999). Being so, it is necessary to provide formal means of reconciling the minimalist concept of *phase* with incrementality in processing.

2. INCREMENTALITY AND CONTEXTUAL INFORMATION IN LANGUAGE PROCESSING

In sentence comprehension, incrementality may be related to the sequential parsing and interpretation of sentence fragments from left to right, and their immediate mapping onto referents/events as the input is perceived, rather than having a full string of lexical items maintained unanalyzed in working memory until parsing/interpretation is completed (cf. Altman e Steedman, 1988). The theoretical dispute regarding incrementality is though related to the type of information and to the time course such information would be accessed. Would information from higher levels, such as semantic and contextual information, be accessed during on-line computation? Vosse & Kempen (2009), referring to syntax-first (or garden-path) and constraint-based (van Gompel et al. 2000) models, state that:

> Both types of models presuppose that the ultimately delivered syntactic structure for a grammatically well-formed sentence has to be compatible with the conceptual (semantic/pragmatic) content expressed in the sentence. They are also similar in assuming incremental processing: The syntactic parser attempts to assign a structural place/role to every new input word immediately, without waiting for the rest of the sentence. The two types of model differ with respect to the time course of syntactic and conceptual processing. According to syntax-first models, when encountering an ambiguous input string, the parser derives one syntactic structure during a first stage of processing. Here, only the morphological and syntactic properties of the new input word (in particular its word-class) are taken into account. After thus having computed a syntactic structure for the ambiguous input string up to and including the most recent input word, the parser submits it to a conceptual processor, which attempts to assign it a plausible meaning. If this second processing stage does not yield a satisfactory result, the syntactic parser concludes it has been "led up the garden path" and undertakes a reanalysis of the input string. Reanalysis manifests itself in increased processing times (e.g., longer gaze durations, more regressive eye movements).

Unlike the syntax-first models, the constraint-based ones assume parallel processing and rely on numerous studies presenting evidence which suggest fast integration of contextual

information, immediate referential search and anticipation of structural/semantic relations during sentence processing to argue against a modular view.

There is experimental evidence that discursive contexts are taken into account very early in online processing. In a self-paced reading experiment, Grodner, Gibson & Watson (2005), investigating RCs, showed that, when previous contexts are manipulated, supportive contexts presenting a set of contrasts (1), compared to null contexts (2), facilitate the processing of restrictive RCs.

(1) Supportive context
A vicious guard dog bit a postman on the leg and another postman on the arm.
The postman that the dog bit on the leg needed seventeen stitches and had a permanent scar from the injury.

(2) Null context
The postman that the dog bit on the leg needed seventeen stitches and had a permanent scar from the injury.

Eye tracking studies also indicate fast integration of contextual information (Eberhard et al., 1995). Ambiguous reduced RCs like "The student spotted by the proctor ..." (in which, in general, there is a tendency to read *spotted* as a main clause verb) may have a relative clause reading induced by previous discourse contexts that refer to an event in the future, such as, *"... tomorrow ... the proctor will notice one of the students cheating*" (Trueswell & Tanenhaus, 1992). Discourse information seems, then, to be incrementally accessed during intermediary stages of sentence processing. Even more blatantly, neurocognitive data have been presented in support of the effect of contextual information in the decisions of the parser. In a well-known study conducted in Dutch (Brown, van Berkum & Hagoort, 2000), the effect of previous context in solving temporary lexical ambiguity with regard to the syntactic category to which the word *dat* belongs (a complementizer, introducing a complement sentence; or a relative pronoun, with a neutral antecedent) has been investigated by means of ERPs. In particular, the P600 effect was investigated. This effect has been traditionally interpreted as a syntactic effect resulting from reanalysis. Hence, the presence of this effect would inform the preferential analysis for the critical element (*dat*) in different syntactic and discourse conditions. In this study, the gender of the noun that could be taken as the head of a relative clause was manipulated (neutral / common) as well as the previous context (either

with a single or two possible referents to the DP at stake). The P600 effect was obtained when previous context favored the relative clause reading, even though the structural preference of the parser is taken to be the complementizer analysis, in the light of syntax-first models (Frazier, 1978; 1987). It is interesting to notice that this effect was obtained even with a common gender antecedent, which would not allow *dat* to be interpreted as a relative pronoun, provided there is a context favoring the anticipation of a restrictive RC (see Brysbaert & Mitchell, 2000 for a discussion).

