INCREMENTAL UNIFICATION-BASED LR PROCESSING[*]

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A good theory of linguistic competence must ultimately be compatible with realistic accounts of generation and interpretation. Since processing is successive, an optimal computational system is one that makes constituents of expressions available beginning with the leftmost one and does so in an incremental monotonic fashion. Yet, major linguistic theories like Minimalist Grammar, HPSG, Categorial Grammar, LFG, etc., which start derivations with lexical items and proceed to build expressions bottom-up, invariably yield hierarchical structures in which the leftmost constituents must also be the highest, and therefore the last ones to be built. This is exactly the opposite of what should happen in an efficient processing system and questions the adequacy of the respective theories. Within Chomskyan linguistics, the problem has only recently attracted attention, but, to my knowledge, only Steedman's Generalized Categorial Grammar handles it well, although at the cost of using powerful type-conversion and combinatory operations well beyond set-building Merge. Although, as argued elsewhere, Merge is not adequate to handle the complexities of structure-building, Steedman's tandem of Functional Application-Composition and Type-Shifting is much too powerful, since it has the effect of licensing virtually any constituency whatsoever, so it is worth while exploring approaches more powerful than unstructured Merge, but less so than Steedman's. In this paper, one such approach is explored which, granted detailed lexical items, yields the core facts of English surface order invoking only general principles of computational economy, and conceptually necessary operations like Satisfaction-via-Unification and Hold.

THE PROBLEM: A KEY PROCESSING OBJECTION TO BOTTOM-UP GRAMMARS

As Bresnan (1978) and Ades and Steedman (1982: 517) claimed long ago, a theory of linguistic competence must ultimately be compatible with realistic accounts of processing, and, as a matter of fact, the best processing models available are incremental monotonic ones, cf. Levelt (1989: 24), a fact explicitly recognized in Steedman's Combinatory CG (cf. Steedman 1996: 7; 2000: 6, 229, 261, etc.). Steedman's (2000: 261) following statement to this effect is hard to outperform: "Competence grammar and performance mechanism originally evolved as components of a single biological system <…> Any claim about competence grammar is ultimately a claim about the entire computational package. As soon as our linguistic theories have attained the level of descriptive adequacy, they will have to be judged not merely on their purity and parsimony as theories of competence, but on their explanatory value as part of a psychologically and biologically credible performance system." Yet, this plausible, and crucial constraint on linguistic theory has not (to my knowledge) been paid much attention to in other major approaches. For example, in Chomsky's Minimalist Grammar the problem was timidly raised only recently, cf. Phillips (2003).[1] Yet, the standard minimalist account of syntactic derivations (SDs hereafter) as resulting from lexical arrays (LAs, hereafter) through recursive bottom-

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[1] The structures Phillips (2003) aims at are binary-branching trees like those resulting from Merge, but they are obtained through an incremental LR and top-down derivation which entails destructive readjustments all the way down. A major problem for Phillips is that Right-Edge Merge may in itself be 'conservative', instead of 'destructive', and in that case it will yield left-branching structures, not the desired right-branching ones, so Phillips (2003: 44-45), has to introduce a rather implausible 'economy' condition that paradoxically primes right-branching (=destructive) Merge if possible, although it cannot literally forbid conservative Merge, since left-branching outputs must still be allowed in order to generate appropriate constituents and readings in certain cases of modification, coordination, and ellipsis. Such a condition is implausible in a minimalist framework if only because it primes mergers inside X, which entail searching within X, over mergers at the root of X, which entail no search, i.e., Phillips' 'economy' paradoxically primes the costlier option. Yet, it is that dubious condition that is meant to do all the real work in Phillips' proposal. Right-Edge Merge by itself cannot prevent a term from being merged at *any* point from which it c-commands an appropriate selectee, but the resulting structures will then not yield correct P sequences when linearized according to Kayne's Linear Cooccurrence Axiom. On the other hand, although Phillips does not discuss the consequences of his approach, it entails rather more than deciding where to start traversing trees; in fact, it is unfeasible except via significant reformulation of all essential principles of grammar. In particular, the Lexicon, Theta Theory, and Linking Theory must be completely rewritten, as must the Theory of Chains, Merge and the principles that constrain it, i.e., Merge cannot be just set-building under a No Tampering constraint, structure-building can no longer be Last Resort, etc. The details cannot be discussed here in full, but, for such reasons, Phillips' proposal does not seem to me a real answer to the problem at hand. A rather more radical departure from tradition is needed.

up application of Merge in successive phases, although programmatically monotonic, as the computational component (CHL, hereafter) is claimed to be more efficient if it can forget about what it has already computed, is not Left-to-Right-incremental (in fact, it is *anti*-LR-incremental, cf. *infra*), and to that extent implausible from a processing perspective (cf. Steedman 2000: 229).

The problem, in a nutshell, is that, if linguistic expressions are built bottom-up by an operation like Merge subject to a strict Extension Condition, as Chomsky (1992, 1995, 1998, 2001, 2005) claims, and surface order follows from the resulting hierarchical structure and Kayne's (1994) Linear Co-occurrence Axiom (LCA, hereafter), their leftmost constituents at the PHON interface must also be the highest and therefore the last to be built, exactly the wrong state of affairs if processing is to be LR-incremental, for it entails that a lot of structure ready for Transfer to, and immediate processing by, the PF component must be half-built and kept waiting while further structure is being built on top, with a massive increase of computational load. That is what Transfer (earlier Spell-Out) as an end-of-phase operation entails, but even if Transfer operates as soon as an input to PF is ready, the problem is that, under the standard bottom-up approach, the input often just cannot be ready until a lot of further structure is built (e.g., a subject, in spite of being a specifier of VP, must wait for IP, a *wh*-phrase must wait for FocP or CP, etc.). As a consequence, PF processing necessarily occurs haltingly, by batches, instead of in a smooth incremental way. In both clauses and nominal phrases, for example, the nominative/genitive subject is the last argument to be merged in its pronounceable position (in Spec I and Spec D, respectively), and yet, it must obviously be pronounced/parsed earlier than what follows it in TP/DP. In other words, what bottom-up grammars yield for a typical clause is essentially a right-branching structure like (1), whereas what efficient generation/perception seems to call for is a left-branching one like (2), cf. Steedman (2000: 229, 242).

(1) [He [must [have [seen us]]]]
(2) [[[[He] must] have] seen] us]

Needless to say, whereas the structure in (1) is strongly supported by the way grammatical processes like theta-marking, c-selection, binding, displacement, coordination, or ellipsis are supposed to operate (cf. Zagona 1988, Pesetsky 1995 or Cinque 1999, on VP constituency; Cinque 1994 and papers in Cinque ed. 2002 on nominal structures, and Lobeck 1995, Bondi-Johanessen 1998, and Merchant 2001, on coordination, anaphora, and ellipsis), a structure like (2) obviously violates crucial constraints (e.g., locality, selection, theta theory, binding theory, etc.) and would be considered by most syntacticians plainly unacceptable. For one thing, (2) is just impossible if the subject argument depends thematically on the full VP, as has been assumed since Chomsky (1981), or, even if it does not, if it must still be attached above everything else in the VP, as all classical 'linking theories' (e.g., Larson 1988; Jackendoff 1990; Grimshaw 1990; Dowty 1991; Baker 1997; etc.) and currently popular accounts of argument structure like Hale and Keyser (2002) entail.[2]

Yet, the evidence in favor of LR-incremental processing, and a structure like (2), is also fairly robust, so what seems involved here is total irreconcilability between otherwise highly satisfactory structure-dependent competence grammars and realistic accounts of parsing-generation.This difficulty is endemic in all P&PT work, as in all current minimalist accounts, and ultimately affects all lexicalist competence grammars, although it has largely been ignored, the usual excuse among syntacticians being that the grammar and the parser need not correspond to any significant extent (cf. Berwick and Weinberg 1984: 78-82), but that strategy is ultimately dubious, cf. Steedman (2000: 6, 227-228, 261, 281, fn 3) and rather less defensible in current derivational minimalist models with phases than in the representational ones common in the seventies and eighties.

Unfortunately, once the problem is acknowledged, there is no easy way out. Outside P&PT/ Minimalist Grammar, the strategy has been a) to abandon constituency altogether and try to make lexical items and their dependencies do all the work, or b) to radically revise standard assumptions concerning constituent structure, its status within the grammar, and the way it is derived. The former approach has been adopted in dependency grammars (e.g., Word Grammar, cf. Hudson 1984, 1990). As to the latter, it is common in several versions of Categorial Grammar (CG, hereafter) which, being

[2] Chomskyan syntactic theory will be primarily referred to here, but it goes without saying that practically all other major syntactic approaches (except Word Grammar) assume a structure like (1). Structure (2) is also incompatible with the various Obliqueness Hierarchies proposed/assumed in Relational Grammar, Lexical Functional Grammar, Functional Grammar, GPSG, HPSG, etc.

constituency-based, and fairly conventional as to the definition of types and the bottom-up process of cancellation, nevertheless allow for both orthodox and unorthodox constituency during the parsing-generation process by invoking powerful combinatory rules like Associativity (see Lambek 1958), Type Raising, and Function Composition (see Wood 1993, and Steedman 1993, 1996).

Actually, in some versions of CG, orthodox and unorthodox constituency coexist, but at different levels. For example, Dowty (1996) keeps constituency orthodox at the tectogrammatical level, but assumes flat linear structures at the phenogrammatical level, and similar strategies have occasionally been adopted elsewhere (e.g., in Sadock's Autolexical Syntax, cf. Sadock 1991), including P&PT (e.g., in the dualistic approach to constituency explored in Pesetsky 1995), and Chomsky's Minimalist Grammar, where the representation L is a hierarchical binary-branching structure essentially like (1), whereas the representation P is assumed to be a flat sequence with no syntactic constituency and only chunks of phonetic material determined by efficiency considerations at the articulatory interface.

Yet, from the point of view of generation, all those solutions leave our problem intact: transfer to PF and the articulatory devices must wait for too long while structure is being built bottom-up; on the other hand, from the hearer's point of view, a flat sequence of PHON information is obviously inadequate, so the message must be immediately reanalyzed to restore the missing hierarchical structure or the hearer will not be able to process it.

As a matter of fact, neither (1) nor (2) (nor both, actually) suffice to account for all the facts at P and L. On the whole, structure (1) allows for better predictions at L, although it fails to explain certain problematic facts of non-constituent coordination, ellipsis, and anaphora that structures like (2) can account for, whereas (2) accounts for such residues, but, as stated, contravenes major grammatical principles and is generally inadequate to handle scope and the bulk of the facts at L, and, properly, neither (1) nor (2) is adequate at P. At both P and L there are facts that seem to support both (1) and (2) (beside a linear sequence P, an L structure, and an Information Structure, cf. Steedman 1996, 2000), so to have one's cake and eat it in this respect, the two incompatible structures (1) and (2) should be simultaneously available throughout, along with a strictly 'phonetic' one, a 'semantic' one, and an Information Structure with consequences at both interfaces, P and L, which is tantamount to claiming that a new concept of structure and its role in the grammar is urgently called for.

