LANGUAGE PROCESSING, LINGUISTICS AND CONSTRAINTS

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1. Introduction[1]

Over forty years after the advent of the so-called Chomskyan revolution and twenty-five plus years into a solid psycholinguistic research agenda, a crucial question to ask about the nature of language concerns the way one conceives of the initial spark that gets it started, at least as far as comprehension is concerned. Recently, Gibson and Pearlmutter (1998, 2000) and Lewis (2000a, 2000b) (but see also Tannenhaus and Trueswell 1995; Carreiras 1997; and Pearlmutter 2000) have debated whether that spark is deterministically created in the same narrow place, always, or, on the contrary, whether the ignition that the system needs to get started may come from a variety of different places, a broad base. It is customary to assume that if it starts always in the same place the system will subsequently opt for a serial route, and that, conversely, if multiple sources are initially considered it will prefer a parallel development. I will not be primarily concerned here with that subsequent development, but will rather concentrate on the state of knowledge that has recently accumulated about the initial spark itself. With that in mind, in the rest of this paper I would like to argue the following points. Firstly, after the initial disappointment with Chomsky's early generative grammar (Johnson-Laird 1970, 1974; see Tannenhaus 1988, for a review), recent advances in psycholinguistics have progressively drawn generative grammar nearer

to linguistics in the sense that, like this, the field now appears to have acquired on its own the kind of linguistic experience that allows it to become sensitive to an extremely complex set of interacting factors and perspectives whose integration from above is no longer felt to be (suspiciously) just around the corner. And secondly, in coming to terms with, and closer to, the complexity of linguistics itself through the realization that no magic facile answers to the puzzle of language are available, psycholinguistics is now navigating its way towards one of the two positions in the debate. In effect, more like linguistics, psycholinguistics is, perhaps still a little inadvertently, heading for a constraint-satisfaction type of approach to the nature of language, that is, to a broad base for ignition, as opposed to a deterministic narrow base.

Since the last twenty-five years have ultimately been all about that initial moment of processing, it seems to me that this is an interesting conclusion. In order to defend it, I will draw on two lines of evidence of the four I can think of as relevant to the debate. The first one concerns the development of psycholinguistic speech processing itself, and will constitute the bulk of this work. With a view to narrowing down the discussion, I will trace the evolution of the structure that has probably received the most attention in the literature, the Complex NP + Relative Clause construction (henceforth CNP + RC), and argue that the number and the quality of the factors which have been recently found to be operative in the processing of that structure point to a dynamically changing network of constraints. The second line of evidence will be used to illustrate in what ways a range of (obviously non-corresponding) linguistic constraints constitutes the norm in linguistics as well, and what that means for psycholinguistics. Making a quick reference to the grammar of control, I will argue that, given its typical complexity, no computational account is likely to be able to explain the processing of such complexity in a couple of magic processing strokes. In other words, I will contend that there are no grounds for assuming that the processing of linguistic reality must be any easier than the linguistic reality itself. This point makes sense in the context of a series of well-known formalist accounts of parsing which dominated psycholinguistic research in the 80s and early 90s by appealing, deterministically, to merely two or three kinds of syntactic geometry. In my view, such a reductionist way of approaching language processing is, given the nature of what is processed, extremely optimistic. For reasons of space, I will not be able to discuss here two other factors that I believe point in the same direction. One is the evolution of linguistic theory itself, which, even at its most formal, has moved from the strong autonomy of strict overgenerating syntactic rules in the 60s and 70s, to the lexicon, and principles and parameters in the 80s and early 90s, and from these even further away from a radically syntactocentric view of language to an emphasis on interface levels in the new millenium (Chomsky 1965, 1981, 1993, 1995). The second factor has to do

with a methodological issue that is becoming crucial to the whole experimental agenda in psycholinguistics, namely: how is initial processing exactly to be defined and distinguished from later reanalysis. Over the years, latencies which used to be considered early effects of processing have been progressively deemed late by formalist theoreticians every time (that is, *after*) non-structural forces were shown to operate in their range (see, for instance, van Berkum *et al.* 2000, for a recent criticism of Brysbaert and Mitchell 2000, apropos the laters's prior accusation that the former's previous work could not be taken as evidence of early processing). There is a growing concern that the distinction between early and non-early processing has become too tenuous to form the basis of theorising as it now stands.

Finally, it is as well to add at this point that I will be concerned with recent psycholinguistic research only in as much as it reflects properties of the nature of language. Even if, as I will be contending, the view of language that emerges from such research is coincident with that obtained with the tools of (at least a large part of) linguistics, such a coincidence is extremely revealing in itself, given both recent history and the by now very different agendas and methodologies that linguistics and psycholinguistics have. However, the battle between all the different processing models is, in principle, outside the scope of the present paper.

2. The Complex NP + Relative Clause contruction

Consider the following sentence:

(1) Someone shot the servant of the actress who was on the balcony

The pattern in (1) has received a great deal of attention in the syntactic processing literature. It instantiates a so-called adjunction ambiguity in the sense that the relative clause (RC) occurring after the complex noun phrase (CNP) can be legitimately adjoined to either one of the two nouns (*servant* or *actress*). Psycholinguists are particularly observant of such ambiguities (which, though generally unperceived by us, are pervasive in our language use) because they can shed light on the architecture of the linguistic mind. They force us to ask what option —of the two available in (1)— the mind favours, and why. In this respect, psycholinguists do not have the benefit of theoretical linguists, who can remain satisfied with a phrase-marker that shows the RC to be connected with, or simply inside, the previous NP as a whole. Since people do assign interpretations to (1), as well as to countless other examples with similar ambiguities, a psycholinguist needs to know how the ambiguity is resolved (that is, who was on the balcony in (1)). The attempt to do this is expected to reveal, something about the nature of language.