In the visual world paradigm, it was found that, when listening to sentences like "Pick up the beaker", participants began to fixate more often on the target referent of the DP than on unrelated objects around 200 ms after the onset of the target word (Allopenna, Magnuson & Tanenhaus, 1998; see also Dahan, Magnuson & Tanenhaus, 2001; Tanenhaus et al., 2000), suggesting continuous mapping between unfolding sentences and potential referents.

In a similar vein, it has been shown that given a sentence such as "The boy will eat the cake", participants directed their gaze to the picture of a cake (in a set with other "non-edible" figures) before the post-verbal noun. That is, the selection features of the verb promoted the anticipation of a semantically plausible complement (Altmann & Kamide, 1999). There is also indication that the information conveyed by the verb can elicit the anticipation of even more distant arguments, such as goals (Kamide, Altmann & Haywood, 2003). Besides the selection features of verbs, predictive eye movements seem to vary as a function of the tense of a verb as well (Altmann & Kamide, 2007) and are claimed to be sensible to the argument status of PPs, as suggested by results in which a PP following a verb was correlated to more looks towards it when it was a complement of the preceding verb than when it was an adjunct (Boland, 2005).

As for RCs, Eberhard et al. (1995) report an experiment in which listeners were presented to a set of playing cards miniatures and asked to follow an instruction containing a subject RC, such as "Put the five of hearts that is below the eight of clubs above the three of diamonds". The sentence, depending on the set of cards, would allow reference disambiguation at an early (eg. below), mid (eg. eight) or late (eg. clubs) point in the sentence. Eye-movement latencies to the target cards measured from the onset of the disambiguating words revealed a significant effect of disambiguation point (Eberhard et al., 1995). Results such as these seem to provide evidence in favor of an incremental mapping between expressions and their referents.

These results are, at first sight, hard to reconcile with an autonomous parser. In fact, it would be difficult for a processing model incorporating an autonomous parser to account for

these results if semantic interpretation and referential mapping are considered to occur only after a clausal unit has been analyzed. The possibility, however, of characterizing the immediate mapping of DPs or even the immediate mapping of D onto a referent by a processing unit equivalent to a syntactic *phase* can be taken as the first step for an on-line model to reconcile incremental processing with an autonomous parser.

In sum, there is evidence that sentence analysis proceeds incrementally and that DPs can be immediately mapped onto referents and even anticipated in the speech stream as suggested by the immediate search for the target referent of a DP as soon as a verb is recognized. The results of an eye-tracking experiment (Forster et al 2010a; 2010b) corroborate this view by showing that the subject of an object RC is sufficiently informative to enable the identification of the referent of the complex DP.

In the next section, the relatively high processing cost of object RCs will be considered and the eye-tracking experiment in Forster et al (2010a; 2010b) will be briefly described in order to illustrate this point.

3. THE ON-LINE MAPPING OF A COMPLEX DP ONTO A REFERENT

It is widely attested that object RCs impose considerable demands on processing, particularly in center-embedded position (Gibson et al., 2005; Traxler, Morris & Seely, 2002). Nevertheless, processing cost can be minimized in different processing conditions. Factors such as *animacy* of the DPs involved (Correa, 1995a; Mak, Vonk & Schriefers, 2002; Caplan et al., 2005), *plausibility* (Traxler, Morris & Seely, 2002) and the nature of the intervening material, i.e. the referential character of the subject of the RC (Warren & Gibson, 2005; Gordon, Hendrick & Johnson, 2004) seem to facilitate the processing of these sentences. There is also evidence suggesting that the anticipation of syntactic and semantic relations proceeds as the sentence unfolds (Kamide, Altmann & Haywood, 2003). These results are usually interpreted in the light of constraint-based theories (cf. Trueswell & Tannehaus, 1994). The immediate mapping of a complex DP containing a RC may also be taken as a possible means of minimizing processing cost (Forster et al, 2010b). The results presented below provide evidence for the solution of the reference of the complex DP, as distinctive information obtained either from the gender of the noun or the subject of the RC is encountered.