As stated, the main alternative on offer is the flexible constituency of Combinatory Categorial Grammar (cf. Steedman 1996, 2000), in which just about any constituent structure can be generated and monotonically computed on demand, but via such powerful transformational operations as Type Shifting and Functional Composition, both well beyond the non-tampering set-building operation that Chomsky (2005) considers the optimal form of structure-building. Of course, as argued in detail elsewhere, (cf. Escribano 2005b, 2006b), Chomsky's Merge does not yield an adequate picture of linguistic computation, so far from my intention to save Merge at all costs, but, to compute a rich and flexible (i.e., realistic) linguistic structure, it is not necessary to resort to Steedman's powerful combinatory machinery, although far richer lexical items than Steedman's may well be needed. It is precisely that trade-off that will be explored here: certainly we shall be proposing richer lexical items, but, in exchange, our computational component is strictly constrained; in fact, our CHL boils down to 1) an unquestionably necessary operation of Satisfaction of lexical attributes through Unification, cf. Shieber (1986), and 2) since satisfaction is stepwise, an equally necessary operation Hold that keeps attributes active in short term memory until they can be attended to, cf. *infra*.

INCREMENTAL UNIFICATION-BASED LR STRUCTURE-BUILDING

To the extent that the present approach aims at optimizing CHL, it is a contribution to a minimalist theory of Human Language, but it diverges from standard minimalism in important respects, largely those for which it draws inspiration from unification-based approaches like LFG, GPSG, HPSG, and Categorial Grammar. In particular, whereas minimalist SDs start from random 'numerations' or obscure 'lexical arrays' and the minimalist CHL rests on the principles of Lexical Integrity, Inclusiveness, Phrasal Atomicity, unstructured Merge, and No-Tampering (cf. Chomsky 2005), here lexical items (LIs, hereafter) are activated to the extent their attributes unify with certain features of pre-linguistic conceptual representations (see Levelt 1989, and Escribano 2005b), the real objects of

computation are not LIs, but [Attribute: value] pairs (cf. Shieber 1986, Johnson 1988), Lexical Integrity, No Tampering, and unstructured Merge are definitely rejected, and computation is, on the contrary, based on invasive operations penetrate LIs and phrasal objects and 'tamper' with their [A: v] pairs in important respects, cf. Escribano (2005b, 2006b,c). Of course, in this approach, LIs remain available as such in the Lexicon, but no operation of CHL involves a LI as such. The real protagonists are [A: v] pairs, and linguistic computation is simply the licensing or valuation of such objects.

Lexical items and their attributes

According to the modular view of the Mind that underlies Chomsky's P&PT/MG, the minimal definitional constraint on CHL is that it must satisfy interface conditions (ICs, hereafter) at PHON and SEM, and since PHON and SEM must systematically correspond, it is necessary to assume some device that guarantees that correspondence. Since PHON-SEM pairings, although systematic, are arbitrary (Saussurean), the standard view is that PHON and SEM information is systematically paired in certain conventional chunks of form and meaning in a/the Lexicon, an assumption we also adopt here. On the other hand, since CHL is a specific mental organ, there are conceptual reasons to expect it to have its own internal functioning pre-requisites, a set of attributes we shall accordingly dub SYN(tax). We, thus, reach the conventional view that a LI is minimally a set {PHON, SEM, SYN}. In fact, for completeness' sake, to this must be added a set of MOR(phological) attributes, including at least M-TYPE, ranging over such values as root, stem, prefix, suffix, word, and phrase, and M-STRUCTURE, a feature structure specifying the internal constituency of complex (derived, inflected, compound) LIs, although such details will not be discussed here.

We may further assume for present purposes that there is a unique lexicon storing all lexical information (instead of two or even several, as often assumed in the psycholinguistic literature). However, Chomsky's further views that a) full LIs are all simultaneously inserted **at the start** of SDs and b) that **only full LIs** can be manipulated by the CHL (i.e., Lexical Integrity) are both far from optimal from the point of view of Economy and probably false. Assumption a) entails that CHL must carry along its SDs a lot of information that it cannot even see, for it becomes relevant only at/near the PHON/SEM interfaces. As to assumption b), there is convincing evidence that certain features must be selectively accessed earlier than others at certain stages of SDs. To name the obvious, in language perception, PHON information in LIs must surely be accessed first, leading to activation of specific LIs, whereas, conversely, in language production, initially only SEM information determines which LIs are activated, with no immediate role for PHON features at that stage unless deliberate effects, e.g., rhyming, are intended, an unusual circumstance.

Thus, let us say that SDs start when CHL accesses a SEM (or PHON) attribute of a LI and tries to satisfy IC. In language generation, granted a pre-linguistic conceptual representation (cf. Levelt 1989), its linguistic expression entails access to one or more matching LIs. In each particular case, a SEM attribute of a LI, i.e., a component of SEM(LI_i) will be searched for and accessed first, although CHL will also eventually have to look for PHON(LI_i), or the ICs at PHON will not be satisfied. Correspondingly, in language analysis, PHON(LI_i) attributes will be accessed first, but, unless CHL eventually proceeds to locate their SEM(LI_i) counterparts, IC will be violated at SEM. In either case, thus, when CHL tries to associate PHON(LI_i) and SEM(LI_i) attributes a lexical item LI_i is inevitably activated and ICs force its various aspects to be properly specified, cf. Escribano (2005b; 2006b).

Of course, PHON, SEM, SYN (and MOR) are cover terms for sets of attributes that must now be unpacked, although PHON information (e.g., stress, etc.) and MOR information plays a marginal role in this discussion and will not be developed in any depth. In what follows, it is the SYN and SEM information that is in focus, or, rather, the SYN and SEM attributes that CHL must refer to, since not all SEM information is computationally relevant. Also, it is convenient to distinguish between **inherent** properties of LIs, [A: v] pairs whose values are fixed for each LI as stored in the lexicon, and **context-dependent** ones, attributes with the uninterpretable value '?'[3] that must eventually unify with one of the proper values in the range of A supplied by some other object in the SD.

[3] The symbol '?' is here taken to stand for the empty set, since it tmust be unifiable with any 'v' supplied by whatever object gets constructed with LI in the SD under way.

Inherent SYN(tactic) attributes must minimally include, for all LIs, (major) CAT(egory), ranging over the set {N, V, A, P, Adv, Q, D, Comp, Infl, etc.), and, for specific subsets of LIs, 'subcategories' like GENDER, ranging over {Masc, Fem, Neuter}, NUMBER, ranging over {Sg, Pl, Dual}, CASE, ranging over {Nom, Acc, Gen, Dat, Obl, etc.}, PERSON, ranging over {1st, 2nd, 3rd,…}, DEGREE, ranging over {Default, Compar, Super}, VFORM, ranging over values in the set {Inf, Prs, Pst, Ing, En, and Pass}, LFORM, ranging over specific lexemes (to the extent they are selectable, cf. *keen* ***on*** *X*, *comply* ***with*** *X*, etc.), and syntagmatic information, i.e., *n* C-SEL(ection) features, depending on the adicity of the LI, ranging over the categories or even specific LIs it C-selects as a head. At least all those attributes are relevant to processes of selection and agreement, although showing this in detail requires more space than is available here. Finally, the SYN box of LIs must contain a context-dependent S(YNTACTIC FUNCTION) attribute with the value '?' that eventually unifies with one of the values in the set {Subj, Obj, Compl, Modifier, Operator, etc.), as the syntactic context determines, and *n* context-dependent [VAL(arg): ?] attributes, one for each of its complements, ranging over suitable objects available in the SD that can satisfy the LI.

Inherent SEM attributes, on the other hand, must include DEF(inition), ranging over well-formed expressions of the metalanguage,[4] S(EMANTIC)-TYPE, ranging over values in the set {Individual, Substance, Set, Property, Event,…}, E(VENT)-STRUCTURE (number of distinct sub-events profiled by a LI and causal-temporal relations among them), P(REDICATE)-ROLE, ranging over the set {Activity, State, Process, Achievement, Accomplishment, Action}, and PRED-ARG STR(UCTURE), a feature structure[5] specifying the head's adicity and the nature of the arguments it S-selects via *n* appropriate S-SEL(ECTION) features. As to context-dependent SEM attributes, they must include ARG(ument)-ROLE, relevant to all LIs naming participants and ranging over 'argument roles' like {Agent, Experiencer, Theme, Goal, Recipient, Beneficiary, Instrument, etc.}, REF(erence), relevant to both events and participants, ranging over a set of indices attached to entities in the (model of) the universe of discourse (irrelevant here), and I(NFORMATION)-S(TRUCTURE)-FUNCTION, ranging over the set {Topic, Focus, Subject…} of functions relevant at the level of Information Structure (I-S, hereafter). Finally, an *n*-adic predicate must contain *n* [A: v] pairs where A stands for one of LI's argument roles (AGENT, EXPERIENCER, etc.) and 'v' is '?', the empty set, eventually unified with the referent of one of LI's complements.

By way of example, a LI for the word *he* will minimally look like (3), and a LI for the verb *died* will contain the information in (4) (computationally irrelevant attributes like DEF directly omitted).

(3) [LEX: HE]
PHO = [SOUND: /hi:/], [STRESS: weak],…
MOR = [M-TYPE: word], [M-STR: null]
SEM = [S-TYPE: individual], [HUMAN: +], [ARG-ROLE: ?], [REF: ?], [I-S-FUNC: ?]
SYN = [CAT: det], [GENDER: masc], [NUM: sg], [PERSON: 3]; [CASE: nom],
[S-FUNC: subj] [C-SEL: null]

(4) [LEX: DIED]
PHO = [SOUND: /dayd/, [STRESS: strong],…
MOR= [M-TYPE: word], [M-STR: [[HEAD: V_{Af}], [COMPL: V_{st}]]
SYN = [CAT: V], [AUX: -], [VFORM: pst], [PERSON: ?], [NUM: ?]
[C-SEL(x): [[CAT: D] [CASE: Nom]]][VAL(x): ?]
SEM = [S-TYPE: event], [REF: ?], [E-STR: [[HEAD: $E1_{Ach}$], [COMPL: $E2_{Sta}$], [REL: >]]
[PAS(E1): P_{inch} (x, E2)], [PAS(E2): P_{sta}(x)], [P-ROLE(E1): achievement],
[P-ROLE(E2): state], [S-SEL(x): anim], [ARG-ROLE(x): theme], [VAL(TH): ?]

[4] The attribute DEF will not be developed here, since it is not selectable as such and therefore it is not a computationally relevant attribute of LIs. In general, the problem of how lexical meanings should be defined cannot be addressed here and is simply put aside, but it is clear that identifying certain syntactically relevant aspects like event structure, predicate-argument structure, thematic roles involved, type of arguments selected, etc., as in most generative approaches to lexical semantics, does not exhaust the matter. Such aspects must surely be in LIs, since the operations of CHL clearly depend on them, but in addition SEM must include a proper 'definition' in whatever format is deemed appropriate.

[5] Feature structures correspond to boxes containing all the [A:v] pairs that define a linguistic object and are extensively used in unification-based approaches like LFG, GPSG, HPSG, CG, etc. See Shieber (1986) and Johnson (1988) on feature structures and their logic.