Frazier (1977) and later Frazier and Rayner (1982) proposed that the human parser subjects all linguistic inputs to an initial syntactic analysis. At this initial stage, information which may be derived from the meanings of the nodes in the tree, context adequacy, knowledge of the world, and other non-syntactic sources will simply not be consulted, even if conspicuously evident. It is assumed that at this initial stage there is simply no time to consult meanings, so what the parser should be doing is to build up a tree which is full of vacuous category labels, like NP, N or *Inflex*. This syntactocentric model, known widely as the Garden Path theory of speech processing (henceforth, also GP), bases its seriality (first is syntax, then all the rest) on the presumed need for the human sentence processor (henceforth HSP) to minimise memory costs. A crucial feature of the model is that the HSP will always prefer simple analysis to complex. Simplicity in its turn is defined by reference to two main principles that the HSP must obey: minimal attachment (MA, "Do not postulate any unnecessary nodes" (Frazier 1987: 562), actually a specific instruction for the processor to prefer interpretations which require fewer nodes in the tree over other interpretations which require more nodes), and Late Closure (LC, "If grammatically permissible attach new items into the clause or phrase currently being processed", Frazier 1987: 562). LC, in particular, ensures that memory is not given an excessive workload by integrating each new bit of the tree with the material immediately preceding it. Another crucial feature of the model is that, since the sound logic of the computational economy that it is based upon will benefit all languages, its predictions are meant to apply universally.

So GP is a modular account of parsing in that it strongly defends informational encapsulation (Fodor 1983) and shallow output of each submodule working inside the big language module. Each submodule does its job as a mechanical reflex, blind to information (and/or interference) from other modules. Once the job is done, its output is handed over to the next in a markedly serial chain. Admittedly, GP theoreticians have never bothered to fully specify all the links in the chain. They have, however, made a point of emphasizing that the first link must be syntax. As far as (1) goes, the model predicts a preference for the second noun (*actress*) through the mandatory application of LC: based on the geometry of the tree, the lower noun is closer to the RC, so it should carry the adjunction.

But the model is wrong. In a questionnaire study Cuetos and Mitchell (1988) found out that in Spanish, readers preferred N1 as a host for the RC. More importantly, the Spanish preference for high-attachment was later confirmed on-line in self-paced reading tasks (Mitchell and Cuetos 1991; Mitchell *et al.* 1995). To the sentences in the previous questionnaire study were added continuations which forced disambiguation in either one of the two possible directions (for instance, 'with her husband' forces disambiguation towards N2 in (1)). Mitchell *et al.* found out that every time disambiguation was forced towards the N2 site the

disambiguating region took longer to read than when it was forced towards N1. This was taken as evidence that readers must have initially favoured the N1 site and were later forced to undertake time-consuming reanalysis.

The Spanish data have been subsequently confirmed abundantly. The English data, however, have shown a less reliable pattern of results, although a slight preference for the lower NP may be discerned, at least in British English. Most other languages examined tend to side with the Spanish results (e.g. Zagar *et al.* 1997, for French; Hemforth *et al.* 1998, for German; Brysbaert and Mitchell 1996, for Dutch; see also Cuetos *et al.* 1996 and Carreiras and Clifton 1999, for overviews of cross-linguistic findings, with special reference to Spanish and English). This means that, firstly, LC (or at least LC alone) cannot explain the facts of (1); and secondly, GP´s presumption of universality is seriously undermined.

Mitchell *et al.* (1992) proposed a different account of parsing based on the frequency with which competing alternative structures occur in the language at large. They conducted a corpus study in both English and Spanish which showed a statistical prevalence of the N1 site for Spanish (60%) and a dispreference for this site in British English (38%). The match between the on-line measures and the corpus counts is exactly what the Tuning theory of speech processing would predict. Tuning does not rely on computational principles like LC or MA. It is, however, still a structural model in that it maintains that ambiguities are resolved by consulting vacuous trees (not meanings). It simply asserts that the tree which has proved more successful in the past will the chosen one. Being an exposure-based theory, Tuning has naturally evolved to claim that subjects' initial syntactic preferences will be a direct reflection, not only of the general prevalence observed in their language at large, but also of their own individual exposure. Given such theoretical premises, experiments in which subjects (both young and adult) were immersed in N1- or N2-biassed regimens for specified periods of time have ensued, with the result that the recent manipulation of their exposure was shown to be enough to cause them to abandon the general tendency and favour that imposed by the regimen. Again, this is exactly what Tuning would predict (Corley 1996; Brysbaert and Mitchell 1996; García Orza 2001).

But, just like GP, Tuning is a universal theory of parsing, and it turns out that its universal pretensions constitute too strong a test for the model. Recently, corpora studies and on-line measures have been shown not to coincide in Dutch (Brysbaert and Mitchell 1996; but see also Brysbaert *et al.* 1999, and De Baecke *et al.* 2000, for some important qualifications to these findings). Additionally, Gibson *et al.* (1996), Gibson and Schutze (1999), and Pickering *et al.* (2000), for instance, have recently shown the model's predictions are wrong when applied to other syntactic patterns. The conclusion is that frequency may be a powerful determinant of

(initial) adjunction, but hardly the only one. Another relevant shortcoming of the model is that it is hard for its proponents to spell out what Mitchell (1994) has referred to as the problem of the 'grain size', that is, precisely what should count as a segment subject to frequency effects. In the case of (1), for instance, should we consider the frequency of the overall [CNP + RC], that of particular prepositions inside the CNP (more on prepositions below), that of the RC with particular nouns?, etc. Given such openness in the delimitation of the object of analysis, proponents of the model are often accused of being able to accommodate *any* finding.

