

Projecting Grammatical Features in Nominals: Cognitive Theory and Computational Model

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Abstract

A localist theory of the representation and projection of grammatical features in nominals is presented in which words and phrases functioning as specifiers and modifiers—in addition to heads—project grammatical features to encompassing nominals. Grammatical features may be redundantly encoded in words and phrases fulfilling different grammatical functions. At the level of the nominal, the projected grammatical features are collected into a set without duplicates. Redundantly encoded grammatical features may occasionally conflict or a grammatical feature may be unspecified—without the expression being ungrammatical—necessitating mechanisms for handling conflicts and accommodating unspecified features. An incremental, serial, pseudo-deterministic system for processing nominals which operates over an interactive (context-sensitive), parallel, probabilistic, constraint-based substrate is presented and motivated. Within this overall processing capability, non-monotonic mechanisms of blocking and overriding of grammatical features, without backtracking, are presented for handling conflicts. These non-monotonic mechanisms are part and parcel of normal processing and are not viewed as exceptional. Construal mechanisms for handling unspecified features are also needed. In the simplest case, the referent of the referring expression provides the (semantic) basis for construal of unspecified features. The processing of nominals within a computational cognitive model of language processing implemented in the ACT-R cognitive architecture is used to demonstrate and support various representational and processing claims.

Representational Considerations

The current linguistic standard as exemplified in X-Bar Theory (Chomsky, 1970; Jackendoff, 1977), Generative Grammar more generally (cf. Radford, 1997, 2004), and HPSG (Sag & Wasow, 1999; Sag, Wasow & Bender, 2003) is that heads project the category of the phrases they head. In the case of a noun phrase, it is assumed that a noun head projects the category of the noun phrase. It is also typically assumed that heads project various grammatical features to the phrases they head (or that grammatical categories are really just collections of grammatical features). For example, the noun head of a noun phrase may project grammatical features like person, number and gender to the noun phrase. More specifically, if the noun phrase is “the man”, the noun head “man” may project the grammatical features *third-person*, *singular*, and *male*. The person and number features are assumed to be needed for determining agreement in expressions like “the man runs” and the number and gender features are needed for binding pronouns and reflexives appropriately as in “the men_i like themselves_i” or “the man_i believes he_i is smart”. Projection of features is especially important to localist theories in which there is no non-local access to grammatical features (cf. Sag 2009). For example, on localist principles, in “the man runs”, only grammatical features associated with the noun phrase “the man” are accessible to satisfy agreement with the verb “runs” (or its projection).

There is no non-local access to the agreement features of “man” which have not been projected to the noun phrase.

It is sometimes also assumed that only heads project grammatical features. For example, the head feature principle (HFP) of HPSG is (largely) based on this assumption (Sag & Wasow, 1999), and in the Minimalist Program as described in Radford (1997) only semantically interpretable head features are retained in LF representations. However, this assumption leads to a system of linguistic representation in which most of the subcomponents of a phrase must be heads in order to project the needed grammatical features to the headed phrase, or to a system in which heads must redundantly encode features marked on non-heads. Consider the simple expression “the man”. If the grammatical feature *definite* which is part of the grammatical behavior of “the” needs to be projected to the encompassing phrase and the grammatical features of “man” also need to be projected, then the following options are apparent: 1) “the” is the unique head (cf. Abney, 1987) and we must somehow mark the grammatical features of “man” on “the”; 2) “man” is the unique head and we must somehow mark the definiteness feature of “the” on the head “man”, 3) both “the” and “man” are heads and project grammatical features, or 4) we must relax the assumption that only heads project grammatical features (the approach adopted herein).

In the first approach—the functional head approach—since “the” is the unique head, “man” is typically treated as a complement of “the” (complement being the best available place in the X-Bar schema for the non-head noun given a functional head). How then do the grammatical features of “man” get projected to the encompassing phrase (typically called a determiner phrase or DP)? Grimshaw (2000) introduces the notion of extended projections in which a noun complement can project grammatical features without violating basic notions of endocentricity (Bloomfield, 1933) by assuming that the noun complement and functional head are of essentially the same syntactic category with respect to grammatical feature projection. In fact, Grimshaw treats the noun complement as an extended head. However, treating the noun as both a complement and an extended head distorts the basic notion of complement (which we take to be largely synonymous with argument). The basic function of complements is to describe distinct objects that are related to the head of an expression. The description of these distinct objects requires its own grammatical features. In order to accommodate functional heads, Grimshaw is forced to adopt a distinction between complements of lexical heads and complements of functional heads, since complements of lexical heads do not project features, whereas complements of functional heads do. Radford (1997) presents an alternative approach in which the grammatical features normally associated with nouns are redundantly encoded on the determiner. This approach leads Radford (1997, p. 188) to suggest that “the” in “the students take themselves too seriously” has the features *third-person*, *plural* and *nominative*—since “the” is the head of the subject! Worse, in an expression like “the man”, “the” would presumably encode the gender feature *male* as well (although Radford does not discuss this possibility). Besides the fact that there is no grammatical evidence that “the” encodes these features, note the tremendous ambiguity that such an approach introduces: “the” will have multiple sets of grammatical features which can only be resolved by the overall context in which it occurs.