Most attributes of (3), e.g., SOUND, M-TYPE, CAT, S-TYPE, etc., have inherent values automatically imposed no matter the context of use, but some must be left unspecified in the Lexicon awaiting a proper valuation *via* construction with adequate objects in a specific SD. For example, granted Case Theory, the S-FUNCTION of he is inherently 'subject', but since *he* must be available in very different contexts of use, attributes like [REF: ?] and [ARG-ROLE: ?] or [I-S-FUNC: ?] must obviously be unvalued in the lexical entry [HE] and get a proper value quickly in the SD or *he* will be uninterpretable at the SD will abort,[6] and [CASE: nom] is context-sensitive and must be licensed, even if it is already instantiated in the lexical entry of [HE]. Correspondingly, in (4), the SOUND, M-TYPE, M-STR, CAT, S-TYPE, etc., of [DIED] are inherent and context-insensitive, but [VFORM: pst] must be licensed (i.e., finite verb forms are possible only in restricted circumstances), [PERSON: ?], and [NUMBER: ?] are unvalued and must be valued through unification with appropriate attributes of a subject (i.e., agreement), and the (syntactic) [VAL(x): ?] and semantic [VAL(TH): ?] value of the argument of [DIED] must be supplied in the specific SD context. This should suffice as an illustration of the issues; to avoid tedious repetition, further detail about LIs and their attributes will be added in what follows as it becomes relevant to understand how particular SDs get computed in specific cases.

Computational principles

What drives CHL computations is the detection of uninterpretable [A: v] pairs in LIs activated in SDs. An [A: v] pair may be uninterpretable for either of two reasons, a) it has the empty set '?' as its value, or b) its value is in the range of the attribute, but the [A: v] pair, not being selected with such a value by any other LI in the SD, cannot be licensed in that context, cf. Escribano (2005b; 2006b). Thus, linguistic computation must essentially do two things: replace '?' with a legitimate value in the range of A and license the instantiated values of context-dependent [A: v] pairs.

The ultimate functional motivation underlying all linguistic computation is the intuitive idea of INTERPRETABILITY: an uninterpretable attribute, like an unvalued variable in a mathematical calculus, is intractable (irresoluble) for CHL and makes the SD abort unless quickly disambiguated. As understood here, thus, linguistic computation is a last resort process that essentially reduces to valuation/licensing of uninterpretable [A: v] pairs under a strict concept of Economy, i.e., unless an operation values or licenses an uninterpretable attribute, it is uneconomical and cannot take place.

Of course, strictly speaking, uninterpretable attributes must be temporarily allowed in SDs, since CHL activates LIs that contain them and their satisfaction 'takes time', but uninterpretability prevents further computation and to that extent satisfaction must be as quick as possible (cf. *infra*). Since satisfaction is a binary relation between satisfier and satisfied, CHL computation is necessarily stepwise, i.e., it is a sequence of changes of state, as in standard minimalist models, but, crucially, as understood here, it is also LR-incremental with respect to the linear output at the PHON interface, in the sense that what precedes an object 'i' at PHON is computed earlier than what follows 'i' at PHON. In other words, contrary to what happens in standard bottom-up minimalist models, an optimal correspondence is assumed here between the order in which an item is computed and the order in which it surfaces at the PHON interface.

The retrieval (from the Lexicon) and activation of particular LIs leaves them in the working area of, and visible to, CHL, which can detect their uninterpretable attributes. Once an uninterpretable [A: v] pair is detected by CHL, computation is triggered and primarily entails three routines: SEARCH, SATISFACTION-via-UNIFICATION (S-U, hereafter), and HOLD. Informally, what they do is this: SEARCH inspects the CHL's working area, i.e., in this order, a) active lexical information in the SD (= minimal search domain, granted Economy), and b) the Lexicon (extended search domain), looking for appropriate values/licensers; S-U replaces the '?' variable of unvalued attributes with proper values or checks that previously instantiated values unify with those of relevant context in the SD; finally, since S-U is necessarily stepwise, HOLD temporarily stores away uninterpretable [A: v] pairs until SEARCH and S-U can operate again to make them interpretable, thereby implementing delayed satisfaction and displacement effects, cf. *infra*.

[6] Comparable reasoning applies to PHON properties like STRESS, etc. not discussed here.

All three are conceptually necessary: SEARCH is needed, granted the INTERPRETABILITY principle, to the extent LIs may, by definition, appear in the Lexicon with unvalued attributes; S-U crucially allows linguistic objects to satisfy each others' combinatory needs, which supports recursive construction; and HOLD is conceptually necessary as a consequence of two related facts, i.e., 1) that S-U is a stepwise procedure applying to one attribute at a time, which entails that the satisfaction of certain attributes must wait while others get satisfied, and 2) that, since relevant attributes may belong to different LIs, items needed to satisfy an uninterpretable attribute may not be strictly adjacent to its carrier. On both counts it follows that, apart from general considerations of computational efficiency (minimal load, etc., cf. *infra*), a PRIORITY (or Strength) hierarchy, or special universal or language-specific 'templates' may well be needed to determine the order in which different types of attributes must be satisfied, cf. Escribano (2004), and *infra*.

Obviously, all the operations involved in CHL are in themselves trivially simple and arguably **not** specific of the Language Faculty, which questions the recent 'recursion only' hypothesis, cf. Hauser, Chomsky and Fitch (2002), Fitch, Hauser and Chomsky (2005), and detailed discussion and criticism in Escribano (2006b). On the contrary, under present assumptions, it is the attributes themselves and a few additional principles that do most of the work, as shown directly.

Incremental LR Derivations

Assuming, as in Escribano (2005b), a pre-linguistic conceptual representation (CR, hereafter) of a State of Affairs (SoA, hereafter), say the death of a previously mentioned individual, and assuming that Speaker (S) and Addressee (A) are at a stage of discourse at which communication by S of such a SoA to A is of interest to both S and A, etc. (i.e., the usual Gricean conditions on cooperative communication), S may decide to make a statement on the matter (cf. *infra* on what such a choice entails) and a LI (e.g., the proper name by which the deceased is known to both S and A, or an appropriate substitute like (s)*he,* in this hypothetical case) will be activated by the CHL as the name of the default Topic of his/her statement, to be followed by a suitable Comment, in this case a verb like *died* (*passed away*, *left us,* etc.).[7] It seems natural to further assume that, in the unmarked case, the human participant, being cognitively and affectively more prominent, is focused on first, as the 'topic' (here also a subject), and that whatever expresses 'what about him' follows as a 'comment'. If so, a SD will start when, say, a LI like [HE] is activated in CHL's working area. If the lexical entry of [HE] is (3), its inherent [PERSON: 3], and [NUM(ber): Sg] features clearly need licensing, since they will have to 'agree' with parallel features of the oncoming predicate, its instantiated [CASE: Nom] feature will be legitimate or not depending on the presence of a finite verb selecting a nominative DP (cf. e.g. **he to die is unthinkable*),[8] its [ARG-ROLE: ?] attribute is unvalued and will have to get valued through unification with a proper thematic value supplied under construction with a predicative head, and its [REF: ?] attribute is also uninterpretable until valued with respect to the SoA under discussion in the discourse context. Granted this much, is it possible to predict what will happen in the SD next?

Assuming (for the sake of preliminary discussion, cf. *infra*) that no other LIs (e.g., invisible Comp, a functional head Topic, or Infl-like categories like a separate Tense head, etc.) are involved, yes, it is, if trivially so, in this case: CHL will search in the Lexicon for a second LI matching the concept [DIE] and containing attributes capable of unifying with/satisfying the still unvalued or unlicensed attributes of [HE], e.g., English [DIED](alternatively, *passed away*, etc.), and [DIED] will be activated on the working area of the CHL and, of course, immediately start demanding satisfaction of its own unvalued/unlicensed attributes. At this stage, then, the SD contains two active LIs and CHL for the first time faces the need to establish which LI will be fully processed and phonetically realized first.

[7] No attempt will be made here to address the complex problem of choice among expression alternatives like neutral *(has) died* rather than euphemistic alternatives like *passed away*, *left us*, etc. Obviously such choices respond to the full complexities of the situational and discourse context in which they occur, which impose additional constraints on what is or is not appropriate. We disregard such matters here in order to concentrate on what happens when a communicative intention which is opportune, relevant, cooperative, suitable to the discourse context, etc. must be executed by the CHL.

[8] Obviously, we are assuming the **facts** captured by Case Theory in a P&PT framework, i.e., nominative is licensed in a tensed context, accusative after transitive verbs, genitive at the head of possessive noun phrases, oblique after prepositions, null (PRO) in non-finite contexts, etc., although new formulations of the case rules will be needed if the present approach is adopted. Such details will not be addressed in this short paper.

According to our principle of LR-INCREMENTAL processing, since what results at the PHON interface is a sequence *he+died*, not ***died+he**, clearly [HE] must be attended to first, which is only natural granted its topic-subject status, and there will follow a series of S-U cycles gradually unifying-satisfying a) the unlicensed [CASE: Nom] specification of [HE] with the value of the C-selected argument of [DIED], and b) the unvalued [ARG-ROLE: ?] attribute of [HE] with the ARG-ROLE value (= Theme) of the unique argument selected by [DIED]. If we assume that [REF: ?] on [HE] is given as value an arbitrary index 'i' subsequently valued *via* access to discourse/situation-related encyclopedic information about who the participants in the SoA are, the result is [REF: i], which makes [HE] fully interpretable and ready to be transferred to the PF component[9] and the articulatory systems.

That leaves us with the LI [DIED] and its own pending satisfaction requirements, i.e., putting its own [REF: ?] feature aside (with an 'e' [= event] index to be eventually valued with reference to the model of the SoA), its unvalued agreement-related features [PERSON: ?] and [NUMBER: ?], its C-selection-related features [C-SEL(x): [[CAT: D] [CASE: Nom]]] [VAL(x): ?] (i.e., a subject is needed, but unavailable until the verb is constructed with one), and its S-Selection-related attribute [VAL (TH): ?], corresponding to the fact that [DIE] selects an argument with the ARG-ROLE of Theme, although the value of that argument is unavailable until the verb is constructed with a suitable nominal. However, if [HE] is already active, unification with it automatically supplies all necessary information: 1) [PERSON: ?] and [NUMBER: ?] on [DIED] get values from the corresponding valued attributes of [HE], a case of trivial unification (since any value will unify with the variable '?' = the empty set) that has the effect of licensing both [HE] and [DIED] in what concerns agreement-related features; 2) the C-SEL(ection) attribute of [DIED] will also be licensed, since the CAT value of [HE] is precisely D and its CASE value is Nom, exactly as required; 3) the verb's S-SEL(ection) attribute will also be licensed, since [HE] is [Human: +], hence *a fortiori* [Animate: +], and a potential Theme of *die*; and 4) finally, the value of the [VAL(TH): ?] attribute of [DIED] will unify with the index 'i' in [REF: i] on [HE], which effectively makes [DIED], too, fully interpretable and leaves it ready for transfer to PF and the articulatory systems.

The preceding toy SD is already a fairly representative case of S-U, but since in that case only two LIs were involved (*ex hypothesi*), and all attributes in need of valuation/licensing were contained in either of them, that SD does not allow us to probe into the issue of the surface consequences of satisfying attributes of different LIs in different order. The problem of processing priorities becomes more interesting as soon as the attributes/values needed for full interpretability of the LIs involved are distributed among three (or more) LIs, which forces at least one choice with consequences for LR-order at the PHON interface.