The failure of universal models of parsing to accommodate different parsing strategies across languages has resulted in the appearance of parameterised theories (e.g. Konieczny *et al.* 1994; Hemforth *et al.* 2000; Gibson *et al.* 1996, 1997, 1999). Based on Chomsky's theory of Universal Grammar (a grammar devised in part precisely in order to account for differences across languages), parameterised theories of parsing can explain cross-linguistic differences away by positing that a certain parameter is set to a stronger or a weaker value in a given language, but not in another. Notice that, just as an appeal to frequency is psychologically motivated given the well-known role of experience in molding cognition down to the level of lexical processing (Swinney 1979; Rayner and Duffy 1986), so an appeal to parameters is linguistically motivated, not only because it is based directly on a linguistic theory, but also because linguistic explanations often involve more than one or two explicative factors (see below). A well-known parameterised theory is Recency and Predicate Proximity (RPP; Gibson *et al.*, 1996). Predicate Proximity (PP) stipulates a bias to attach modifiers as closely as possible to the root of a predicate. This is a second way in which parameterised theories of parsing move in the direction of linguistics since the (also vacuous) trees their proponents have in mind do not assign the same role and potency to all the nodes in the tree. Indeed, most syntactic theories are premised on that fact that the predicate is the centre of the clause. In Gibson *et al*'s model, PP interacts with another principle, recency, which is essentially the same as LC. According to Gibson *et al.*, the different results obtained for structures like (1) in Spanish and English can be easily explained if we assume that Spanish sets PP high, with the consequence that distant attachments are costly. English, a language with characteristic syntactic rigidity, would rather set on a stronger recency parameter. The model has received support from structures like (2):

(2) a. The lamp near the paintings of the houses which was damaged in the flood.
b. La lámpara cerca de los cuadros de las casas que fue dañada en la inundación.

in which CNPs with three NPs before the RC show its expected pattern of facilitation (first N3, then N1, then N2. See Gibson and Schutze 1999).

However, not even two principles instead of one appear to be enough to save this model either. Leaving aside its failure to explain other structures and the validity of the grammaticality judgement task that its authors used to obtain their results (Cuetos *et al.* 1996), it has recently become known that the pattern of adjunction for structures like (1) is sensitive to the kind of preposition intervening between the two nouns that make up the CNP (Gilboy *et al.* 1995; Frazier and Clifton 1996; Frenck-Mestre and Pynte, 2000a, 2000b). Since neither recency nor PP should be affected by the type of preposition, it is clear that RPP cannot capture all that is relevant for the processing of adjunction ties.

If parameterised theories like the RPP model meant a certain progress towards more linguistically tuned accounts of parsing, Construal theory, advocated by GP theoreticians in an attempt to cope with the failures of their original GP model, is even more likely to please linguists, while not discouraging psychologists (Frazier and Clifton 1996, 1997, Gilboy *et al.* 1995). Construal advocates still maintain that LC and MA are mandatory universal principles, but they now circumscribe their operation to primary syntactic relations. For non-primary relations they postulate a new principle that gives the model its name: *construal*. 'Construed' relations are not solid, automatic, phrase-structure adjunction ties, but merely 'associations' with some portion of a sentence which are "interpreted using both structural and nonstructural information" (Gilboy *et al.* 1995: 133), including a *referentiality principle* to the effect that attachees are more likely to prefer referential hosts (so nouns with determiners to nouns without determiners, a relatively uncontentious claim). Primary phrases include: (a) the subject and the main predicate of a clause; (b) their obligatory constituents (complements); and (c) the complements and obligatory constituents of primary phrases. Non-primary phrases include, among others, RCs, adjunct predicates and phrases related via conjunction. Once a substring is analysed as a non-primary the Construal principle enters the processing scene in a very specific way:

> *Construal principle*: associate a phrase XP (which cannot be analysed as instantiating a primary relation) into the current thematic processing domain; interpret XP within the domain using structural (grammatical) and nonstructural (extragrammatical) interpretive principles.
>
> *Current thematic processing domain*: the extended maximal projection of the last theta-assigner. (Gilboy *et al.* 1995: 134)

The specification of a current thematic processing domain cast in GB terms has interesting consequences for the way we analyse the structure in (1), for it turns out that one is now forced to look into the internal structure of the CNP for predictions regarding the 'association' of the RC. This is so because when the CNP contains a preposition which is capable of assigning a theta-role (basically a

preposition with semantic content), the current processing domain excludes N1, which means that the association of the RC with the first site is strongly dispreferred. This is the case of segments like 'the book of the student that' or 'the steak with the sauce that', where the prepositions assign 'possessor' and 'accompaniment' theta-roles respectively, and where the RC is predicted to prefer low attachment. By contrast, in 'the sketch of the picture that' the very same preposition *of* is not a theta-assigner but merely a case assigner, which means that the whole NP sequence constitutes the entire theta-domain. In this case, the RC is associated with the whole CNP and the final interpretation is determined by all kinds of late information sources, including communicative efficacy, context fit, and culturally-shared pragmatic knowledge.