The second approach is simply the reverse of the first approach with “man” functioning as the “head” and the grammatical features of “the” needing to be redundantly encoded on “man” or handled via something like extended projections. The grammatical evidence suggests that singular count nouns are not marked for definiteness (in English), and insisting that they carry a definiteness feature adds ambiguity that cannot be resolved by the noun. For example, to handle “a man” vs. “the man”, “man” would need to be coded as either *indefinite* or *definite*, depending on the determiner. At least the determiner “the” or “a” is available when “man” is processed and can influence the selection of the appropriate grammatical features for “man”. This is not the case in the first approach.

In the third approach, both “the” and “man” are treated as heads (on the same level) and can project grammatical features to the encompassing phrase. For example, in Cann (2001), “the”—which functions as a specifier—is treated as a secondary head. The primary problem with this approach is the positing of two heads to capture the fact that both the determiner and noun need to be able to project grammatical features to the encompassing phrase. As will be argued below, modifiers (but not complements) can also project grammatical features. Rather than proposing a three-headed monster to allow modifiers and specifiers to project grammatical features as well as heads, we will relax the assumption that only heads project grammatical features.

In the fourth approach—which is adopted and motivated in this paper—if we allow non-heads to project grammatical features to encompassing phrases, then in the example “the man”, the determiner “the” can project the feature *definite* and the noun “man” can project the features *third-person*, *singular* and *male*. We will further assume that “man” is the head of the expression based on semantic evidence that the expression “the man” can be used to refer to an object of type man—assuming a semantic motivation for the functional category head (see Ball 2007a for further details). If “man” is functioning as the head, what is the functional status of “the”? A traditionally suggested candidate is *modifier* (cf. McCawley in Cheng & Sybesma, 1998), but a better candidate is *specifier*—we agree with Cann (2001) and Chomsky (1970), in this respect. To the extent that the functional categories *modifier* and *specifier* are distinct, determiners are better treated as specifiers since they combine with nouns to form complete noun phrases (e.g., “the man”) whereas modifiers often combine with nouns to form incomplete noun phrases (e.g., “old man”). (For arguments against the distinction between specifiers and modifiers, see van Eynde, 2006.) This is an original insight behind the idea put forward in Chomsky (1970) that specifiers combine with heads to form maximal projections. Ball (2007a) adapts Chomsky’s formalism in positing four phrase internal (or sub-maximal projection) functional categories: *specifier*, *head*, *modifier* (called *adjunct* by Chomsky) and *complement*. HPSG (cf. Sag & Wasow, 1999) adopts the same set of basic phrase internal functional categories. Huddleston & Pullum (2002) adopt the sub-phrasal functional categories *determiner* (where determiner is a functional category and determinative is the part of speech of words like “the”), *head*, *modifier* and *complement*. Biber, Conrad & Leech (2002) adopt the same functional categories as Huddleston & Pullum, but do not make a distinction between *determiner* as a functional category and *determiner* as a part of speech. In this paper, *determiner* will be used as the part of speech

of words like “the” and *specifier* as the grammatical function that is typical of determiners.

Allowing for specifiers to project grammatical features (which is also assumed by Grimshaw, 2000, in the case of possessive nominals), one can ask if modifiers and complements can also project grammatical features. If “two” in “the two books” is functioning as a modifier, then the modifier “two” can project the number feature *plural*. Since “books” also projects the feature *plural*, projection of this feature by “two” is redundant. However, in an expression like “the two on the counter are ready”, the grammatical evidence suggests that “two” projects the feature *plural* as indicated by the *plural* agreement with “are”. In this example, is “two” functioning as a modifier or head? On the assumption that the head is empty, it is functioning as a modifier. Further support for the existence of empty heads in noun phrases (which are henceforth called nominals since a noun head need not occur) is provided below.

With respect to complements, to the extent that “of books” is functioning as a complement in “a pile of books are on the table”, it appears that complements can also project grammatical features—at least the number feature. However, I do not believe that “of books” is functioning as a complement (i.e., to the extent that nouns take complements, it is the combination of the noun—in this case “pile”—with the non-optional preposition “of” that licenses the complement, not the noun by itself), and if there is a phrase internal functional category that does not project grammatical features it is the complement category. Complements describe objects that are related to heads. The elements of the complement project grammatical features to the complement phrase, which requires its own set of grammatical features, but complements do not contribute to the grammatical description of the head per se. Given the basic function of complements (which has unfortunately been clouded with the introduction of functional heads), it would be surprising if they projected features to the encompassing phrase. If “of books” is not functioning as a complement in “a pile of books”, what is its grammatical function? “Of books” may be functioning as a modifier of “pile”, with “pile” functioning as the head (in which case “a pile of books is on the table” would be expected), or “books” may be functioning as the head of “a pile of books” with “a pile of” functioning as a phrasal specifier (or “pile of” functioning as a modifier). Note that in the latter case, the *plural* feature of “books” overrides the *singular* feature of both “a” and “pile” and yet “a pile of books are on the table” is grammatical for many speakers of English. It is also the case that the closer proximity of a non-head noun to a main verb, relative to the head noun of the subject which normally determines verb agreement, can influence verb agreement in ways that are not discussed in this paper, but which could explain the plural agreement between “books” and “are” without assuming “books” is the head of “a pile of books” (cf. Quirk et al., 1985). More generally, if a non-head noun (i.e., pre- or post-head modifier) is more cognitively salient than the head noun as in “a pile of books” or “the airspeed and altitude setting **are** unchanged”, the non-head noun, or conjunction of nouns, may block or override the number feature of the head noun.