Suppose the expression to be derived by CHL is not *he died*, but, for whatever conceptual reasons are appropriate in the discourse context, *he has died*. In that case, the LI [HE] is, of course, (3), but two new lexical entries are needed, for the LIs [HAS] and the participle [DIED]. Constructing them is relatively trivial, [HAS] will have the obvious agreement features and VFORM with the value 'present', whereas the VFORM on $[DIED]_{Act\text{-}Prt}$ will have the value 'EN', etc. Perhaps the only aspect that requires careful thinking and argumentation, omitted here for brevity's sake, is what [HAVE] C- and S-Selects, and whether it takes an argument or not. The matter is controversial, but, for present purposes, let us simply assume that auxiliary *have* C-selects a VP[VFORM: EN]] and S-Selects an 'event' which does satisfy the only 'argument' of [HAVE].[10] Remaining details are ignored here, although they will be referred to as needed in what follows.

Now, the fact that three LIs, each with its own satisfaction demands, are involved in the generation of *He has died* poses the question, In what order are their respective attributes to be satisfied? We may continue to assume that *he*, as conceptual 'topic', will be activated and attended to first, as above, but

[9] The PHON attributes of a LI of course also need valuation/licensing, e.g., a certain degree of stress must fall on a syllabic head which is not fixed in the Lexicon, the instantiation of a certain phonetic realization (a specific 'allophone') is licensed or not depending on the context, sandhi is legitimate or not, etc. Such PF matters will not be discussed here.

[10] Admittedly not a standard view. In P&PT/Minimalist grammar, it is customary, on the contrary, to assume that auxiliaries are not argument-taking predicates but just functional heads. Well, functional heads need, C-select, and S-select complements, too, and complements **must** be arguments. The difference is one of ontological type of the denotata: some arguments correspond to events, rather than individuals. Thus, there is an ontological type difference, to be sure, but no generative grammarian at this stage will claim that only individuals are arguments, so the decision to exclude events from the category of arguments is simply arbitrary. Observe that, by parity of reasoning, a CP complement of *say, ask*, etc. not denoting an individual, would have to be excluded too; yet nobody would seriously consider the possibility of re-classifying *say* or *ask* as one-place predicates.

what about *has* and *died*? Granted extant principles, can we expect the output *He has died* instead of the ungrammatical **He died has*? In the latter case, of course, additional principles will be needed to exclude it.

We may construe the alternative SDs corresponding to *He has died/*He died has* as a matter of relative PRIORITY of satisfaction of the ARG-ROLE and the 'inflectional' attributes: if the [ARG-ROLE: ?] attribute of [HE] takes priority, quick unification with, and therefore immediate activation of the thematic governor LI, $[DIED]_{Act\ Prt}$ will be mandatory, since [DIED], but not [HAS], can assign to [HE] a proper ARG-ROLE; on the contrary, [DIED] cannot license either the agreement-related attributes (PERSON, NUMBER) nor the CASE attribute of [HE], whereas [HAS] can, so, if it is 'inflectional' features that take priority, immediate unification with [HAS] will be the right option. Since only one of the two possible outputs (i.e., *he has died*) is acceptable, it seems as though inflectional attributes (i.e., agreement and Case features) take priority. If so, we might have to assume principle (5) (parallel to 'strength' in classical minimalist work like Chomsky 1995):

(5) INFLECTION MUST BE SATISFIED FIRST

Obviously, (5) is still only a rough postulate at best, since even in a short SD like that of *he has died*, other attributes than inflection and ARG-ROLE are involved. Can (5) stand in view of the overall situation? Well, at the stage [HE] is already fully interpretable and [HAS] is activated, the latter's own C- and S-selection features start claiming satisfaction. The auxiliary [HAS] C-selects [VFORM: EN] and S-selects an event, by assumption, and both requirements can be satisfied if [DIED] is next unified with [HAS], but that can hardly motivate activating [DIED] **before** [HAS] itself is active in the SD. At that stage, only the fact that [DIED] can supply a value to the ARG-ROLE feature of [HE] can induce CHL to search for it and activate it before [HAS]. Yet, in view of native speakers' judgments on the status of *he has died/*he died has*, the [ARG-ROLE: ?] attribute of [HE] can wait, so (5) may well be on the right track.

Yet, 'may' is surely in order, for, in this case at least, exactly the same result can be obtained if we assume just a general principle of economy like (6), based on computational load alone, and its corollary (7), which limits the number of attribute-value pairs that HOLD may keep in its short term memory.

(6) MINIMIZE COMPUTATIONAL LOAD
(7) MINIMIZE HOLD

The reasoning involved is as follows: if [HAS] is unified with [HE] first, only the unvalued [ARG-ROLE: ?] in [HE] will have to be stored in memory by HOLD; on the contrary, if [DIED] is unified with [HE] first, [ARG-ROLE: ?] in [HE] will immediately get valued, but [CASE: Nom], [PERSON: 3], and [NUMBER: Sg] in [HE] will have to be stored by HOLD until [HAS] is itself activated and unified with the transitory SD object [HE+DIED] at a later derivational stage. Hence, in this case, the right result follows from computational economy alone, according to (6) and (7), even if we do not specifically assume a lower-level priority principle like (5), a nicer result. Whether computational economy in itself suffices to predict the correct LR sequence at PHON generally is, of course, an empirical question (all relevant core cases should be checked, one by one), but an easy one to settle, at least in principle, and, as a matter of fact, in constructions not involving 'displacement' effects (cf. *infra*), it certainly does, as briefly illustrated in what follows, although displacement phenomena do seem to require additional low-level principles.

For example, if CHL must generate an expression like *he writes fiction*, and not **he fiction writes*, it is easy enough to derive the right result from (6-7) alone: assume that the topic-subject [HE] is activated first, for reasons already discussed, and that at some immediately subsequent stage HOLD is storing its unvalued [ARG-ROLE: ?] attribute, along with its unlicensed [CASE: Nom], [PERSON: 3], and [NUMBER: Sg] attributes. Now, observe that activating [FICTION], rather than [WRITES], first does **not** facilitate satisfaction of **any** of those features of [HE]; on the contrary, it has the effect of adding to the HOLD stack the unvalued [ARG-ROLE: ?] attribute of [FICTION] and its own

unlicensed [CASE: Acc].[11] On the contrary, activating [WRITES] first immediately empties the HOLD stack: the [ARG-ROLE: ?] attribute of [HE] will quickly be valued (Agent, since the activity verb *writes* licenses an Agent), and its [PERSON: 3], [NUMBER: Sg], and [CASE: Nom] attributes will be successively licensed via S-U with the corresponding attributes of [WRITES]. Thus, in the case of an ordinary transitive construction, too, the mechanics of S-U and general economy considerations like (6-7) do certainly suffice to force CHL to generate the right output.

Much the same applies if CHL must derive a more complex SD corresponding to e.g., *he has written fiction* instead of **he has fiction written, *he fiction has written, *he fiction written has,* etc. We illustrate with the first of that series of anomalous sequences: Activating [FICTION] before [WRITTEN] has the effect of loading the HOLD stack with the unvalued [ARG-ROLE: ?] attribute and the unlicensed [PERSON: 3], [NUMBER: Sg] and [CASE: Nom] attributes of [HE], plus all the unvalued C- and S-selection attributes of [HAS] and the unvalued ARG-ROLE and unlicensed CASE attribute of [FICTION]. On the contrary, if [WRITTEN] is activated before [FICTION], the unvalued argument, and all the C- and S-selection attributes, of [HAS] can immediately be satisfied, and, since [FICTION] has not yet been activated and is not yet in the SD, no new features are loaded into the HOLD stack. Needless to say, computational load in HOLD would increase even more severely if we were to activate LIs in the order corresponding to the representations **he fiction has written*, or **he fiction written has*, etc.; I leave it to the interested reader to calculate how many unvalued/unlicensed features will accumulate in the LOAD stack were CHL to compute such SDs.

Lower-level Priority principle(s) may, nevertheless, be needed in order to tip the scales in SDs that involve polyadic predicates like *give*, *send*, *bet,* etc., as in *he gave me money,* vs. **he gave money me*. Of course, in such circumstances, leaving the Topic-Subject-Agent *he* aside, the verb *give* C- and S-selects two internal complements with two different ARG-ROLEs (Recipient/Theme) and two different CASE (Dat/Acc) values, and there seems no obvious reason why activating one of them first should be computationally more advantageous. Of course, Case theory may be tinkered with in various ways (e.g., the relative 'strength' of Case attributes can be fixed through priority rules like DAT < ACC, or Structural Case < Inherent Case, etc.), but, at this stage of development of the present approach, it seems preferable to flatly stipulate that there is some kind of cognitive prominence hierarchy (e.g., a 'thematic hierarchy', cf. e.g., Grimshaw 1990, Dowty 1991, Baker 1997, etc.) that determines more prominence for (Human) Recipients than (Inanimate) Themes and therefore calls for activating the Recipient *me* before the Theme *money* rather than the converse. In the case of the 'oblique' construction of *give*, etc., as in *he gave money to me,* vs. *?he gave to me money,* we could also make the right SD follow from such a prominence hierarchy (e.g., if *to me* is a Goal, rather than a Recipient, and Theme is more prominent than Goal). That much has often been assumed in the past and can also be assumed here.

Yet, other, possibly complementary, approaches are certainly available, and some are arguably less stipulative. For example, we could alternatively derive the same result *via* a completely different strategy, one in fact available to account for both DOC and Oblique cases, i.e., assuming the relevance of the Information Structure in general and the discourse function Unmarked Focus (U-Focus, hereafter) in particular to LR order, we could endow unmarked foci with the attribute [D-FUN: U-Foc], and introduce a principle like (8) capable of overriding possible Priority-related constraints.

(8) U-FOCUS LAST: ~[D-FUN: U-Foc] < [D-FUN: U-Foc][12]

Since the main semantic difference between the DOC and Oblique complementation patterns of triadic predicates like *give* is precisely that such an alternation allows different arguments to get the status of U-Focus, cf. (9), principle (8) suffices to force *money* and *me/to me* to be activated in the order corresponding to their LR slots at PHON, respectively.

[11] In the absence of an overt case inflection it is possible to assume either that nouns are activated in SDs with a valued Case attribute (with Acc(usative) as its value) or with an unvalued [Case: ?] attribute. Nothing hinges on this for present purposes, but, for the purposes of the present argumentation, we assume the former; cf. Escribano (2005b) for further discussion of what is at stake.

[12] A distinction is needed between unmarked phrase-final focus ('End-Focus') and the focusing of WH- , Neg, and other operators, which, on the contrary, shifts them leftwards, to the beginning of the clause, perhaps to the domain of a special Foc head. Properly, thus, in languages like English it is necessary to assume two 'focus' positions, one unmarked (U-Focus) and one related to operators ('O-Focus'), cf. Escribano (1990, 1991a) and below, and Rizzi (1997) on the standard minimalist view of the 'left periphery'.

(9) a. What did he give you? He gave me MONEY/*He gave money to ME.
b. Whom did he give money? *He gave ME money/ He gave money to ME.

It is also the choice of U-Focus that ultimately explains alternative LR order in pairs like (10).

(10) a. I talked about this problem WITH BILL
b. I talked with Bill ABOUT THIS PROBLEM.