3.1. IMMEDIATE MAPPING IN THE PRESENCE OF DISTINGUISHING VISUALLY PRESENTED EVENTS

The experiment reported in Forster et al. (2010b) is part of a broader investigation in the reduction of processing cost by the integration of information in incremental sentence processing (Forster, in prep). In this experiment, test-sentences (sentences containing object restrictive RCs) were presented simultaneously to two scenes illustrating different actor-action-patient events, one of them corresponding to the RC (see Fig. 2). The non-target scene was similar to the target one, except for a distinguishing element (DE). The DE was the independent variable, with 4 levels: (A) the patient, (B) the actor, (C) the pair actor-action and (D) the action (see Fig. 2, slide 2). The working hypothesis was that participants would look for the target referent as soon as the complex unfolding DP could be related to the distinguishing visual information provided. Three segments of the test-sentences were delimited for analysis, as shown in (3): Segment 1 (S1) comprises the region from the head noun to the determiner of the RC; Segment 2 (S2) corresponds to the noun of the subject of the RC, and Segment 3 (S3), to the region from the verb of the RC on.

(3)	A garota que o	bombeiro	pegou vai comprar um brinquedo
	The girl that the	*fireman*	*caught will buy a toy*
	S1	S2	S3

The dependent variables were: (i) the number of target first fixations at S1, S2 and S3; (ii) target total fixation duration (the sum of the time of all fixations at each point) at S1, S2 and S3. It was predicted that if contextual information is incrementally accessed during comprehension, the referent of the complex DP would be searched for as soon as distinguishing information was available. If so, a greater number of first fixations and longer fixation durations would be expected to occur at S1 in condition (A), since the noun head of the RC is different in each scene, at S2 in conditions (A), (B) and (C), as far as the agent of the RC is different in each scene. Differences between conditions were not expected at S3, since referent mapping would be possible in all conditions.

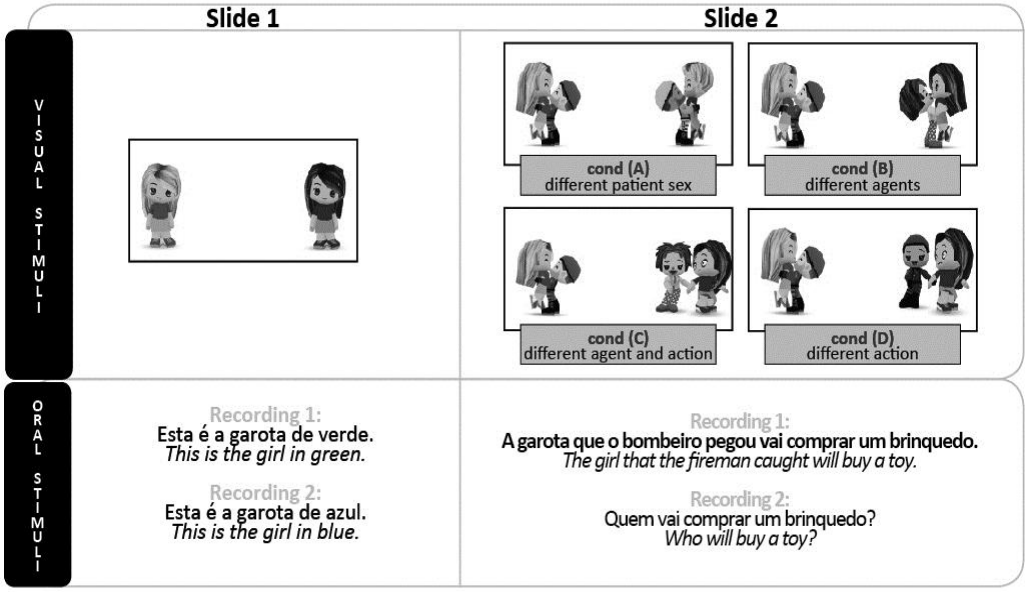

Figure 2: Example of visual and oral stimuli in Forster et al (2010b).