Definiteness, Person and Number

What the determiner does when functioning as a specifier is provide the primary indication of the definiteness of the nominal in which it is embedded. I use the term “primary” since not all nominals contain a determiner and yet they nonetheless provide an indication of definiteness. For example, the nominal “books” in “books are fun to read” is *indefinite*. Since the nominal only contains the plural noun “books”, “books”—and more generally plural nouns—must be capable of providing an indication of definiteness. An alternative is to assume a zero determiner (cf. Biber, Conrad & Leech, 2002) that projects the definiteness feature. But that leaves unexplained why “books” but not “book” can occur alone as a nominal.

If we allow both specifiers and heads to project grammatical features, there is the possibility of conflict between the grammatical features that each projects. For example, the nominal “the books” contains both a determiner and a plural noun. On the assumption that “the” projects the feature *definite* and “books” projects the feature *indefinite* there is a conflict. This conflict can be resolved if we assume that the definiteness feature of the specifier is primary and blocks the definiteness feature of the head. Thus, “the books” refers to a *definite*, but *plural* quantity of books. Note that “books” may still project the features *third-person* and *plural* which are not blocked by “the”. On the other hand, the determiner “a”, unlike “the” projects the number feature *singular* and blocks the number feature *plural* making “a books” ungrammatical. Within this formulation, why “a books” is ungrammatical, whereas “the books” is grammatical is an interesting and as yet unanswered question. This question is complicated by the fact that “a few books are on the table” is grammatical, suggesting that at least under some circumstances the singular number feature of “a” can be overridden.

An assumption worth exploring is that for a nominal to be grammatical it needs to encode a set of grammatical features which, as a minimum, might include definiteness, person and number—regardless of whether these features come from the specifier, modifier or head. Adopting this assumption (for now), the ungrammaticality of “the” and “a” used by themselves as nominals can be explained if they do not encode for one or more of these grammatical features. In the case of “a”, the person feature may not be encoded, and in the case of “the” both person and number are not encoded. Similarly, *singular* count nouns like “dog”—unlike *plural* and *mass* nouns—fail to encode the definiteness feature and do not normally occur alone as nominals. On the other hand, the fact that “that” and “these” can occur alone as full nominals suggests that they do encode for these grammatical features. “That” is *definite*, *third-person*, *singular*, and “these” is *definite*, *third-person*, *plural*.

Animacy and Gender

We have so far argued for the existence and projection of the grammatical features definiteness, person and number. But what of the grammatical features animacy and gender? It is clear that nouns like “man” and “woman” encode the gender features *male* and *female*, but it is unclear that nouns like “book” and “rice” encode a gender feature. One could posit a *neuter* gender feature and make it the default for nouns, but an alternative is to simply assume the absence of a gender feature. Allowing the gender

feature to be absent or unmarked is consistent with a dependency between gender and animacy in English. It may be that the gender feature is only encoded by nouns which are *animate* (or more specifically *human*). If a noun is *animate (human)*, it may have a gender feature, otherwise, it does not encode for gender—except for a few well-known exceptions like proper nouns naming ships. The existence of a distinction between *animate* and *inanimate* nouns makes the *neuter* gender feature unnecessary. Gender does not apply to *inanimate* nouns.

In contrast to the blocking of the head feature for definiteness by the specifier, one can ask if any head features can override specifier features. If we assume a grammatical feature for animacy, and if both specifiers and heads can code for this feature, the grammatical evidence suggests that the animacy feature of the head is primary. For example, in “that dog”, if “that” encodes the animacy feature *inanimate* and “dog” encodes the animacy feature *animate*, then the animacy feature of “dog” overrides the animacy feature of “that”. In support of “that” having the feature *inanimate*, consider “I like that” in which “that” indicates an inanimate object (i.e., it cannot typically be used to refer to something that is animate). In support of treating animacy as a grammatical feature (i.e., a feature that has grammatical consequences) consider

1. The food_i given the dog t_i (was crunchy)
2. The dog_i given t_i the food (was hungry)
3. The man_i that I gave t_i the book
4. The book_i that I gave the man t_i

My preference is for “the food” to be the understood object of “given” in 1 (indicated by the position of the trace with matching index) and for “the dog” to be the understood indirect object of “given” in 2. This preference hinges on the animacy of “the food” and “the dog”, showing that animacy can have grammatical consequences. Likewise in 3, “the man” is the understood indirect object of “gave”, and in 4, “the book” is the understood object. Again, animacy is the determining factor in this grammatical preference, suggesting the need to encode animacy as a grammatical feature.

Subjective and Objective Case

A grammatical feature which has not been discussed to this point, is the feature case. A small set of pronouns are clearly marked for case in English. The pronoun “I” is marked for subjective case whereas the pronoun “me” is marked for objective case. But what about the pronoun “you”? Are there two separate entries in the mental lexicon—one marked with subjective case and the other marked with objective case—or is the pronoun “you” simply not marked for case? And what about common and proper nouns? Are all common and proper nouns doubly marked for subjective and objective case, or are they simply not marked? Since the pronoun “you” and common and proper nouns can occur as the heads of subjects and objects without grammatical effect—e.g., “you like me” vs. “I like you” and “the tree fell” vs. “he felled the tree”, and “John likes me” vs. “I like John”—we will assume that “you” and common and proper nouns are not marked for case. Note the implication that only case marked pronouns participate in case agreement.