Notice that the corresponding WH-questions are, respectively, *Who with did you talk about this problem?* but not **What did you talk about with Bill?* and *What did you talk with Bill about?*, but not **Who did you talk with about this problem?*

Also, under this approach, so-called 'Locative Inversion', as in *Down the hill rolled John* (vs. *John rolled down the hill*) is just a consequence of associating U-Focus with the subject. Analyzing such pairs, Collins (1997: 134, note) suggests that the underlying numerations might differ somehow; well, they do: The inverted construction arises, granted principle (8), when the subject is simultaneously U-Focus. The fact that only unaccusative predicates allow Locative Inversion is explicable if we assume that the external arguments of dyadic predicates, being default topics, never receive U-Focus, whereas Themes are the default unmarked foci in both transitive and presentational constructions (cf. *There arose* ***a phenomenal scandal***).

Of course, providing detailed SDs to show how the right LR order can be predicted for all typical English constructions would be tedious and require more space than is available in a short paper like this, but most of the core surface order facts (of English, in this case) do follow without further stipulations from computational economy (6-7) or, in the worst case, general principles like (5) or (8) already introduced. Since modifiers have not been discussed at all so far, let us quickly look at (the) core facts in the area of modification.

For example, as is well known, unless 'dislocated' (cf. *In Boston, everybody sails*), modifying PPs never precede their modifieds, cf. *He died in London* vs. **He in London died*, or *the girl at the door* vs. **the at the door girl*, etc.; see Escribano (2004, 2005a) for an explanation along conventional, if somewhat unorthodox, minimalist lines. Under present assumptions, too, why this is so is fairly obvious, so a quick explanation will hopefully suffice: Activating [IN] right after [HE], as in the first unacceptable case, for example, does not facilitate the satisfaction of **any** of the attributes of [HE] temporarily stored in HOLD; on the contrary, it delays it and only adds to the queue in HOLD *in*'s own unsatisfied C- and S-selection attributes, thereby increasing computational load, in violation of principles (6-7). However, if, on the contrary, [IN] is activated only after all the attributes of [HE] and [DIED] have been satisfied, which follows immediately if *in London* is the U-Focus, as in *He died in London*, [IN] will be in a position to immediately saturate its own external argument (= the event described by *he died*), and only its second argument, to be satisfied by a locative term like *London*, will have to be stored in HOLD, but even that only while the very next LI is activated, since nothing else requiring satisfaction can interfere.

The same reasoning applies to PPs and complex APs modifying nominals, cf. **the at the door girl* vs. *the girl at the door*, **a keen on jazz friend of mine*, vs. *a friend of mine keen on jazz*, etc. In the first example, activating [AT] right after [THE] does not facilitate the satisfaction of the C- and S-Selection attributes of [THE], whereas activating [GIRL], of course does, and, at the same time, having [GIRL] active in the SD immediately allows for the satisfaction of the external argument of the preposition [AT], whereas if [AT] is activated before [GIRL] is, that attribute must be added to the HOLD stack, along with the selectional attributes of [HE] still in need of satisfaction. I leave it to interested readers to satisfy themselves that comparable reasoning applies to the cases involving non-trivial APs with complements like *keen on jazz*.

The order of activation, and therefore the surface appearance of adjectival and adverbial modifiers **without** complements of their own (i.e., bare adjectives and adverbs, like *good* in *a good car* or *slowly* in *he drives slowly*) is more difficult to account for, at least in some cases. Predicting whether such modifiers will be activated and satisfied before or after their respective modifiés on sheer grounds of computational efficiency according to (6-7) is less straightforward, and the fact must not be lost sight of that different languages favor each of the alternative orders. In the case of *a good car* vs. **a car good*, for example, on sheer computational economy grounds the optimal choice is

activating [CAR] before [GOOD], since that facilitates immediate satisfaction of the C- and S-selection attributes of *a* without hindering a quick satisfaction of those of the adjective *good* (satisfied by [CAR], already active in the SD, by hypothesis). On the same grounds, on the contrary, activating [GOOD] before [CAR], as in the right PHON output, entails keeping the C- and S-selection attributes of the determiner [A] in HOLD during one extra computational cycle and should be dis-preferred according to (6-7) unless other principles intervene. Of course, they arguably do: U-Focus is surely involved in the case of adverbs like *slowly* in *he drives slowly* (cf. **he slowly drives*), and also in the ordering of attributive adjectives, cf. *a clever BOY* (with U-Focus on *boy* and unmarked intonation) vs. *a CLEVER boy, cf. I did never he say he was slow, on the contrary, I said he was a CLEVER boy.* Similarly, *a boy clever at GADGETS* is fine, whereas **a clever boy at gadgets* overloads HOLD in violation of principles (6-7) and **a clever at gadgets boy* definitely violates the rules of U-Focus apart from also overloading HOLD.

Other key modification facts, on the contrary, do follow from computational economy alone. For example, nothing needs be added to account for the fact that an adverb never intervenes between a verb and its direct object, cf. **I saw again him* vs. *I saw him again*. Simply, activating *again* after *saw* contributes nothing to the satisfaction of the C-/S-Selection of *saw* or the valuation of its [VAL(TH): ?] attribute; on the contrary, it delays it and forces the features to stay in HOLD longer, so there is no reason to activate *again* before *him*, which, if activated instead, will immediately facilitate the satisfaction of all the features in HOLD. Of course, we also expect the adverb to be able to intervene in e.g., *I saw* ***today*** *the girl who raised that nasty objection to your explanation,* but in that case the heavy nominal is surely functioning as U-Focus and falls under principle (8) above. Thus, in general, principles (6-8) above do still account for the core facts, but admittedly more sophisticated reasoning is needed, and there are other factors involved (argument structure, etc.) that cannot be discussed here, cf. Escribano (2004, 2005a, 2006a).

Displacement

The hard nuts for our incremental LR approach, of course, as for all other syntactic approaches, are those involving 'displacement' (e.g., Subject Auxiliary Inversion, as in ***Has*** *he arrived?,* Operator-Movement, as in ***Whom*** *did you invite?* or ***Neve****r had I been treated like that!,* Topicalization, as in ***Money****, he hasn't got much,* and Relativization, as in *I liked the photo* ***which*** *you sent me*).

Such constructions also inevitably raise severe processing problems for all bottom-up approaches, and for the same reason the position of the subject did: In general, *has*, *whom*, *money*, etc. surface at the front of their respective clauses and, ideally, should be processed (pronounced, interpreted) first, and yet, if SDs proceed bottom-up, as assumed in most theories of grammar, they cannot but be the **last** elements to be attached to them. For concreteness: within P&PT/Minimalist theory, until a functional head Comp, Top or Foc is merged to IP (cf. e.g., Rizzi 1997 on the structure of the 'left periphery'), no feature in need of satisfaction may possibly exist in the SD to license an 'economic' raising of a tensed auxiliary, a focus, or a topic phrase, and yet, by definition, such functional heads cannot be merged to the SD until their respective sisters are fully built. In other words, once more, everything that follows the auxiliary, WH-Focus, or Topic, respectively, must have been fully built before such elements are merged (or 'second-merged', if the P&PT/Minimalist account is assumed), exactly against what efficient processing would demand.

Under the present incremental LR approach, on the contrary, by hypothesis, if Aux, Focus, or Topic surface at PHON first, of course they must also be fully processed first. That is what we would expect from a theory of grammar which, like Steedman's Combinatory CG, claims to be monotonic, LR-Incremental, strictly monostratal, and capable of explaining how speakers construct transparent interpretations for what they perceive at PHON. Apart from general principles like (5, 6, 7, 8), which continue to play a key role, the LR-incremental computation of clauses with apparent displacement entails additional assumptions, of course, but all linguistic theories need them, and the specific ones introduced here are hopefully not any more complex or unreasonable than those in use elsewhere.

As currently understood in Minimalist grammar, cf. Rizzi (1997) and Chomsky (1998, 1999, 2001, 2002, 2005), 'displacement' effects arise as a consequence of the fact that certain syntactic objects may simultaneously function as arguments or modifiers of clause-internal heads and also instantiate

especially designated 'discourse' functions like Subject, Operator, Topic, Relativizer, etc. licensed by additional functional heads in the left periphery of the clause. Consequently, displacement reduces to 'movement' (actually, copying) of certain phrases into structural positions from which they can 'check' special features of 'dedicated' functional heads like Comp, Top, Foc and Infl.

Observe, however, that formulating an explanatory hypothesis about the underlying structure of the left periphery of the clause and the character of the heads and phrases that appear in it is **not** explaining e.g. why relatives must take scope over and precede topics, topics operators, operators subjects, etc. The 'deep' reasons underlying such facts must surely be connected with a) the respective functions such elements discharge, and b) their relative cognitive prominence, but have not to my knowledge yet been explicitly stated, although, of course, we may reasonably guess at them. For example, as regards relatives, unless they are placed at the top of their CP, the CP will not become a proper predicate of the nominal antecedent of the relative operator, cf. Escribano (2003); as to topics, at bottom Information-Structure 'subjects', if the speaker wants to introduce a topic distinct from the grammatical subject, unless he does so first and adds the remainder of the clause as his comment, he will not succeed in saying what he wants; similarly, as to operators, unless there exists a 'high' dedicated position for operators from which they can take scope over and bind their respective variables anywhere else in the clause, the operator-variable relation will not generalize; or, finally, in what concerns subjects, unless there is a specially dedicated position, say specifier of 'Pred' (= Infl), in which an argument automatically becomes the subject of the whole predicate, the VP's predicate-argument structure will not of itself yield a propositional structure, etc. Functional 'explanations' of that kind surely underlie deep clause structure as understood by Chomsky, Rizzi, Cinque (and others pursuing completely different approaches like Functional Grammar, Role and Reference Grammar, etc.), as they do underlie the present account, but no attempt will be made here to formalize them. For present purposes, it should suffice to say that just as other approaches can at bottom stipulate the structure of CP, comparable stipulations will be introduced here.

In particular, apart from the U-Focus principle (8), a 'template' like (11) may be needed to fix the relative cognitive prominence, and the order of activation in SDs, of the linguistic objects carrying the unique clause-level functions of U-(unmarked) I-(llocutionary)FORCE, TOP, FOC, M(arked) I-Force) and PRED(ication). In the worst case, i.e., to the extent deeper functional reasons like those briefly discussed above cannot be substantiated, (11) will account for whatever aspects of the surface order of e.g. complementizers, topics, operators, subjects, etc. that do not follow from computational economy (6-7), priority of inflection (5), and U-Focus (8).

(11) I-S HIERARCHY: I-FORCE < TOP < OP < FOC < PRED < SUBJ….

Thus, as in P&PT/Minimalist Theory, it is conceptually necessary to assume something like Comp, minimally a unique [A: v] pair here dubbed [I(llocutionary)-FORCE: v], where 'v' ranges over values like Decl(arative), Int(errogative), Imp(erative), Des(iderative), Hyp(othetical)…etc., that fixes the illocutionary force of every clause,[13] and since deciding what kind of speech act a speaker is about to perform is likely to be the earliest thing (s)he does, it is reasonable to assume, as in (11), that such a Comp-like attribute [I-FORCE: v] will be the **first** item to be activated in any SD. Simply, the category carrying the I-FORCE attribute precedes all categories that do not contain such a feature, i.e., everything else in the clause.