The results show that the predictions were confirmed. When the gender information of the head of the RC (Condition A) was informative for the identification of the referent, there were more and longer fixations at the target referent at Segment 1 (S1) (pairwise comparisons show that this condition differs significantly from conditions (B) (TFF[4]: $t(19)=2,37$ $p< .03$, TFD: $t(19)=2,99$ $p< .01$) and (C) (TFF: $t(19)=2,63$ $p< .02$; TFD: $t(19)=2,69$ $p< .02$)). At Segment 2, which informs the subject of the RC, there were more and longer fixations in conditions B and C (pairwise comparisons reveal that those conditions differ significantly from condition (D) (respectively, TFF: $t(19)=2,52$ $p< .03$; TFD: $t(19)=3,17$ $p< .01$ and TFF: $t(19)=2,24$ $p< .04$; TFD: $t(19)=2,29$ $p< .04$)). At S3, the verb of the RC, which enables the head noun to be reactivated in object position, all four conditions present a high number of first fixations and long fixations duration.

Both number of first fixation and total fixation duration measures suggest that listeners attempted to map DPs onto possible referents as soon as possible during sentence processing. The results obtained in S1 indicate that the distinguishing information provided in condition (A) – gender -- led participants to direct their gaze to the target referent. Those obtained in S2 indicate that the subject of the RC enables the referent of the complex DP to be searched for. Therefore, information conveyed prior to the RC verb, which restricts the reference set, allows referent mapping to be anticipated. The overall high number and long duration of fixations obtained in S3 appear to reflect the checking of the anticipated solution for the reference when the RC can be fully analyzed.

[4] For convenience, target first fixations will be referred as TFF and total fixation durations as TFD.

These results are then compatible with previous research (Allopenna, Magnuson & Tanenhaus, 1998; Dahan, Magnuson & Tanenhaus, 2001; Tanenhaus et al., 2000). It might, however, be argued that the effects that have been captured stem from a lexical search prior to analysis of the sentence and that the availability of the image of the scene described by the RC while it is presented facilitates the immediate mapping of a noun (eg. *fireman* in (3)) with the image named by it. A follow-up experiment has shown, nevertheless, that the immediate mapping of DPs can be attested when the scene described by the RC is presented prior to the test sentence and just the target and the alternative referents are visually available during the RC processing. Statistically significant results have been obtained in the same direction of those of the first experiment (Forster, in prep.) These results are, therefore, compatible with the view that complex DPs are immediately mapped onto referents as the sentence is analyzed.

4. RELATIVE CLAUSE PROCESSING IN AN INTEGRATED MODEL OF ON-LINE COMPUTATION

The integrated model of on-line computation (MINC) incorporates much of the operations of the language computational system characterized in the MP (namely, *Merge*, *Agree*, *Move* (*Merge+Copy*)) as necessary operations for the syntactic formulation of sentences in production, and for sentence parsing in comprehension. [5] These operations apply to the formal features of lexical units recovered from the lexicon and, in the case of Merge, to previously formed syntactic objects previously formed as well. From a formal perspective, there is no reason to speculate on possible motivations driving the presence of particular lexical items in the Numeration. From a psycholinguistic point of view, however, the items in the "Numeration" (i.e. accessed from the Mental Lexicon) are part of the grammatical encoding of a message by the speaker, which presupposes that lexical items are searched due to their interaction with conceptual and intentional systems. As for the hearer, the items in the "Numeration" (i.e. accessed from the Mental Lexicon) are the result of the lexical recognition, which enables the parser to operate on the input string. An on-line model of computation would, therefore, have to take this into account. Moreover, the bottom-up mode of derivation

[5] *As an anonymous reviewer points out, there is some oversimplification in this overall presentation of the MINC in relation to the operations incorporated from a minimalist derivation, in so far as other sorts of Merge operations would be required in a bidirectional model. In fact, MINC incorporates an operation responsible for inserting constituents generated in a bottom-up way in parallel derivational spaces into a functional skeleton generated in a top-down way, which might be thought of as a distinct kind of Merge.*

adopted in formal derivations in the context of the MP has been argued to be incompatible with the incremental character of language processing (Correa, 2005; 2008).