For “you” and common and proper nouns which are not marked for case, case agreement does not arise.

Selective Coding of Grammatical Features

It was claimed above that *singular* count nouns do not encode for definiteness, whereas *plural* and *mass* nouns encode the *indefinite* feature. The encoding for definiteness allows *plural* and *mass* nouns, but not *singular* count nouns, to function as full nominals. Pronouns and proper nouns, like *plural* and *mass* nouns, differ from *singular* count nouns in encoding for definiteness which also allows them to function as full nominals. It was also claimed that only a small number of pronouns encode for *subjective* and *objective* case. And it was claimed that only nouns which are *animate (human)* may also be coded for gender. This selective encoding of grammatical features is founded on the basic principle that **where there is no grammatical distinction, there is no marking for a grammatical feature**. Without grammatical evidence, there is simply no basis for learners of English to learn the distinction. The following discussion explores the consequences of this basic principle for the representation and projection of grammatical features.

Person and Number in Subject-Verb Agreement

Under the assumption that grammatical features are only posited when there is a grammatical effect, we can revisit the grammatical features person and number which are presumed to be involved in subject-verb agreement. Consider the simple paradigm involving the present tense verb “sit”:

Person	Number	
	singular	plural
first	I sit	we sit
second		you sit
third	he sits	they sit

First note the assumption that there is no *second-person singular* form in English (vice Huddleston & Pullum, 2002, p1463) since “you” always shows *plural* agreement, even when referring to a single individual (e.g., “John_i, you_i **are** a saint_i”). Insisting on the existence of a *second-person singular* form of “you” conflates the concept of notional concord (or more specifically notional number agreement) with grammatical concord (or grammatical number agreement) (Quirk et al., 1985). Notionally (or semantically), “you” may refer to a single individual, but grammatically, it is construed as plural. As Quirk et al. (1985) note, when notional and grammatical **number differ**, notional concord often dominates in determining subject-verb agreement. (As I write this, I see that Microsoft Word does not like my use of “number differ” above suggesting “number differs” or “numbers differ” instead. If you actually see “number differs” in the text, then Microsoft Word has intervened at some point and corrected my use of notional number.) Although there is a difference between notional and grammatical number, we do not claim that grammatical number is purely syntactic. Rather, grammatical number is a conventionalization of notional number which can occasionally evoke alternative

construals as in the case of words like “scissors” and “pants”. The categorization of objects as singular and plural—like most human categories—is not based on necessary and sufficient criteria, but is subject to basic processes of construal which occasionally conflict (cf. Langacker, 2000). For example, in “notional and grammatical number differ” the modifier “notional and grammatical” is *plural* (with the *plural* feature coming from the conjunction “and”), whereas the head “number” is singular. For me, it feels more natural to treat “notional and grammatical number” as plural, despite the singular head “number”. This suggests that the number feature of a modifier may occasionally block the number feature of the head.

Given the above paradigm, *third-person singular* agreement appears to be special in English, with the present tense verb “sit” having a special form which adds an “s”. All other present tense verb forms lack this verbal marking. However, if we ignore *first-person singular* agreement for a moment, then it looks like the “s” marking on the present tense verb is associated with *singular* agreement and no marking on the present tense verb is associated with *plural* agreement. This is the converse of number marking on nouns: *plural* nouns are marked with “s” and *singular* nouns are unmarked.

Noun + “s” → plural

Present Tense Verb + “s” → singular agreement

If we can somehow model the treatment of *first-person singular* agreement without invoking a general *person* feature, then the grammatical feature *person* can be eliminated, leaving only number to determine subject-verb agreement. From the perspective of projecting grammatical features, the pronoun “he” projects a *singular* number feature that must agree with the “s” marking on the present tense verb. On the other hand, regardless of what “I”, “we”, “you” and “they” project for number, there may be no agreement with the verb. But if there is no subject-verb agreement, how do we preclude combinations like “I runs” or “we runs”? If we re-introduce an explicit *plural* agreement requirement then we can eliminate “we runs” since the *plural* number projected by “we” is incompatible with the *singular* agreement marking on “runs”. But that still leaves “I runs” unexplained. In fact, *first-person singular* agreement is the special case, not *third-person singular* agreement. If “run” agrees with *plural* subjects, and “runs” agrees with (*third-person*) *singular* subjects, then why do we say “I run” and not “I runs”? Must we assume two versions of “run”, one which agrees with *plural* subjects and one which agrees with *first-person singular* subjects? If not, how do we model *first-person singular* agreement? One common approach makes a distinction between *third-person singular* and *non-third-person singular*. The “s” on the verb agrees with *third-person singular* subjects whereas the lack of an “s” agrees with *non-third-person singular* subjects. In this approach, nominals are marked for person and number and *non-third-person singular* can be further subtyped to include: *first-person singular*, *first-person plural*, *second-person plural*, and *third-person plural* (a rather unusual collection of subtypes).