In allowing for at least a two-step process of parsing, Construal has made sure that cross-linguistic variation may be provided that, firstly. it affects non-primary relations; and, secondly, it occurs at a later stage in processing. For instance, the difference between English and Spanish observed in (1) has been ingeniously explained by the operation of Gricean principles ('avoid obscurity', 'be clear', etc) that are allowed to influence processing at a second stage. Thus, since in English, but not in Spanish, the CNP structure (*the book of the student that*) co-exists with the Saxon Genitive (*the student's book that*) and this latter precludes the RC from referring to 'student', speakers´ and reader's choice of the prepositional structure makes more sense when they mean the RC to refer to that noun. The slight N2 preference found in English may be explained in this way. In fact, Gilboy *et al.* found out in their questionnaires that most of the difference between the English and the Spanish data affects only two types of CNP: the 'alienable possessive' type (*the book of the student that*) and the 'kinship relationship' type (*the relative of the boy that*) only. Those are precisely the types where the Saxon Genitive is common in English (see also Brysbaert and Mitchell 1996, for initial partial evidence from Dutch).

Construal has made a startling contribution to a more finely-grained understanding of the factors involved in the processing of language. There is little doubt that its formal sophistication is a definitive step forward. Also, it is as well to notice that the primary vs non-primary distinction that it is based upon has a solid linguistic motivation for the model now claims that since complements and modifiers are linguistically different things they are probably treated differently by the HSP. That kind of isomorphim between basic tenets of linguistic theory and psycholinguistic thinking has always been a desired property of the form of collaboration between the two disciplines involved. That, together with the level of detail in the specification of the current processing domain are no doubt great assets of the theory.

Unfortunately, however, all that does not seem to be enough to capture the complexity underlying the processing of (1) either. Using an eye-tracker methodology, Zagar *et al.* (1997) found both a solid preference for the N1 site in French, as well as no effect of context whatsoever in first-pass measures, which they interpreted as evidence of a structural bias. If the high-attachment preference observed in most languages were due to late interpretative processes, such a pattern of facilitation should not be expected. Also, the strong preference for adjuncts like *yesterday* to obey locality (LC) in adjoining to the more recent clause in sentences like *John said he will come yesterday* is evidence that some adjuncts at least do not wait for 'late interpretive processess' to find a host, and that, therefore, the primary vs non-primary distinction is not all that counts in the processing of adjunction. Besides, how precisely adjunction remains in suspension (Deevy 2000) and is later resolved by a host of late-acting factors, and how these are to be ranked, has never been clear (Traxler *et al.* 1998). Nor is it clear how precisely the model can account for individual differences and habituation patterns reported in the recent literature (Corley 1996; Brysbaert and Mitchell 1996; García-Orza 2001). Finally, Mitchell *et al.* (2000) have recently questioned the Gricean explanation involving a choice of structures (the Saxon Genitive) on evidence from Dutch and Afrikaans, where the Saxon Genitive is also at work but no N2-bias has been observed.

In fact, the last four or five years have seen a revival of the [CNP + RC] debate just when Construal seemed to have explained it definitively. The revival in question manifests itself through the appearance of newer and newer factors or parameters bearing on the adjunction of the RC to the CNP. Although we cannot hope to go into the specifics of each new parameter here, it is important to form an idea of both their number and qualitative character. Apart from the four we have already mentioned, the following brief list includes more:

1. Prosody-segmentation. Gilboy and Sopena (1996) claim that differences between Spanish and English are caused by the different segmentation techniques used in experiments. These often include large segmentation (the whole CNP) and small segmentation (each NP is given a separate display). The differences in segmentation are almost negligible in the English results because English subjects, unlike Spanish ones, do not rely on a fixed intonative contour, as phrasal accent is more variable in English. In Spanish, however, large segmentation favours N1 because when the two NPs are shown together only the higher one has "relativised relevance" (Frazier 1990), being typically the main assertion of the sentence, as the head of the lower NP and closest to the VP head. Small segmentation results in increased N2 preference. It is assumed that segmentation maps onto pronunciation through subvocalization. Segmentation-related effects have been found for a variety of structures (Pynte and Prieur 1996; Schafer and Speer 1997; Carlson *et al.* 2001).

2. 'Same-size-sister'. According to Fodor (1998), what differentiates results in the [CNP + RC] construction from results obtained for other structures where LC is typically shown to be right is the heaviness of the attachee relative to that of the host configuration. Assuming that a constituent "likes to have a sister of its own size" (p. 285), it follows that light constituents will prefer to attach low whereas heavy ones will opt for high heads. Notice that, as Fodor herself points out, this a peculiar antigravity law. That would explain why some studies (Fernández and Bradley 2000) have found size effects in the sense that a short RC like *who cried* is preferably linked to the lower site in a sentence like *Somebody shot the servant of the actress who cried*. A principle of *balance* would prevent the short RC from attaching to the long CNP. Fodor suggests, and this seems to be important, that the universal research programme advocated by formalists can be salvaged if one assumes that prosodic processing works in parallel with syntactic processing and has an impact on ambiguity resolution. Since languages differ in their prosodic packaging, cross-linguistic variation is in principle easily accounted for. This new proposal is in part a reformulation of Frazier and Fodor's (1978) old Sausage Machine model in the light of the arguments put forward by Gilboy and Sopena (1996). (See also Thornton and MacDonald 1999, for other structures. On 'prosodic visibility' and the syntax-prosody mapping, see Schafer and Speer 1997; Pynte and Prieur 1996; Carlson *et al.* 2001).

3. The mixing of theta-marking and non-theta-marking prepositions affects processing. In particular, Frenck-Mestre and Pynte (2000a) have shown that having French readers initially read a series of NP1-*with*-NP2-RC sentences affects their subsequent processing of another series of NP1-*of*-NP2-RC sentences. The pattern of habituation they found is asymmetrical in that prior exposure to *of*-CNPs does not change the preference of *with*-CNPs for low-attachment. In part, this is to be expected given Construal premises (although such premises are not the only theoretical explanation of the facts): while the *of*-domain is open to two nouns, the theta-domain imposed by *with* affects only the second noun, which makes it impervious to modification of attachment preferences.