The fact that the lexical items taking part in the syntactic computation have been retrieved from the lexicon as a means of grammatically encoding a message, given a particular intention, is captured in the model in terms of a bidirectional derivation in parallel derivational spaces. It is assumed that in a bi- directional model a bunch of phrases are build in a bottom-up fashion, in parallel derivational spaces, and then they are inserted in syntactic skeletons that have been derived in a top-down fashion. What determines the directionality of the derivation is the nature of the lexical item that is selected to the computation: functional items enter into the computation as maximal projections giving rise to top-down functional skeletons, since they encode reference, which, in an on-line model requires interaction between functional categories and intentional systems during lexical access. Elements from lexical categories, such as N, V, Adj and lexical prepositions, on the contrary, give rise to bottom up computation, in so far as they express conceptual information and an argument structure may be predicted once they are recovered from the lexicon. The syntactic objects so derived are inserted in the top down functional skeletons in their proper place. Bi-directionality reconciles, therefore, the advantages of a bottom-up procedure responsible for capturing argument requirements of lexical heads with the idea that referential anchoring encoded in D and T, illocutionary force encoded in C would set the picture for the on-line computation to proceed. In other words, in this model, functional nodes, guided by the speech intent, give rise to the top-down derivation of syntactic skeletons in which bottom-up derived syntactic objects stemming from lexical nodes are attached (Correa, 2005; 2008; Correa & Augusto, 2007; 2011). Minor adjustments are, nevertheless, required in order to account for the left-to-right scanning of the lexical string as the sentence is perceived in comprehension. Hence, for syntactic computation during the parsing of a sentence, a top-down skeleton stemming from C would be created as the leftmost element was recognized and processing would proceed with the parsing and assembling of functional and lexical structures (top-down and bottom up) as the string was perceived from left-to-right.[6] These features of the model will become clearer when the on-line computation of RCs is considered.

[6] Other left-to-right solutions to incorporate a minimalist derivation into a parsing model have been attempted by Phillips (1996) and Fong (2005). It is worth mentioning that the terms top-down and bottom-up refer to the directionality of the computation, independently of whether it is implemented in the parsing or in the grammatical encoding of a sentence. They are not used in its most technical sense, as in formal grammars or in computer programming. As pointed out by an anonymous reviewer, it should be acknowledged that some authors make it clear that a different concept is required in order to characterize some sort of top-down

Another feature of MINC worth mentioning here is the distinction between costless and costly syntactic movement – the former not being computed on line and the latter being due to discourse demands. RCs are a particular instance of costly computation. These features of MINC together with the assumption of DPs as *phases* make it possible to account for the immediate mapping of complex DPs with RCs.

As already mentioned though, the concept of *phases*, when brought to the model of on-line computation, needs to be conceived of left-to-right/top-down. Being so, considering the structure of an RC, Figure 3 depicts the elements corresponding to the complement and the edge/head of a *phase* as they are spelled out:

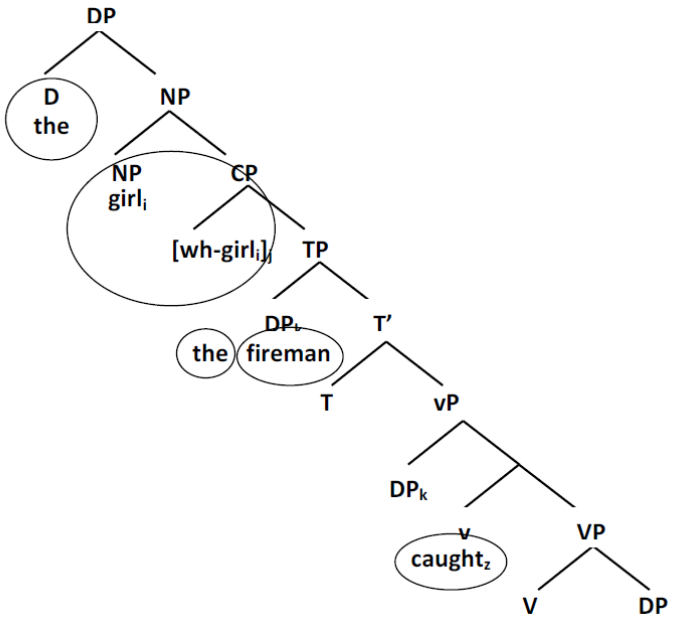

Figure 3: Left-right/top-down characterization of the phase material spelled-out in a relative clause

Given the concept of phase, the elements in circles in n Fig. 3 would be available for operations out of the syntactic domain. The D element constitutes the head of the DP. Its complement – the NP *girl* - would be spelled out with the edge/head of the next phase, that is, the CP. The next DP in the subject position would constitute another *phase*, in which a head and a complement are identified. Lastly, the verb would be part of an independent phase.