Assuming that declarative is the unmarked illocutionary value choice for I-FORCE and that (in English and similar languages) the default value requires no specific action (i.e., Decl is the zero option), statements will apparently start with the activation of topic-subjects, as in our examples above (or a choice of Topic, if different from the subject, cf. *infra*), whereas questions, commands, etc., being marked illocutionary options, will require some perceptible realization of the marked [I-FORCE: Int] attribute at/near the start of the respective SDs. Of course, variation is to be expected across languages as to what counts as a perceptible realization of illocutionary features (e.g., an affix, a word like Eng. *that*, etc.). In the case of modern English questions, a minimal solution to cases of marked illocutionary force might be to interpret the attribute [I-FORCE: Int] as a WH-Q operator (as in Katz & Postal 1964), and associate it with whatever the question focuses on. In the case of 'yes-no

[13] The term 'force' translates Frege's 'Kraft', and was popularized by Searle and others working on the typology of speech acts.

questions', the Operator focuses on the polarity of the clause, which, in English, when unmarked (i.e., positive, the default case), is associated with the same items that support marked predication (i.e., Chomsky's 'Infl' as instantiated by various auxiliaries). Thus, in a polarity question like *Has he arrived?* [I-FORCE: Int] will be instantiated in the LI that carries [I-S-FUNC: Pred], i.e., the tensed auxiliary [HAS]. In the absence of Comp and a Topic, that assumption, along with (11), will have the effect of activating whatever carries [I-S-FUNC: Pred] & [FORCE: Int] at the very start of the SD.

Thus, in the case of clauses with just Subject Auxiliary Inversion like ***Has*** *he arrived?* the incremental LR SD is straightforward: 1) Since the subject is not a topic, and there is no other topic, the [I-S-FUNC: Pred] and [I-FORCE: Int] carrier [HAS] is activated first, and its inflectional and C/S-selectional attributes immediately start asking for licensing/satisfaction; 2) granted principle (5) above, the inflectional attributes [VFORM: Pres], [PERSON: 3rd], [NUMBER: Sg], [CASE: Nom] of [HAS] will take priority over its C/S-selectional attributes and a LI expressing a third person singular subject, [HE] in this case, will be activated next, instead of the VP complement (specified [VFORM: EN]) C-Selected by [HAS]; 3) that temporarily leaves the C/S-selection attributes of [HAS] (i.e., [C-SEL: [VP-EN]], [S-SEL: Event]) in HOLD, of course, but the opposite strategy of satisfying the C-/S-selection attributes of [HAS] first would violate (5) and be more costly, in the face of (6-7), since HOLD would then have to store all the auxiliary's (4) inflectional attributes **plus** all the C-/S-selectional attributes of [ARRIVED]; 4) on the contrary, activating the subject [HE] next after [HAS] directly allows for immediate licensing of all the inflectional attributes of [HAS] and [HE] through unification; 5) of course, it adds the [ARG-ROLE: ?] attribute of [HE] to the still unattended (2) C-/S-Selection attributes of [HAS] already in HOLD, which will thus temporarily contain three attributes pending satisfaction, but just three, instead of four from [HAS] plus three (i.e., [C-SEL: DP], [S-SEL: Phys], and [VAL(TH): ?]) from the verb [ARRIVED], i.e., seven!); 6) finally, activating [ARRIVED] after [HAS] and [HE], in that order, immediately facilitates satisfaction of the remaining unsatisfied attributes, i.e., the C/S-selection attributes of the former, and the ARG-ROLE attribute of the latter. Thus, principles (5) and (6-7) do yield the right output in this case.

Interrogative clauses may also contain marked, and therefore visible WH-Q-Focus operators that, granted (11), must be activated after interrogative I-FORCE, with which they must 'agree', but before PRED(ication). A clause like *Whom did you invite?* contains such a visible operator, i.e., the WH-item *whom* behaves as the O(perator)-Focus of the interrogative clause, and, being not only a Focus but also an Operator, instead of appearing in U-Focus position at the end of the clause, as principle (8) predicts, it surfaces at the front, in the 'operator tract' of the clause.[14] Since being a WH question entails being a question, a visible WH Operator like [WHOM] contains an unlicensed attribute [I-FORCE: Int] to be licensed through unification with whatever instantiates marked illocutionary force (the tensed auxiliary that also instantiates [I-S-FUNC: Pred], in the case of English). Thus, granted (11), we expect the WH-Q-Focus operator to precede and quickly unify with the [I-S-FUNC: Pred] and marked [I-FORCE: Int] carrier [DID].[15]

Hence, the incremental LR SD of a WH-question like *Whom did you invite?* will require the following steps: 1) The WH-Q-Focus Operator [WHOM] containing unlicensed [I-FORCE: Int] is activated first, which makes its **two** inflectional attributes [I-FORCE: Int] and [CASE: Acc] and its unvalued [ARG-ROLE: ?] attribute start demanding satisfaction (the latter through the eventual activation of the role assigner and accusative case-governor [INVITE], in this case). Of course, we might expect the main verb [INVITE] to be activated next (i.e., **Whom invite* ...) since that could facilitate the satisfaction of an inflectional attribute, [CASE: Acc], the [ARG-ROLE: ?] attribute of [WHOM], and one of [INVITE]'s own C-/S-selection attributes (the Theme).[16] 2) However, activating [DID] instead will allow for immediate licensing of the inflectional attribute [I-FORCE:

[14] The existence of clauses containing multiple interrogative WH phrases, all but one postverbal, would seem to be a counterexample to the rule that Operator-Foci occur at the front of SDs. However, there is evidence that, in English, at least, even though two or three WH phrases co-occur in the same clause, only the preverbal one functions as an O-Focus. Thus, the appropriate answer to questions like *Who threw what at whom?* is only *It was **Mary** that threw a bottle at John*, not *It was **a bottle** that Mary threw at John* or *It was **John** that Mary threw a bottle at.* Since, in English and similar languages, not so in Eastern Indo-European, each clause can have at most one O-Focus attribute, only one WH-item may appear in pre-subject position, cf. **Who what at whom threw?*

[15] Non-matrix interrogatives, on the other hand, represent the case in which a focused interrogative WH-phrase itself (N.B., not the clause, which acts as a zero REL clause) satisfies the selection requirements of the governing verbs. The details are too intricate to be discussed here, but just consider the deletion effect called "Sluicing", as in *I have a pair of binoculars, but I don't remember where ø*, *She was very considerate, but I wonder why ø*, *We managed, but I still don't know how ø*, *He sells something, but he never told me what ø* (etc.).

[16] The attribute of [INVITE] demanding an Agent, of course, would have to remain in HOLD until a proper subject is activated.

Int] in [WHOM] as well as activate predication (instantiated by an attribute [I-S-FUNC: Pred], roughly similar to Infl), which, according to (11) must be activated next; since untensed [INVITE] does not carry either [I-FORCE: Int] nor [I-S-FUNC: Pred] attributes, whereas auxiliary [DID] does, it is the tensed auxiliary [DID] that becomes active next, satisfying both. 3) Once [DID] is active in the SD, its own various attributes start demanding satisfaction, along with [CASE: Acc] and [ARG-ROLE: ?] of [WHOM] already in HOLD. Now, according to principle (5), inflectional attributes are satisfied first, but both [WHOM] and [DID] have them (in HOLD, at this stage), the first has one such attribute, to be satisfied by [INVITE], whereas the second has [PERSON: ?], [NUMBER: ?] and [CASE: NOM], to be satisfied, in this case, by the subject [YOU], so a question arises as to which of [WHOM] and [DID] should be inflectionally attended to first. If the former, [INVITE]must be activated next; if the latter, [YOU] must.

Obviously, at this point, the economy principles (6-7), in tandem with (5), prove crucial: if [INVITE] is activated next (cf. **Whom did invite you?*), it will become possible to quickly attend to the [ARG-ROLE: ?] and the inflectional needs of [WHOM], which will be licensed and removed from HOLD in the next S-U cycle, but in exchange in the meanwhile all the inflectional attributes of [DID] but [I-FORCE: Int], i.e., [VFORM: Pst], [PERSON: ?], [NUMBER: ?], [PRED: +], and [CASE: NOM] will have to be stored in HOLD while [INVITE] gets partly satisfied; on the contrary, if [YOU] is activated next (cf. *Whom did you invite?*), the inflectional [CASE: Acc] attribute of [WHOM] remains in HOLD, but **all** the inflectional attributes of [DID] as well as those of [YOU] (i.e., its CASE and its two 'agreement' features, PERSON and NUMBER) can be immediately looked to in the very next S-U cycle, a better solution given (5). 4) Finally, [INVITE] is activated in order to satisfy the remaining unsatisfied features, i.e., the [CASE: Acc] attribute of [WHOM] gets licensed, along with the [ARG-ROLE] attributes of both [WHOM] and [YOU] and the remaining selectional attributes of both [DID] and [INVITE]. Thus, (5) along with the economy principles (6-7) and (11) does lead to the desired output.

On the contrary, if ARG-ROLE and SELECTION attributes had priority, *contra* (5), we would expect the output **Whom invite you did?*, where the two arguments of [INVITE] are quickly licensed before [DID] appears in the SD. On the other hand, the equally unacceptable **Whom invite did you?* should never arise, since activating the SD segment *[WHOM+INVITE] in that order would entail accepting ARG-ROLE first, rather than INFLECTION FIRST (5), whereas activating [DID], rather than [YOU], next to quickly satisfy [VFORM: Inf] on [INVITE]), an inflectional attribute, rather than completing the satisfaction of the ARG-ROLE specifications of [INVITE] amounts to reinstating (5), an obvious inconsistency. In sum, principle (5) seems to be on the right track, although it will not of itself lead to the desired results in complex cases unless economy principles like (6-7) and further constraints like (11) are also in the grammar and interact with it as described.