4. The lexical frequency of the nouns involved. Pynte and Colonna (2000) have shown that when N1 is of lower frequency than N2, French readers are more inclined to attach the RC high. By contrast, when N2 is less frequent than N1, N2 is the most likely host for the modifying clause. This is consonant with the functional role that RCs typically perform in language: to help narrow down the actual reference of a previous 'undefined' noun. Lexical frequency is different from the lexically-specified tendency that some nouns may have to take modifiers (MacDonald *et al.* 1994). As Corley (1996) has pointed out, in the case of [CNP + RC]s in particular, such lexical forces are not likely to have a major role in determining adjunction.

5. The restrictive/non-restrictive nature of the RC. This is not a dimension of analysis that has been subjected to experimental investigation directly, but rather a hidden variable that, according to Baccino *et al.* (2000), may have been at work in previous experiments. In particular, Baccino *et al.* point out that Frenck-Mestre and Pynte's (2000a, 2000b) solid N1 preference found in their French and Italian sentences is 'contaminated' by the restrictive/non-restrictive dimension of the RCs in them in that the French researchers used proper nouns in the N2 slot, thus promoting an N1 bias. Baccino *et al.* assume that readers will first try to interpret the RC as a restrictive modifier, rather than as a non-restrictive one, and since restrictives cannot modify proper nouns, the only possibility for these nouns to host the RC is via the (putatively reanalysed) non-restrictive interpretation of the clause. In the light of Frenck-Mestre and Pynte's counter claim that "Baccino *et al.* seemingly undercuts their own proposal that modifier attachment is governed by strictly syntactic considerations [because] (t)the interpretation of a relative clause as being restrictive rather than appositive is *most certainly* a referential process" (emphasis added), it seems evident that the psycholinguistic discussion can benefit from classic knowledge of the syntax of RCs (Ross 1967; Jackendoff 1977; Emonds 1979; Stuurman 1983). Given the well-known syntactic differences between the two types of clause, and the recent Frenck-Mestre and Pynte-Baccino *et al.* debate, psycholinguistic theories of the way they are processed should be (and surely are) under way.

6. Number. The Mismatch Asymmetry Effect first observed in production studies (Bock and Ebenhard 1993) captures the fact that a plural NP in a CNP domain increases processing of a singular verb. According to Deevy (1999, 2000), the plural feature is marked or specified by the processor whereas the singular is unmarked (also Pearlmutter 2000). In combination with Construal theory, which claims that the RC is not initially attached to the CNP but merely associated with it, the necessary checking of a plural agreement feature from the verb in the RC is momentarily blocked, thereby disrupting processing, as feature checking is delayed till the RC gets finally adjoined. The processing of a plural verb is fine because the potentially conflicting presence of a nearby singular noun is not even checked. It is assumed, besides, that overt agreement information on the singular is not available.

Deevy's research builds on previous findings that plural number has an impact on processing. This is an important discovery as plurality itself cannot be taken to affect the geometry of a tree. However, her theory that interference is explained if one assumes Construal postulates is not entirely clear. Deevy (2000) can in fact only show interference when the plural NP is the second NP in a CNP (*the niece of the actors who was*), but not when it is the first (*the nieces of the actor who was*). Since, as Deevy herself points out, Nicol *et al.* (1997), (also Pearlmutter 2000),

have shown that "disruption is not a function of mere linear proximity of the marked plural to the agreeing verb" (Deevy 2000: 70), this new asymmetry (the second plural NP, but not the first, affects processing), is totally unaccounted for. So is the fact that Deevy's condition with [singular NP1 + singular NP2 + singular VP] (*the niece of the actor who was…*) behaves exactly like the mixed type [plural NP1 + singular NP2 + singular VP] (*the nieces of the actor who was…*) but unlike (faster than) the other mixed type ([singular NP1 + plural NP2 + singular VP]: *the niece of the actors who was*). Finally, plurals have also been shown to attract adjunction of the RC in corpus studies of Dutch (de Baecke *et al.* 2000) and Galician (García-Orza *et al.* 2000). All in all, checking of plural agreement appears to be yet another relevant parameter in the determination of adjunction in at least the [CNP + RC] construction, but still not quite *the* parameter, yet again. Incidentally, as far as gender (not number) agreement goes, Brown *et al.* (2000: 66) have recently obtained electrophysiological evidence that "discourse-semantic information can momentarily take precedence over lexical-syntactic information".

7. Animacy. The same corpus studies in the preceding paragraph have found a marked animacy effect in the sense that a human NP inside a CNP domain is much more likely to attract the RC than NPs denoting non-human entities. In combination with plurality, animacy appears to act as an adjunction magnet. Brysbaert et al. (1999) have obtained similar results. It should be noted that the N2-biassed 'alienable possessive' type referred to above (Gilboy *et al.* 1995), as in *the book of the student that...,* contains an animate second noun. Additionally, Barker *et al.* (2001) have found out, in production, that animacy interferes with agreement in other structures, "indicating that the mechanism involved in implementing agreement [an ostensibly grammatical process] cannot be blind to semantic information". Prat-Sala and Branigan (2000) have reported that animacy plays a significant role in choosing among competing syntactic alternatives in Spanish and English, also in production.