Person	Number	
	singular	plural
non-third (first)	I sit	we sit
non-third (second)		you sit
third	he sits	they sit

A simpler approach only distinguishes *first-person*, leaving *second-person* and *third-person* unmarked. Note that there is a single first-person, subjective, singular pronoun “I”, whereas all common and proper nouns would need to be marked as third-person in the alternative approach. Under this approach verbs ending in “s” exhibit (*non-first-person*) *singular* agreement and unmarked verbs exhibit *first-person singular* or *plural* agreement.

Person	Number	
	singular	plural
first	I sit	we sit
non-first		you sit
non-first	he sits	they sit

This *first-person singular* approach works for the special case of present tense “be” as well, with one caveat. Consider

Person	Number	
	singular	plural
first	I am	we are
non-first		you are
non-first	he is	they are

The *first-person singular* agreement “I am” is special, otherwise present tense “be” agrees with either singular subjects via “is” (s-form) or plural subjects via “are” (plural agreement form). The caveat is the base form of “be” (i.e., “be”) is not the same as the plural agreement form (i.e., “are”) as it is for other verbs.

Unlike present tense verbs, past tense verbs (with the exception of past tense “be”) do not show agreement in English.

Person	Number	
	singular	plural
first	I sat	we sat
non-first		you sat
non-first	he sat	they sat

There is simply no grammatical basis for assuming subject-verb agreement with past tense verbs other than “be”. On the other hand, the case of past tense “be” is special and interesting

Person	Number	
	singular	plural
first	I was	we were
non-first		you were
non-first	he was	they were

Under the assumption that subject-verb agreement is only marked for *singular* or *plural* agreement (with the *first-person singular* exception for present tense verbs), the past tense of “be” turns out to be entirely regular!

Having eliminated the person feature (except for the special case of the first-person subjective singular pronoun “I”), we should revisit the claim that a nominal requires the features definiteness, person, and number, as a minimum, to be grammatical. If nominals need only be marked for definiteness and number to be grammatical, then what of the determiners “the” and “a”. “The” is *definite*, but is not marked for number and can’t occur alone as a nominal. “A” is *indefinite* and *singular*—so why can’t the determiner “a” occur alone? Perhaps because the quantifier “one” provides this capability, blocking the use of “a” for this purpose (see Pinker, 2000, for a discussion of blocking in the case of regular past-tense verb forms when an irregular past-tense form exists). Or it may simply be the case that the use of “the” and “a” alone has not been grammatically conventionalized in English as it has in other languages (e.g., Spanish “la que yo quiero” – “the (one) I love”).

The best evidence that pronouns are marked for the grammatical feature person is not provided by subject-verb agreement. Rather, it has to do with the binding of reflexive pronouns (cf. Radford, 1997). It appears that person agreement is required to handle examples like:

5. I like myself
6. You like yourself; You like yourselves
7. He likes himself

However, establishing the compatibility of the reflexive pronoun with its antecedent may make use of a default mechanism in the case of *third-person* agreement. For example, in “they like themselves” it could be that *third-person* marking on “they” and “themselves”—along with plural marking—could determine the agreement of “they” with “themselves”. However, in “the men like themselves”, “the woman likes herself” and “John likes himself”, in order to use person marking to determine the correct reflexive pronoun, all common and proper nouns would have to be marked as *third-person*. A simpler alternative is to assume special handling of *first* and *second-person* pronoun agreement with corresponding reflexives, combined with a default, unmarked person agreement for *third-person* pronouns, nouns and proper nouns with the

corresponding reflexive pronoun. Second-person agreement is special in any case in that subject-verb agreement is plural (e.g., “You like...”), whereas, reflexive agreement depends on the notional number of the referent (i.e., “yourself” vs. “yourselves”).

The Genitive “Case”

In English, there are a small number of pronominal function words which are marked for the genitive grammatical feature (often called genitive case) (e.g., “my”, “your”, “her”, “mine”, “yours”, “hers”) combined with a general capability to indicate the genitive grammatical feature of full nominals by attaching “s” to the head of the nominal (e.g., “the man’s book”). The reason “case” is quoted in the heading above is that the genitive marker is a nominal internal marker which establishes a referential relationship between two nominals—the genitive marked nominal which is called a reference point (Taylor, 2000), and an encompassing nominal. On the other hand, subjective and objective case marking marks a non-referential relationship between a nominal and the head of the encompassing clause. These are very different grammatical functions and subsuming them under the label “case” seems inappropriate. The primary grammatical evidence for treating the genitive as being like subject and object case marked pronouns is the existence of distinct subject, object and genitive pronominal forms as in “he, him, his” and “she, her, hers”. However, there are really two genitive forms, one that functions as a nominal specifier and is in complementary distribution with determiners (e.g. “my” in “my book”, “their” in “their house”), and one that has a more complex function and is in complementary distribution with non-genitive pronouns (e.g. “mine” as in “it is mine” vs. “it is him”, “theirs” as in “theirs is nice” vs. “he is nice”). In neither of these functions is the genitive nominal like a subject or object pronoun in that the genitive nominal provides a reference point for determining the referent of the overall nominal, but is not the head of the overall nominal as is the case for subject and object pronouns. A nominal like “mine” in “mine is nice” is a complex referring expression that indicates two objects, the referent of “me”—the reference point—and the referent that is (abstractly) possessed by “me”—the referent of the overall expression. This referent is identified with respect to the reference point without the possibility of a head occurring in the case of “mine” (e.g. “*mine book” vs. “my book”). Despite the complex nature of words like “mine” and “my”, we will refer to them as possessive pronouns and possessive determiners, respectively (following Biber, Conrad & Leech, 2002).