Topicalization, as in ***Money**, he does not have much*, is supposed in P&PT/Minimalist accounts like Rizzi (1997) to involve displacement of a phrase to check off some feature of a 'functional' head Top, claimed to exist in the left periphery of the CP. The observable ordering facts also indicate that Topics are 'above', and, granted Kayne's LCA, correspondingly surface 'to the left' of WH and other operators at the PHON interface, cf. ***An offer like that**, **why** would anybody say 'no' to?* For that reason, the standard P&PT/Minimalist view of the CP tract of the clause has it that the functional heads involved are at least C > TOP > FOC > INFL ('>' = higher than), in that order, as in (11) above, which correctly predicts the distribution of their respective specifiers, i.e., the Wh+REL Phrase, the Topic, the Focus, and the Subject of the clause do surface in precisely that order in the rare cases in which they all co-occur (as in the admittedly improbable, but well-formed *Tom is a rather flippant colleague **to whom**, **information like this**, **why** would **anybody in his senses** ever want to confide?*). Since Topic is, like U-Focus, an obligatory I-S function, it must be encoded *via* an attribute like [I-S-FUNC: Top] added to whatever visible linguistic object must function as Topic.[17] All clauses have a Topic, but, of course, not all have a dislocated Topic. Dislocated topics constitute the marked option; the default option is for the Topic of the clause to coincide with its subject and be fully integrated in its core structure. Only topics distinct from the subject must get dislocated intonation (comma), and in

[17] [D-FUN: Top], like [D-FUN: Foc], obviously, cannot be instantiated in the Lexicon. No LI can appear in the Lexicon with the intrinsic discourse function of Focus or Topic, just as no LI may be intrinsically specified as 'subject', 'object', etc. It remains a plausible principle of grammar that certain linguistic objects must play some role in both 'syntactic' structure (subject vs. predicate, object, or different kinds of object) and 'information' structure (topic vs. non-topic, focus vs. presupposition, etc.).

that case precede operators,[18] as declared in (11). Depending on the category of the topic (i.e., a NP, AP, PP, VP, etc.), different attributes will have to be stored in HOLD until eventually licensed, e.g., if the topic is a nominal, [CASE: Acc/Dat] will have to be licensed and [ARG-ROLE: ?] valued later on; if it is an adjectival phrase (cf. ***Stupid**, I never said you were*), an AP is always a monadic predicate selecting a Theme, so its [VAL(TH): ?] attribute will have to remain in HOLD to be valued later; if the topic is a PP, it may correspond to an argument (cf. ***On jazz**, my wife is not too keen*), and in that case its [ARG-ROLE: ?] will have to be stored in HOLD pending valuation by *keen* later on, or a modifier (cf. ***With black and white stripes**, we do not have any ties at the moment*), and in that case the PP is, like AP, a monadic predicate saturated by a Theme, but its [VAL(TH): ?] attribute will not be valued until the noun (*ties*, in the example under discussion) is attached; finally, if the topic happens to be a VP in any of its VFORMs (cf. ***Smoking**, I have never seen her, **Say something harsh**, I do not think I ever heard her, **Depressed**, I have never known him to be*), of course its [VFORM: Ing/Inf/Pass] attribute will have to remain in HOLD until eventually licensed by a suitable head, and on the other hand a topicalized VP is always a monadic predicate; it follows that its subject argument will appear later, and therefore an [VAL(AG): ?], [VAL(EXP): ?], etc. attribute will temporarily stay unvalued in HOLD until a subject is attached to the SD. Providing complete SDs for all such cases of Topicalization is tedious and requires more space than is available here, so we will not develop them in detail, but granted (11) the rest falls out as in the preceding SDs: only the principles of Economy (6-7) and Priority (5) are needed to derive accurate predictions as to what will occur in which order at the PHON interface.

Finally, a REL attribute, if present in a clause, converts it into a REL Clause, and its carrier must clearly precede everything else in it, including Topic, Operator (if present), and Subject, unless REL itself happens to be instantiated (in) the subject, as in *I was introduced to the chap **who** published that scandalous paper in Science*. This is a consequence of the special role of REL as a function turning fully saturated clauses into second-order monadic predicates of nominals (cf. Escribano 2003; 2004). Since the output of the REL function C-/S-selects a nominal, a REL clause will never be started before a nominal (the 'antecedent') is available (i.e., REL will never start a SD). On the other hand, since REL 'downgrades' the type of its clausal input (Clause > Predicate), its output (an <<e, t>, <e, t>> function) no longer satisfies REL's own selection specifications, which entails that only one REL attribute is possible *per clause*. Therefore, a principle like (12), which simply says that the REL carrier must be activated before anything carrying no REL, added to (11) neatly suffices to force CHL to activate REL at the front of the subordinate clause, as desired:

(12) REL-OPERATOR PRIORITY: REL < ~ REL

In the present framework, REL can be implemented simply as a further morphological attribute of certain LIs, usually nominals with appropriate case features (*who, whose, whom, what, that*),[19] but also pro-VPs (e.g., *which* in *They asked me to play it, **which** I did*), and pro-APs, as in *Of course, he is very rich, **which** I am not*,[20] although one with unusually drastic semantic consequences. Otherwise, the REL carrier behaves like any other syntactic object: if nominal, whatever its [CASE: …] attribute is will need licensing via activation of an appropriate case-governor, and its [ARG-ROLE: ?] attribute will have to remain in HOLD until a suitable theta-governor is activated; on the other hand, if the REL carrier is adverbial (*when, where, how*), the adverb behaves as a second-order predicate saturated by an appropriate verb(phrase) activated later on, so, until a specific event-denoting verb(phrase) is activated, its [VAL(EVENT): ?] attribute will have to remain in HOLD. Otherwise (12) does all the work needed to activate REL carriers where they must be activated.

Of course, this is only a preliminary sketch of how a proper account of displacement effects might be built within the present incremental, unification-based LR approach. Many low-level details remain to be worked out, and, in addition to Economy (6-7) and Priority of Inflection (5), it has been

[18] Operators (WH-Focus, Neg) are also closely integrated in the clause. Observe that, whereas topics are intonationally dislocated, and separated by comma, operators are not, cf. ***Whom**, did you invite? **Never in my life**, had I felt as miserable as I feel now.*

[19] No attempt will be made here to distinguish *that* from the LIs that visibly carry a REL (= WH) attribute. Such low-level details cannot be spelt out in a programmatic paper like this.

[20] Of course the pro-predicate *which* is possible only in non-restrictive relative clauses, so if a REL attribute is involved, it can hardly have the same semantic type as the REL that turns clauses into predicates. At least two (REL1, REL2) items must be assumed, therefore, but, again, such low-level details cannot be developed here.

necessary to add the the U-Focus principle (8),[21] the I-S 'template' (11), and the REL-Priority principle (12), but such stipulations are no more stipulative than assuming a hierarchy of functional heads like C > Top > Foc > Infl and Kayne's LCA to account for the surface order of constituents of the clause, as in e.g., Rizzi (1997) or Cinque (1999).

Economy

Obviously, the optimal CHL is one that computes as little as possible. The Economy of CHL as here understood has a number of manifestations that may as well be quickly mentioned here. First, the zero option is lexicalization without further computation. If choice of a LI from the Lexicon is sufficient to express what the speaker intends to say and the LI activated happens to contain no uninterpretable attributes (cf. e.g., *Here! John! Fire!* etc.) no syntactic computation whatsoever will occur. In other words, in the most favorable case, to encode a linguistic message only the activation of one LI will be needed. However, even a single LI may well contain uninterpretable attributes, and, in that case, once a LI is activated, CHL must automatically start searching, unifying, etc., in order to satisfy them. That is only the second best option, of course, for uninterpretable attributes of LIs, by definition, have to be licensed/valued *via* access to information elsewhere, in other LIs, which entails SEARCH and then S-U, or even HOLD, if delayed satisfaction is involved. Hence, SEARCH, S-U and HOLD are all computationally expensive and Last Resort processes. The most general economy principle, thus, may be stated as in (13).

(13) ECONOMY PRINCIPLE: Unless an operation is necessary to allow satisfaction of an uninterpretable attribute, it is otiose and cannot take place.

Secondly, since S-U operates on one [A: v] pair at a time, if a LI contains *n* attributes in need of licensing/valuation, each must be individually searched for, and in order to satisfy them S-U will have to apply exactly *n* times. Hence, under present assumptions, the internal complexity of LIs is computationally relevant; LIs are not impenetrable atomic objects, *pace* Chomsky, and therefore the cost of computing them varies according to the number of attributes each contains. If LIs are, for greater simplicity here, not assumed to have internal structure making some attributes more accessible than others,[22] to compute a LI with just one uninterpretable feature has a computational cost (CC, hereafter) of one unit (CC(LI) =1), but the value of CC increases towards *n* as the number of attributes to be satisfied grows. Thus, roughly, the smaller the number of attributes a lexeme has, the cheaper its computation (but see note 17).

Thirdly, we may assume the CC of a SD to be smaller whenever two or more LIs share attributes that can be unified, e.g., identical [A: v] pairs or unvalued attributes. Of course, this is because, in that case, unification reduces the number of attributes requiring satisfaction. For example, the CC of processing a continuous series of pre-nominal adjectives, as in *a beautiful tall slim Indian girl*, is smaller than that of computing the same adjectives if they surfaced non-contiguously, so they never do (cf. **a beautiful tall girl slim Indian*). Obviously, in that case, e.g., the C-/S-selection attribute of *beautiful* is not immediately satisfied (by *girl*), and must be stored in HOLD, but that happens to be the optimal way to compute that series of adjectives, for as the identical C-selection attributes of *tall,* and then *slim*, and *Indian*, are in their turn stored in HOLD, they all **unify** into just one [C-SEL: N…]

[21] So-called "It-Extraposition", "Extraposition from NP", and "Heavy-XP Shift" are also displacement effects induced by the need for heavy segments with 'new' information to act as unmarked Foci. Space considerations prevent us from discussing them here, though.

[22] That is assumed here, although only for the sake of simplicity, a desirable property in an introductory treatment like this. As a matter of fact, though, that assumption is likely to be wrong, i.e., there probably IS internal structure in LIs that makes some attributes more immediately accessible than others (= accessible via a smaller, hence a computationally less costly, search). Such a distribution of information inside LIs is probably related to our principle of priority (of satisfaction), e.g., inflectional attributes are satisfied first presumably because inflection is the outermost component of LIs. Observe that standard morphological theories assume inflectional affixes to be attached at the edge of words, **after** derivational ones are. Correspondingly, certain theories of syntax (e.g., Categorial Grammar) use complex categories in which the order in which arguments can be accessed and satisfied is specified, usually to yield a bottom-up derivation with the subject argument at the top. And, of course, Linking Theories and Thematic Hierarchies are just general templates specifying the order in which the various arguments of polyadic predicates must be satisfied. Thus, it would be quite reasonable to assume that some attributes are less accessible because they are more deeply 'embedded' in the structure of LIs and therefore entail longer and computationally costlier searches. Since the implications of this idea have not yet been calculated in any detail, we leave the matter open pending further research.

pair, instead of four, and when *girl* is finally activated in the SD, its presence satisfies all four unified C-selection attributes in just one application of S-U. Thus, computing four contiguous attributive adjectives is not costlier (in this respect) than computing just one. Needless to say, this favors the adjacency of LIs which share attributes in need of satisfaction.[23]

Fourthly, immediate S-U, of course, if possible, is always cheaper than HOLD plus delayed S-U, so HOLD is avoided whenever possible, which, again, favors LR contiguity between LIs involved in S-U operations. Assuming, for simplicity's sake, that all other things are equal, the CC involved in making use of HOLD can be calculated readily enough: if storing one attribute in HOLD during one computational cycle *c* costs one unit (CC = 1), the cost of storing *n* features is CC = n, and the cost of storing *n* features during t cycles is CC = c*n. In other words, the longer the LR distance between two dependent LIs, the higher CC rises. If we take Economy to entail cost minimization, cf. (6) and (7), a derivation SD_i will always be dis-preferred if there exists an alternative derivation SD_j that satisfies all principles of grammar and has a lower CC. As we said, the zero option is mere lexicalization; S-U occurs only to the extent LIs contain uninterpretable attributes, and HOLD occurs only when immediate S-U is impossible as a consequence of PRIORITY or the other principles above.