Thus, the steps for the parsing of a sentence with a complex subject DP with a RC would proceed as follows: the information provided by the beginning of a string of lexical

directionality in natural language computation by adopting slightly different terms, such as "Root-First Derivations" (Richards, 1999, 2002) "Top-to-Bottom Derivations" (Guimarães, 20004) "π-Derivations" (Drury, 2005), etc."

items would signal to the sentence processor that a sentence with a given illocutionary force has been produced, which would trigger the top-down generation of a functional skeleton starting in a CP. The recognition of a determiner would promote the top-down generation of a DP in a parallel derivational space, which shall be possibly attached in the subject position (Spec TP) of the structure that started from a CP. Assuming DPs as *phase*s, having D as its *head*, makes it possible for the top-down computation of an underspecified DP to trigger the search for its referent on the basis of the interpretation of the features of D at the semantic interface.

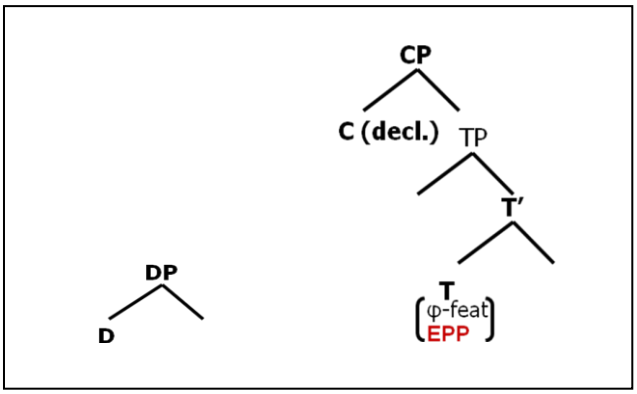

Figure 4: Top-down generation of CP, TP and DP

When the information provided by the features of D (gender for instance) is enough for the referent of the DP to be anticipated, the recognition of the NP may enable the referent to be properly identified, as shown in the experiments mentioned above. However, if there is more than one possible referent in the context, the NP followed by the relative pronoun will signal that some information will be provided as to allow the identification of the referent. Thus, the model also assumes that a DP is not necessarily closed as a phrase as soon as the NP that is the complement of D is processed, given that a subsequent modifier may be present (Correa, 1995b). In the case of RCs, the relative pronoun to the right of a noun would constitute the edge of the *phase* introduced by the CP. Thus, the chunk "*the girl that...*" would allow the recognition of a noun and the bottom-up assembling of an NP modified by a CP, attached to the DP, predicting that *girl* is going to be modified by a clause. Thus, a copy of *wh-girl* would be maintained in a sort of memory box to be discharged later on, as a gap is encountered (Augusto, 2008).

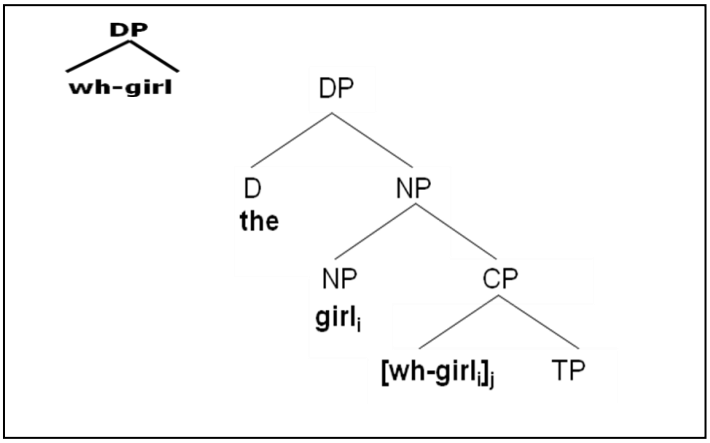

Figure 5: the initial parsing of the RC

The first attempt would be to consider that *wh-girl* could be discharged as the subject of the RC, but the presence of a D from "*the fireman*" in the input would prevent that. Instead, an extra DP has to be assembled in parallel derivational space, anticipating the reference to another entity/individual in the context. The noun *fireman* allows such entity/individual to be identified and contributes for the identification of the *girl* under search, given the visual input available, in the case of the experiments described.