The primary grammatical function of the genitive grammatical feature is to allow pronouns like “me” from which “my” is derived (e.g., “my” in “my book”) and full nominals (e.g., “the man” in “the man’s book”) to function as specifiers within larger nominals. In this function, they provide an internal reference point for identifying the actual referent of the nominal. The genitive nominal functioning as a specifier projects the definiteness feature *definite* to the encompassing nominal, but does not project any other features (the typical behavior of specifiers). English also allows genitives to function as independent nominals. In this pronominal function, possessive pronouns are typically marked by the addition of “s” to the possessive determiner as in “hers”, “theirs”, etc., providing a grammatical distinction from possessive determiners. There is no grammatical distinction in the case of possessive nominals (e.g., “John’s book is red” vs. “John’s is red”). Note, that in this pronominal function, the value of the number feature of

the encompassing nominal depends on the actual referent (e.g., “hers **is** nice” vs. “hers **are** nice”) and not the possessive pronoun or nominal, which only determines the number feature of the internal reference point.

As noted above, the genitive marker establishes a referential relationship between two nominals. Possessive determiners, pronouns and nominals are unique in projecting grammatical features both internally to the reference point they encode and externally to the higher level nominal they project. For example, in the nominal “my book”, the possessive determiner “my” projects the grammatical features of “me” (less case) to the internal reference point that functions as the specifier and the grammatical feature *definite* to the higher level nominal that is headed by “book”.

For pronouns and nominals which are not marked as genitive, how should they be handled? Positing a grammatical feature like *non-genitive* so all pronouns and nominals could carry a genitive marker would be highly inefficient and counter-intuitive. We will simply assume that non-genitives are unmarked for this grammatical feature.

Grammatical Function Revisited

It is well known that the words “that” and “these” can function as full nominals (e.g., “give me *that*” or “*these* are nice”), and when they do, they are often called demonstrative pronouns, whereas when they occur with a nominal head as in “*that* man” or “*these* books” they are sometimes called demonstrative determiners (cf. Biber, Conrad & Leech, 2002). Regardless of part of speech categorization, one can ask—when “that” and “these” function alone in a nominal, are they functioning as a specifier, a head, or both (i.e. fused heads as in Huddleston & Pullum, 2002)? If they are functioning as a specifier, then the nominal is headless. In a formulation in which specifiers as well as heads can project nominals, either is possible (fused heads will not be discussed further). Whether the demonstrative word is functioning as a specifier or head, the endocentric claim that the head of a phrase projects the category of the phrase is brought into question. Do we really want to insist that words like “that” and “these” are subtypes of noun in order for our endocentric assumption to hold (van Eynde, 2006, suggests that we do)? Further, given examples like “the red is nice” where there appears to be no head in the nominal “the red”, and expressions like “what did he eat” where “what” constitutes a nominal, do we really want to insist that nominals must be headed, and headed by nouns? Further, if nominals like “the red” are grammatical, must we relax the claim that grammatical nominals encode the features definiteness and number, as a minimum? An alternative is to assume a construal process (cf. Langacker, 2000) that adds the needed features in the right context (often based on the referent of the expression). In the absence of a noun head, the expression “the red” can be construed as being *singular* despite the absence of a noun that encodes this feature. Such construals have been posited in what is called the “universal grinder” (Pelletier, 1975) as in

8. Her house is 5000 sq. ft. That’s a lot of *house*!

wherein a count noun like “house” is construed as a mass noun that projects the definiteness feature *indefinite* as well as the number feature *singular*. Needless to say, construal processes complicate notions of grammaticality and projection of grammatical

features from lexical items in interesting ways that are difficult to formalize. However, an approach of assuming that there are multiple lexical entries for words like “house” that encode *singular* count noun vs. *mass* noun features flies in the face of usage based notions. Since “house” is almost never used in universal grinder expressions, it is unlikely to be encoded in the mental lexicon as such and universal grinder construal processes presumably operate over *singular* count nouns overriding their *count* feature and adding a *mass* feature and correlated *indefinite* feature.

Such overriding processes are rampant in morphology. The word “house” is *singular*, but the word “houses” is *plural*. The plural morpheme “s” projects the definiteness feature *indefinite* and overrides the *singular* number feature of the base count noun with which it combines. This is particularly obvious in the use of “ones” as in “give me the red ones”. Whereas it may be the case that “houses” occurs frequently enough to be stored in the mental lexicon with the indefinite and plural features, this cannot be the case in general for count nouns. The claim of this paper is that overriding processes are also rampant at the level of phrasal processing. Consider

9. The ball bearings
10. The rice grains

In an incremental language processor, at the processing of the word “ball”, “ball” will be integrated as the head of the nominal projected by “the” and the number feature *singular* will be projected to the nominal. But when “bearings” is subsequently processed, “bearings” will be made the head of the nominal—shifting “ball” into a modifier function—and the number feature will be overridden with the value *plural*. Based on such evidence, it is claimed that **a serial, incremental processor is necessarily non-monotonic**. It is only by ignoring the essentially incremental nature of the human language processor that non-monotonic constraint-based theories can handle such examples.