Fifthly, articulation is also computationally expensive and Last Resort, so, in general, we may expect CHL to keep prominent items containing semantically relevant lexical information at PHON for the hearer to recover, but also to delete or at least phonologically reduce information that in a specific discourse context happens to become redundant. In other words, whenever PHON information is redundant, Economy predicts that it will be 'muted' or 'reduced' to the extent the rules of the language permit. This predicts the existence, in certain contexts, of phonologically null categories (cf. PRO, 'small pro'), as well as Ellipsis (Gapping, Sluicing, etc., cf. Lobeck 1995, Merchant 2001), Coordination Reduction, Shared Constituent Coordination (*alias* Right Node Raising), and if course 'anaphora' (*So*-Substitution, *Do-so* Substitution, *One*-pronominalization, etc.; cf. *infra*). Since predictable information is redundant and omissible, whereas informative material is prominent and non-omissible, we may expect a sort of hierarchy among the items that figure in SDs depending on their syntactic and I-S-Function, i.e., on the whole, heads must be visible, but their obligatory arguments, to the extent they are predictable, are also less informative, less prominent, and more easily omissible, whereas modifiers, being optional and unpredictable, are highly informative and prominent whenever they occur, and cannot be omitted. This has important consequences on possible and impossible patterns of ellipsis and the distribution of PHON prominence.

Protean Constituency, Coordination, and Ellipsis

Observe that such 'structure' as is generated within the present incremental unification-based approach does not play any real theoretical role, for the attribute-value matrices (AVMs, hereafter; roughly, syntactic 'phrases' in other approaches) created during a SD are never referred to as such by SEARCH, S-U, or HOLD at all. Recall that Satisfaction-via-Unification (S-U) affects only attributes and their values, never sets of [A: v] pairs, or, even less, sets of LIs. Sets play no role at all. Of course, a LI may well consist of a set of attributes, some in need of satisfaction, as shown, and CHL has access to LIs and to the sets of LIs already activated in SDs, but S-U necessarily attends to just one [Attribute: value] object at a time; if others need attending to, they simply must 'wait' until the next computational cycle takes place. In this sense, S-U is strongly opposed to Chomsky's (2005) 'unstructured' Merge, which is supposed to be recursive set-building subject to a principle of Non-Tampering. On the contrary, S-U **must tamper** with SD objects or it will not occur at all: unless S-U licenses/valuates an unsatisfied attribute, it is, by definition, otiose, and, granted principle (13), illegitimate; see Escribano (2006b, c) for detailed discussion of Chomsky's recent approach.

Of course, as a SD progresses, CHL keeps activating new LIs and gradually licensing or valuing their attributes, and particularly its HOLD module must keep track of temporarily uninterpretable

[23] Depending on how English auxiliaries are analyzed, they may or may not be another case in point. If it is assumed that all auxiliaries C-/S-select the VP/event expressed by the main verb, keeping them all in a contiguous series before it, as in *He **may have been being** blackmailed*, obviously facilitates unification of their respective C-/S-selection attributes into just one and diminishes CC. On the contrary, if each auxiliary selects a different Verb/event, their contiguity does not improve CC, but as the number of steps such selection features must be kept in HOLD until satisfied also diminishes to just one, the choice must be made on other grounds than CC.

attributes of one or more active LIs. To that extent we may intuitively represent a SD as an incremental graph like (14), but (14) captures only the order in which LIs are activated and eventually surface at PHON; it does not represent SD constituency or the computation under way.

(14) #LI_1( ]) > LI_2 ( ]) > LI_3 ( ]) > LI_4 ( ]) > ……> LI_n] (where ">" = activate)

To suggest this somehow, observe that in (14) no left-edge parentheses are added as new LIs become active. The SD has a natural left edge "#" and a natural right edge "]", and additional temporary right edges "]" are added (and quickly removed, hence the parentheses) as new LIs become active, but there is no 'object' like, say, L1+L2 (= the set {L1, L2}, according to Chomsky (2005), or the result of 'assembling' L1+L2). Lexical information is accessible, but such macro-constituents are simply not there, or, if they are, they are not visible to SEARCH, S-U or HOLD.

This leaves us in the uncomfortable position of having to account for the restrictions that constituency seems to impose on certain syntactic processes that surely apply to 'phrases' (e.g., coordination, ellipsis, anaphora, displacement) without having any such 'constituents' at our disposal; alternatively, such constituents might be created, after all, in the course of SDs, although not by the core CHL operation S-U, but by some other device. If so, CHL yields SDs with **two** levels of representation, after all, although only one is properly 'syntactic'.

Since we cannot both do without 'phrases' and account for coordination, substitution, deletion, and displacement, obviously it is the second alternative that seems more promising, so let's assume that phrases exist, but result from choices the speaker makes as he monitors I-S in his speech and marks relevant chunks thereof by means of intonation, stress, and appropriate pauses. Observe that phonological phrases have long been considered independent of core syntactic principles and processes; what is proposed here, thus, is that 'syntactic phrases' are also independent of lexical satisfaction and the operation S-U. Phrases arise, but are just chunks of SDs like (14) segmented by the speaker as needed in virtue of his communicative intentions and general principles of computational Economy (avoidance of redundancy, recoverability, etc.).

The speaker, of course, must be planning his/her sentence well in advance, and to that extent (s)he may decide to group LIs in ways that allow for optimal delivery and absence of redundancy, e.g., if (s)he is planning a series of coordinate clauses sharing a certain predicate, (s)he may avoid substantial redundancy by gapping a central segment in all the coordinate clauses but the first, which acts as the relevant 'antecedent', as in e.g. *John [has finally ordered] a cheese salad, Tom [has (finally) ordered] spaghetti carbonara, and Alan [has (finally) ordered] a seafood pizza,* but observe that the gapped segment need **not** be a constituent in the sense defined by lexical satisfaction and Merge or X-Bar theory, etc. Similarly, if (s)he is planning a series of coordinates with a common right edge, (s)he may interrupt the SD exactly at the point where the shared segment should start, introduce a pause and an appropriate intonational warning that lexical attributes temporarily get stored in HOLD, proceed with the derivation of the remaining coordinates, and close with the initially suppressed final segment, thereby satisfying all previous coordinate contexts in just one step (which yields a Right Node Raising construction, as in *Tom writes_, Sara illustrates_, and I publish* ***science fiction books for children***). Or (s)he may be planning a series of coordinates sharing the predicate, but with different subjects, as in *John, his wife, their two children, and my daughter* ***traveled back home in John's Q7***, etc., and a so-called Conjunction Reduction construction will result.

In general, then, the chunking of SDs into 'phrases' is a matter of how the speaker plans his I-S. Obviously, though, it is necessary to establish certain constraints on what can and cannot be chunked. A plausible one is that nothing smaller than a LI can be a chunk at the PHON interface, presumably because a LI is the smallest linguistic sign with both autonomously pronounceable SOUND and a focusable I-S-FUNCTION (although from this it does **not** follow that just any LI is likely to become a chunk). Correspondingly, the upper limit on the length of chunks must be (*n*-th order) 'predicates', i.e., roughly, a chunk can coincide with an argument, a predicate, a modifier, or any segment of the clause, but not with the clause in full, since such a chunk would have no utility to the speaker, as (s)he is not going to repeat it either as a coordinate or as an elided constituent of anything else. Crucially, neither the gapped central segments nor the shared right/left edges involved in Right Node Raising and Conjunction Reduction need be 'constituents' in the sense of the syntactic units resulting from satisfaction of lexical properties *via* Merge or earlier X-bar principles. Of course, I-S chunks may

coincide with such *bona fide* constituents, but the point is that they need not. Classical examples of non-constituent gapping or coordination like *I **want to start writing** a novel and my wife [wants to start writing] a play*, or *For Christmas, I have bought **my son a VAIO laptop** and **my daughter an electronic keyboard***, etc. are problematic for traditional syntactic theories to the extent the gapped or coordinated segments are not constituents according to standard constituency criteria, but cause no trouble whatsoever under the present theory of phrases as relatively accidental, context-dependent chunks of I-S (cf. Steedman 1996, 2000 for details on I-S chunks)

Also, the fact that sense-identity tests like *One*-Substitution cf. *I have a black tie with white stripes and he has **one** too*) should yield alternative structures for the same nominal phrase depending on the context in which it is used has always been deeply disturbing for the traditional approach, and, of course, such structural 'ambiguities' are pervasive, cf. e.g., the exchanges between a speaker Sp and addressee A in (15).

(15) a. Sp: I like the tall slim Indian girl with a saffron sari at the door.
b. A: Which **one**? (one = tall slim Indian girl with a saffron sari at the door).
c. S: The tall **one**. *(*one = slim Indian girl with a saffron sari at the door).
d. A: The **one** at the door? (one = tall slim Indian girl with a saffron sari).
e. S: Yeah, the **one** with a saffron sari at the door! (one = tall slim Indian girl)
f. A: I see, the tall slim Indian **one** (one = girl with a saffron sari at the door). Etc.

Now, according to (15b), *tall slim Indian girl with a saffron sari at the door* is a nominal constituent which, in view of (15c), must contain a smaller nominal constituent *slim Indian girl with a saffron sari*, but, granted (15d), the PP *at the door* does not belong to that central constituent, whereas the adjective *tall* does, whereas in view of (15e) it is the segment *tall slim Indian girl* that is a sister to (and under the scope of) the PP *with a saffron sari*, and yet, granted the acceptability of (15f), that structure cannot be correct, since the nominal segment *girl with a saffron sari at the door* must all lie in the scope of *Indian, slim, and tall*. Etc. Obviously, no single conventional phrase structure tree is compatible with all the constituents that *One*-substitution indicates exist in *the tall slim Indian girl with a saffron sari at the door*, but at the same time there is solid evidence in favor of all of the alternative structures called for, and no reason to discard any of them, a rather puzzling state of affairs (cf. Escribano 1991b).

Yet, if the present approach to constituency is right, there is no mystery at all: As the dialogue in (15) develops, both Sp and A keep adapting the I-S of their successive contributions in order to ensure a proper assignment of unmarked Focus, context-sensitive and cooperative responses from each other, and ultimately a successful exchange. Hence, **all** the alternative constituent structures suggested by the *One*-Substitution test in (15a-f) are indeed correct, well motivated, and necessary, although, at the same time, none of them can be individually selected as 'the' right constituent structure of that nominal phrase, which, of course, along with parallel evidence from *Do-So* Substitution inside VPs, offers very strong support for the present theory of phrases as mere reflexes of the speaker's chunking of his linguistic output to adapt it to the needs of I-S and general considerations of Economy.

CONCLUSION

In sum, granted carefully specified LIs, which *pace* Chomsky's recent 'recursion only hypothesis', is a *conditio sine qua non* in any internalist approach to Human Language, a realistic CHL can largely reduce to general non-language-specific invasive operations like SEARCH, SATISFACTION-via-UNIFICATION and HOLD working under general, and also non-language-specific, principles of ECONOMY (13) and computational efficiency like (6-7). Whether language-specific principles are also needed in a realistic CHL is unclear, but, if they are, they apparently reduce to the PRIORITY OF INFLECTION (5) and I-S structure principles like U-FOCUS LAST (8), the I-S HIERARCHY (13), and REL-Priority (14) which might well turn out to be mere consequences of more basic cognitive properties. Be that as it may, as this programmatic paper has tried to show, with just such machinery, it is possible to formulate an elegant incremental unification-based LR processing mechanism that solves the problems surrounding all standard bottom-up approaches to generation and interpretation.

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