Most of the aforementioned parameters are still being investigated and they of course do not exhaust the list of possible determinants of adjunction. Although we cannot afford to extend that list here at length, it is important to realise that there are likely to be many more. For instance, in exploratory questionnaires run at the University of Santiago, we have found a seemingly stable lexical priming effect in Galician, in the sense that for sentences like:

(3) He entered the room of the museum which exhibits local art.

there is an increased probability of the N2 site carrying the adjunction due to the strong lexical and collocational ties existing between *museum* and *exhibit*. Hemforth *et al.* (2000) insist that [CNP + RC]s must also be seen as a process of

anaphor resolution, and that the anaphoric binding of the relative pronoun is open to manipulations of both focus and visibility (in English, but not in Spanish for instance, the (non-subject) pronoun can often be dropped). Moreover, no one has seriously investigated the role of syntactic function, as indeed all experimental sentences used in the now large literature on the [CNP + RC] construction contain CNPs which act only as DOs or as complements of prepositional verbs (Acuña, in press). And if we move outside the [CNP + RC] debate, even more recent proposals are coming to light which may very well end up affecting it. For instance, Pickering *et al.* (2000) have discussed a new processing parameter, which they have termed *informativity*, that amounts to an instruction to prefer testable analyses. Thus, a more frequent option (say, a *that*-complement clause after the verb *realise*) may be abandoned in favour of a less frequent one (say, an object NP) if the latter interpretation is easy to verify almost *ipso facto,* thus allowing the HSP to prevent a major (as opposed to a minor) reanalysis. All in all, although the time has not yet arrived to *definitively* preclude the possibility that all of the aforementioned parameters may fit nicely inside a deterministic, serialised chain consisting of a few ranked types, and although most of these recent parameters have not been subjected to thorough cross-linguistic investigation nevertheless, *cumulatively* the sheer number of factors currently being explored points to a view of ignition which is essentially broad and open in nature and implemented through the competition among different kinds of ranked constraints. Indeed, it is not only the number of parameters but also, and fundamentally, the qualitative nature of many of them. Animacy, plurality, pronunciation, lexical frequency, harmonic rhythmicity or syntactic weight, size (and maybe even indefiniteness, modifiability, anaphor resolution, and lexical priming) can hardly be taken to modify the geometry of a tree. Since, out of all that constitutes the form of grammar, formalist theories of speech processing like GP, Construal, RPP, or Tuning have chosen to rely only on geometrical determinism, it is unlikely that they can accommodate such factors in their models. It is equally unlikely that precisely *all* those factors —of all the factors— will be eventually shown to act late. Indeed, it is not clear why one would wish to confine the immensity of all sentence processing (a scientific area of quintessential difficulty), not just to the form of the message, but to the very restricted part of that form which can only be reducible to (one or two aspects of) the geometry of a tree. Even in Chomsky's current model of grammar (1993, 1995), the extremely reduced (indeed minimalist) syntactic component known as *bare phrase structure* is both: a. affected in its essence by "bare output conditions" (1995) or "legibility conditions" (1999) in the sense that linearisation, for instance, is removed from it and seen as the result of performance constraints (the sensorimotor interface); and b. yet considerably more sophisticated in its dependence on arboreal representations since such notions as asymmetric c-command, for instance, are said

to operate at certain levels of structure (like maximal or minimal projections), but not on others (like intermediate projections). This means that, at the very least, there must be something analogous to projections and levels and commands (not to mention islands, movement, bounding domains, grammatical case, discontinuous relations, feature checking —including number agreement, function, mood, aspect, scope, floating relations, etc.) in the way of processing. Whether we like it or not, nothing about the form of language is ever so simple as LC or PP.

3. Linguistic complexity

The conclusion that the only way to explain both individual and cross-linguistic differences in parsing is to allow for the competition of at least some of those forces to compete fits in well with linguists' accumulated knowledge of language. Indeed, a constraint-based approach to parsing that assumes that representations corresponding to alternative interpretations are activated in a graded and dynamically changing way as the bits of the sentence keep coming and constraints continue to apply is possibly the best way to capture —not isomorphically, as far as we can tell now— the very many different arguments that linguists themselves typically use to provide support for their syntactic analyses. There is hardly any linguistic object, even in the formal realm that syntax is meant to be, that can be described or explained by reference to one or two formal manipulations of a geometrical kind (the equivalent of one or two processing principles like LC or PP). This is no doubt a logical consequence of something that linguists know too well, namely, that language is too complex to be accounted for under such minimalist assumptions.

Consider briefly linguists' typical description and explanation of grammatical phenomena. Control theory is a good example. In Chomskyan-style grammars, Control Theory regulates the way that the missing subjects of infinitivals and gerunds are derived. Hornstein (1999) has recently departed from the standard theory of control as devised by GB linguists by collapsing certain cases of control with syntactic movement (a proposal first made by Bowers 1981). The consequence of a theory of this kind is that the standard distinction between raising predicates (like *seem*) and control predicates (like *try*), as in (4) and (5) below:

(4) John seemed to (t) leave
(5) John tried to PRO leave

is abandoned in favour of a raising view of both kinds of predicates. Thus, PRO disappears from the grammar and *trace* takes its place. Importantly, the theta-criterion, which stipulates that each argument bears only one theta-role and that

each theta-role is assigned to only one argument (Chomsky 1981), must be abandoned too, according to Hornstein, as John in (5) now acquires a second theta-role by virtue of moving to [Spec, VP], basically, the position of subject of *try*.