Besides convincing arguments for the existence of headless nominals like “the red” in “the red is nice”, arguments that nominals can have non-noun heads are also quite common and quite convincing. Dixon (1991) argues that words like “kick” in “he gave it a kick” are verbs that head noun phrases. Pullum (1991) argues that in expressions like “our going to the movies was fun”, “going to the movies” functions as a VP head of the NP “our going to the movies”. The syntactic category NP or noun phrase seems inappropriate to describe such expressions and it is for this reason that the more neutral term “nominal” is used in this paper (although this use of “nominal” unfortunately conflicts with the use in Huddleston & Pullum, 2002). But if verbs like “kick” do not designate grammatical features like number, how can nominals with verb heads be grammatical? There must be some capability to construe the head of a nominal as projecting this feature even when the head is not a noun. When the head of a nominal is a verb or verb phrase, the verb or verb phrase is construed objectively and may project the feature *singular*. However, in “he gave it some kicks”, the plural marking on “kicks” may override the *singular* feature and project the *plural* feature instead. Note that we are not saying that “kicks” is a noun in this context. Of course, if “kick” or “kicks” occurs

frequently enough as the head of a nominal, the words may come to be encoded as nouns in the mental lexicon. In this case, the action of kicking is construed objectively and the words are encoded in the mental lexicon as such, along with the relevant grammatical features. But this cannot be true in general for verbs.

In the version of HSPG described in Sag & Wasow (1999), specifiers combine with phrasal heads to form higher level units like NP and S. However, treating “man” in “the man” as a phrasal head goes against the grammatical evidence since “man” is a word not a phrase. It is not the fact that the specifier combines with a phrasal head that leads to a maximal projection, it is the fact that the specifier combines with a head, phrasal or not, that leads to a maximal projection. (In Sag, Wasow & Bender (2003), the distinction between words and phrases is relaxed such that “man” can be viewed as both a word and a phrase.) Given the functional category head, there is no need to posit an intermediate level of nominal structure as occurs in most variants of X-Bar Theory (cf. Chomsky, 1970, 1995). A lexical head combines with a modifier to form a phrasal head. The lexical and phrasal head have the same grammatical status. Both can combine with a modifier to form a phrasal head and both can combine with a specifier to form a maximal projection. But what is a maximal projection? A maximal projection is simply an expression which has all the grammatical features needed to support its use as a referring expression—at a minimum, definiteness and number in the case of nominals. For nominals, that typically means having a specifier that indicates definiteness and a head that indicates number. But some nominal heads also indicate definiteness and can occur without a specifier—including personal pronouns and proper nouns, plural count nouns, mass nouns and demonstrative pronouns (if they are heads). Further, via construal processes it is also possible for headless nominals to function as referring expressions (e.g., “*the red* is nice”) and for heads to acquire grammatical features needed to support their use as referring expressions (e.g., “I like *goat*”).

There are also limits on the stacking of words which project a definiteness feature. The marking feature of van Eynde (2006) and HPSG, more generally, is an attempt to constrain such stacking. For example, van Eynde (ibid.) treats “the” as being marked and determinate (i.e., *definite*), whereas “books” is unmarked and *indefinite*. In van Eynde’s terms, additional prenominals can precede an unmarked nominal, whereas this is precluded for marked nominals. For example, “books” can occur alone as a nominal, but “the books” is also possible. On the other hand, “two the books” is precluded. However, “all the books” is allowed. There does appear to be a partial ordering of definiteness along the following lines: *universal* > *definite* > *indefinite* (introduction of the *universal* feature comes from van Eynde, 2006). Note that there is no claim that this partial ordering is universal across languages or inviolable even in English—there may be (marked) exceptions to the partial ordering. An *indefinite* nominal (e.g., “books”) can be preceded by a word that promotes it to *definite* (e.g., “the books”), and a *definite* nominal can be preceded by a word that promotes it to *universal* (e.g., “all the books”). On the other hand, since “two” is *indefinite* and “the” is *definite*, “two the books” is precluded, whereas “the two books” is allowed. Further, since “all” is *universal* and “the” is *definite*, “the all books” is precluded. The extent to which this partial ordering holds, and whether nominals containing multiple instances of words which project *universal* and/or *definite*

grammatical features can be grammatical, will not be explored in any depth in this paper. The occurrence of expressions like “the two books” strongly suggests that nominals with multiple words projecting an *indefinite* feature are allowed (e.g., “two” and “books”). And expressions like “She’s Betty Davis, but not **the** Betty Davis” suggest the possibility of multiple words that are *definite* (e.g., “the” and “Betty Davis”). Left unexplained by the partial ordering is why an expression containing the indefinite determiner “a” cannot be preceded by a definite or universal determiner as in “the a book” or “all a book”. Van Eynde (2006) captures this constraint by treating “a” as marked and indefinite. However, the marking approach leaves unexplained how pre-determiners like “all” can occur with marked expressions like “the books” as in “all the books”. Van Eynde (p.c.) suggests that pre-determiners (uniquely) combine with marked expressions. But at the processing of “all” which is ambiguous between a pre-determiner (e.g., “all the books”), a determiner (e.g., “all books”) or a pronoun (e.g., “all are here”), one doesn’t know if a marked determiner will follow. Treating “all” as a quantifier which can function as a pre-specifier (or modifier of a specifier), specifier or head, depending on context, is an alternative which is supported by the incremental nature of language processing.