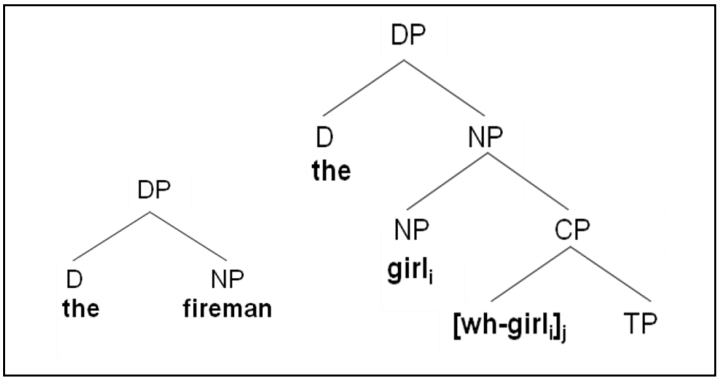

Figure 6: Assembling of a DP in parallel derivational space

The presence of a finite verb guarantees that the DP "*the fireman*" is attached to the main syntactic derivation as the subject of the verb and creates the expectation for a complement, actually the identification of the gap (by the copy of *wh-girl*) and the closing of the complex DP with the RC. So, even though the complete processing of the RC is necessary for the identification of the roles each individual plays in the action being depicted, the identification of the individuals to be considered may be conducted prior to the end of the RC, in accordance with what has been suggested by the experiments reported.

Thus, considering the evidence provided by the experiments in 3.1, it seems reasonable to consider that DPs form *phase*s, that is, independent units which may be transferred to interpretation dynamically as the sentence unfolds. Being so, the incorporation of the notion of *phase*s and dynamic feeding of interfaces in a left-to-right basis is a formal solution for the characterization of incrementality in on-line computation.

5. CONCLUDING REMARKS

This paper aimed at providing a formal solution for the incorporation of *phases* as processing units in the context of MINC. The incorporation of this concept in a left-to-right basis together with computation of DPs in parallel derivational spaces as it is assumed in MINC enables reconciling experimental evidence for incremental processing, particularly, the immediate mapping of a complex DP with a RC onto its referent prior to the verb of the RC, that is, prior to the end of the RC and the identification of the object position in it. From the point of view of the on-line model, the remaining problem is how to incorporate the effect of the immediate mapping of DPs in the overall processing cost while maintaining the assumption of an autonomous parser (Forster, in prep.; Correa, 2012). From the point of view of a theory of language, the evidence for the immediate mapping of DPs onto referents is a further argument favoring the adoption of DPs as *phase*s, given the minimalist assumptions.

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RESUMO: Apresenta-se uma caracterização formal de DPs como *fases* (Chomsky, 2002) no modelo integrado de computação on-line (MINC) (Correa & Augusto, 2007; 2011). A proposta de DPs como fases que sofrem *spell-out*, alimentando dinamicamente as interfaces, conjugada ao modo de atuação do modelo integrado, permite tratar do mapeamento incremental de DPs a referentes. Caracteriza-se *incrementalidade* no processamento linguístico e apresentam-se evidências para o mapeamento imediato de DPs em referentes na compreensão. Em particular, resultados obtidos em experimento de rastreamento ocular no processamento de orações relativas restritivas por falantes de português são relatados. Argumenta-se que a incorporação do conceito de *fase* em modelos de processamento contribui para que se concilie o mapeamento imediato de DPs em referentes com um processador sintático autônomo.
PALAVRAS-CHAVE: computação sintática; minimalismo; DP como fase; processamento de orações relativas.