Consider now Culicover and Jackendoff's (2001) criticism of Hornstein's proposal. The essence of their critique is that "there is a long tradition in the literature to the effect that the position of the controller is determined at least in part by semantic constraints" (p. 493), and that, consequently, "a purely syntactic account —especially (but not only) one that involves movement— will not work" (notice the hedges "at least in part" and "[not] purely"). Of course we cannot hope to go into the details of control theory at any length here. Fortunately for our purposes, however, if we keep in mind the point made in the preceding section, a panoramic view of both the number and the quality of the arguments that surface in the discussion should be enough to reinforce that point. Among those points Culicover and Jackendoff (henceforth C and J) mention the following:

1. A distinction between obligatory vs non-obligatory control.
2. The treatment of the Minimal Distance Principle (MDP; Rosenbaum 1967).
3. VP-Ellipsis reconstruction and controlled VPs.
4. Control in Infinitival Indirect Questions (IIQs).
5. Control by nominals instead of verbs.
6. Control into nominals.
7. Control in adjunct clauses.
8. The *promise* and *order* classes.
9. The *say* and *ask* classes.

Each of the previous points naturally leads to a further set of ramifications which we cannot hope to even mention here. However, the network structure of both the linguistic phenomenon that is analysed (leading from obligatory and non-obligatory control to the MDP, VP-Ellipsis, IIQs, control by nominals, control into nominals, control in adjunct clauses, and the establishment of lexical classes, like the *promise* class, the *order* class, etc.) and of the analysis itself is evident even after such a summary description. In effect, even if one merely wishes to understand and explain (4) and (5), it is simply not possible to explain control by referring to those two structures in an encapsulated manner. Instead, in order to explain (4) and (5), a dense net of linguistic arguments and relations must be taken into account. Such relations may be formal at times (for instance, every time the adjunct in adjunct clauses lacks an overt subject, the surface subject of the main clause acts as the controller), but some times they are lexical, or conceptual (e.g. the *promise* class violating MDP in the sense that, unlike most verbs, with *promise* PRO is controlled by the distant matrix subject instead of the near matrix object: *Jane$_i$ promised Josh$_j$*

to PRO$_i$ come soon), or they have to do with the way an account of the particular grammar of control fits into the grammar at large (like the need for Hornstein to abandon the theta-criterion, or the consequence that, in order to defend his theory, he must allow movement out of a *wh*-island, given the facts of control in IIQs). That in itself makes for a very complicated picture. All in all, it turns out that neither the raw facts of syntax, nor the raw facts of lexical specification, nor the raw facts of semantics can explain the range of structures that form the facts of control. This means that one is bound to conclude that control exists as a grammatical phenomenon only in as much as one recognises its inherently connectionist nature. This is the norm in linguistics because it is part of the nature of language.

Now, Control theory is not simply a linguistic phenomenon like phonemes, inferences, or metaphors. It is something much more circumscribed in that it is studied within the formal realm of grammar. If even within such a circumscribed scenario our understanding of the structure of this notion involves such a polyfacetted, multidimensional, and often apparently contradictory array of radial features of analysis, it is not clear how our understanding of the way we process the very same structure (see Betancort *et al.*, submitted) can be thought likely to depend deterministically, only, on such crude principles of syntactic geometry as LC (or similar ones, like de Vincenzi's (1998) Minimal Chain Principle), or at most on the early or not so early operation of a vaguely-defined theta-domain (vague in the sense that the thematic properties of prepositions are by no means absolutely transparent; cf. Grimshaw 1990). Indeed, a very serious theoretical objection to any deterministic model of parsing that rests almost exclusively on two or three arboreal processing principles for all its predictions is that it is hopelessly arbitrary. In effect, if processing is to be seen as an X-centric process (*eg* a syntactocentric process), then it is not clear why the X-centrism must extinguish itself only after the first X. That is, if the process is serially ranked, what is the relevant ordering of the rank after, say, LC or PP? Are we to assume that all syntactic factors take precedence? If not, which syntactic factors are to be seen as non-initially central: c-command, function, category? And why? What is the rank position of, say, number, or prosody, or syntactic weight, or argument structure, or frequency? If we have ten different forces bearing on the adjunction arena, and granting that the very first one must be (a tiny fraction of) syntax, should we not expect that the very same principle that grants that (tiny fraction of) syntax its priviledged status in the system should also apply to the remaining nine forces in order to determine their relative orderings?

It is possible to see things in a less arbitrary way, provided that one is ready to admit that what we see turns out to be much more complex than we used to assume. And if we keep in mind the by-now large list of factors which recent psycholinguistic research is finding relevant for the full determination of speech processing (like

[CNP + RC]s, in the preceding section), it now appears that psycholinguistics is finally becoming sensitive to the extreme complexity of language that linguists have recognised, and marvelled at, for so long. In as much as both explaining the structure of language, and the processing of that structure involves the accommodation to many interrelated constraints, the solution to the ignition problem is most likely to lie in frameworks that incorporate the dynamically graded (and most probably —but not necessarily— parallel) working of such constraints. Being dynamically graded, constraints may vary in the strength of their applicability (or 'ignitability'), and that variation is precisely what is needed to explain a polymorphic linguistic structure. Thus, for instance, as has already been pointed out, it is very unlikely that RC adjunction in a CNP domain should rely primarily on lexical biases like the propensity of some nouns to be modified. But that does not mean that such a factor is meaningless: it simply means that, in that particular structure, it is bound to be a minor player. If we see processing as the satisfaction of many competing constraints, it is easy to account for the complex scenario where in *some* circumstances *some* nouns do show a strong propensity to 'ignite' an RC. For instance, in *you know, John's the kind of guy...* we surely expect an RC (like *who is always happy)* more than in, say, *this is the end of the story...* (as in *which caused so much concern*). Notice that *guy* is not even a referential NP and *kind* is, yet surely the RC points to *guy* because *kind* is only formally referential and *guy* actually inherits its referentiality (just as in *an apple core* the formally indefinite *core* is actually definite, paraphrasable by *the core of an apple*). By contrast, in *this is the end of the story*, the segments *this*, *end* and (definite) *the story* indicate that the latter noun is anaphorically determined and thus unlikely to need any further major restrictive specification. In linguistic terms, the logic of those adjunction preferences would be analogous to the *promise* class of verbs breaking the structural logic of the MDP. Likewise, it is also possible to conceive of cases where the lexical tie *is* a major player. For instance, it has been shown that a passive interpretation is much more likely after *the evidence examined...* (as in *the evidence examined by the lawyer was conclusive*) than after *the witness examined...*, for obviously witnesses (but not evidence) can examine something (MaDonald *et al.* 1994; Trueswell 1996). That in turn would be the equivalent to, say, the strength of argument structure in determining that the nouns *order / instruction / encouragement / reminder / invitation* (but not *committment / promise / offer / guarantee / obligation / pledge /* or *oath*) should obey the MDP. And the fact that every time that the adjunct in adjunct clauses lacks an overt subject the surface subject of the main clause acts as the controller points to a strength of purely syntactic factors that is tantamount to the strong propensity to obey locality (LC) in adjoining *again* to the second of the two clauses in *John said he would come again*. Proponents of constraint-satisfaction approaches recognise at least the

following types of constraints: 1. Phrase-and clause-formation constraints; 2. Lexical constraints; 3. Contextual constraints; 4. Prosodic constraints; 5. Word-and phrase-level contingent frequency constraints; and 6. Locality (recency) constraints (Bates and MacWhinney 1989; Macdonald *et al.* 1994; Spivey-Knowlton and Sedivy 1995; Tannenhaus *et al.* 2000; Gibson and Pearlmutter 2000). To be sure, not only syntactocentric approaches are deterministic and thus reductionist in nature, but so are extreme lexicalist accounts which ignore locality and similar formal forces (as recognised, for instance, by Trueswell *et al.* 1993. See also Grodner *et al.* 2002, for cases where syntactic complexity is more powerful than lexical biases in determining disambiguation preferences). Some of these constraints may actually work as modules (a module of grammar or of the lexicon, for instance), as long as its operations are not seen as a precondition on the operations of the others, that is, as long as parsing is not seen as deterministically syntactic, or deterministically lexical, deterministically semantic, or deterministically pragmatic. In fact, parsing may even be serial, as long as it is not deterministically serial, so that initial analysis may sometimes be syntactically driven, but also lexically or semantically or pragmatically so. The appeal of such notions as modularity and seriality given such premises remains to be seen. In any case, it is also important to recognise that the six kinds of constraints just mentioned are *kinds*, that is, they are already an extreme reduction of the whole linguistic reality and all the psycholinguistic reality one has to deal with. With hindsight, and in the light of the (necessarily abbreviated) previous account of the forces bearing on the processing of [CNP + RC]s, and of linguistic complexity, the attempt by principle-grounded theoreticians to explain the entirety of the human sentence processing mechanism by having recourse to two or three arboreal processing principles seems naive. What recent research is finding is that the entirety of the human sentence processing mechanism is, not unexpectedly, turning out to be vast.

4. Summary and conclusions

Research into language and language processing is inevitably informed and affected by the researchers' hypotheses about the 'ignition' moment of speech, that is, the precise nature of the spark that gets the whole system started. One can conceive of the two opposite views that aim to explain this moment as two very different kinds of pyramids (and two different views of the nature of language). One, the inverted pyramid, starts in an extremely narrow place, the tip of the pyramid, and grows broader and broader as the system moves progressively away from the initial spark. The other pyramid, the non-inverted type, is rooted in a very broad base and tapers off as the system operations unfold in time. The inverted pyramid is

deterministic in that processing always starts on the same small spot, usually assumed to be syntax. The non-inverted pyramid, conversely, allows the system to get started anywhere along its broad base, with the consequence that ignition is harder to detect as it keeps changing its launching platform with every new structure, and even with any new change to any new structure. In this paper I have tried to present a case for a non-deterministic, non-inverted-pyramid view of parsing (and, more generally, language) based on, firstly, the strength of recent psycholinguistic evidence, as exemplified through the extensively studied [Complex NP + Relative Clause] construction; and, secondly, the nature of language, as this emerges from the world of linguistics. None of the different pieces of evidence reviewed here is conclusive in itself, yet cumulatively they do clearly point in a particular direction, towards a broad base.

Proponents of syntax-based deterministic models of speech processing often accuse constraint-satisfaction theoreticians of not being able to determine where precisely initial syntactic processing takes place, and of being able to explain any finding *a posteriori*. Indeed, the accusation is entirely justified given the dense net of parameters that converge upon the processing system as seen by the latter. In stark contrast with models that claim that ignition may start almost anywhere, formal deterministic models of parsing offer one solace in claiming that it can always be predicted to start in the same small area In this paper I have tried to show that such a complacent view of language processing is unfortunately too reductionist given the nature of what is processed. There are simply no grounds for assuming that language processing should be any easier than language itself, and —as we have seen— language is simply much more complex than proponents of deterministic models of parsing would appear to believe. In fact, even if *all* the non-formal parameters which are recently coming to light were eventually shown to act late (and there are simply no uncontroversial traces of that), formal models of parsing would need to go beyond their penchant for (a very reduced) geometry in order to account for effects caused by syntactic weight, or agreement checking, for instance. That is, even if ignition were only formally guided, the formal determination of that guidance would have to be considerably more sophisticated. In view of the accumulated knowledge of the past four or five years, deterministic parsing seems now much less appealing than it used to. This means that as researchers there may be no option but to become reconciled with the fact that language is systemic, networked and dynamic in nature. Which means that studying it may be considerably more demanding than one would like to admit. Also, considerably more challenging.

Notes

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