Adjectives

Up to this point, adjectives functioning as modifiers in nominals (i.e., attributive adjectives) have only been used to motivate the existence of headless nominals as in “the *red* is nice”. Little has been said about whether or not they project any grammatical features. They appear not to—at least not any of the grammatical features that have been discussed up to this point. For example, in “the big book”, the adjective “big” functions as a modifier, but doesn’t project any grammatical features. Although not the topic of this paper, the same appears to be true of adjectives used predicatively as in “the book is *big*”. In this case, the auxiliary verb “is” projects the grammatical features normally associated with clausal predicates and is typically assumed to be the head, although Ball (2007a) treats the predicate adjective as the clausal head and the auxiliary verb as a clausal specifier. Since adjectives do not project grammatical features like definiteness, number and tense, they do not typically occur alone as well formed grammatical units—with a few exceptions where the bare adjective is licensed by an encompassing construction as in “the book made me *sad*”.

Adjectives are, however, associated with a grammatical feature not yet discussed—what we will call *degree*—which is marked for the comparative and superlative forms as in “big”, “bigger” and “biggest”. A key question is whether or not this grammatical feature is projected to the encompassing nominal. In an expression like “the bigger one is on the table” is the comparative feature projected to the nominal? On localist assumptions, if there is a grammatical effect at the level of the nominal which relies on this feature then it should be projected. We assume that there are such grammatical effects and that the degree feature should be projected to the nominal.

The superlative form is particularly interesting in that it frequently occurs in nominals without a noun head as in “Give me the *biggest*”. There is a clear sense in which “the biggest” identifies a specific object and we might be tempted to associate the grammatical feature *definite* with “biggest”. However, in English, the superlative form

normally requires the definite determiner “the”. To the extent that superlatives encode a *definite* feature, this feature is redundant with the definite determiner which is the primary indicator of definiteness. More problematic is whether or not the superlative projects the number feature *singular*. Assuming that the definite determiner does not project this feature and that the nominal acquires a *singular* number feature, the superlative is the obvious candidate to provide this feature. But consider the following

11. The biggest books are on the bottom shelf
12. The biggest are on the bottom shelf

If “biggest” projects the *singular* feature, then this feature is overridden by “books” in 10, and in 11 there appears to be notional agreement between the referent of “the biggest” and the auxiliary verb “are”—similar to the treatment of possessive pronouns like “hers” discussed earlier. Notional agreement also appears to apply in expressions like “the red is nice” vs. “the red are nice” (which sound OK to me). Note the implication that the referent of an expression—which is typically assumed to be pragmatic information—may determine subject-verb agreement when the subject nominal does not grammatically encode a number feature! Overall, the grammatical evidence for a *singular* number feature for superlatives is inconclusive and we will assume that they do not project a number feature.

Verb Participles

The topic of verb participles functioning as modifiers and heads in nominals is especially challenging. Consider

13. The (rapidly) running bull
14. The (rapid) running of the bull

I think it is a mistake to say that because “running” functions as the head of the nominal in 14, it is a noun. Likewise, it is a mistake to say because “running” functions as a modifier in 13, it is an adjective. It is important to distinguish the function of a word in any particular expression from the part of speech of the word which I take to be based on the overall history of use of the word—along with grammatically conventionalized semantic motivation. Arguments for this position are put forward in Ball (2007a). However, in terms of projecting grammatical features, if “running” is a progressive participle in 13 and 14, then it follows that “running” does not project grammatical features like number which are associated with nouns. In this case, some general mechanism for projecting *singular* number to nominals which reify events is needed—although this mechanism can be overridden when the event is pluralized as in

15. The runnings of the bulls

Again, just because “runnings” is pluralized in 15, does not necessitate treatment of “runnings” as a noun. Part of speech is not determined purely based on distributional evidence, and not even a combination of distributional and morphological evidence. In 15, the morphological evidence conflicts: “-ing” provides a strong indication of the progressive participle, and “-s” provides morphological evidence of a noun. However, we

do not want all progressive participles to be triply encoded as nouns and adjectives in the mental lexicon, just because they can function as modifiers and heads in nominals. Doing so would significantly increase the amount of ambiguity in the mental lexicon—causing more problems than it would solve. On the other hand, we do want to allow heads of nominals to be pluralized, even when they are not nouns as in “the *hold outs* are being counted” or “he knows the *ins* and *outs* of baseball”, which suggests that pluralization may not be a purely morphological process. If distributional evidence were the only or primary determinant of POS, then all nouns would need to be doubly encoded as adjectives (or the categories noun and adjective could be collapsed) since nouns, like adjectives, can function as pre-head modifiers as in “the *altitude* restriction”—i.e., nouns have a similar distribution to adjectives in nominals. For additional arguments against the use of purely distributional evidence for determining POS, see Croft (2001, p.29ff).

Wh-words

Wh-words are unique in that they are really complex part of speech categories. In addition to being wh-words, they are also categorizable in terms of their correspondence to other part of speech categories. For example, the wh-words “who” and “whom” are also pronouns as suggested by their ability to occur alone as nominals (e.g., “Who is it?” and “To whom did he send a letter?”), along with the explicit case marking on “whom”—where case marking is limited to a small class of pronouns. The wh-word “what” is also a demonstrative pronoun since it can occur alone as a nominal (e.g., “What did he do?”) or with a head noun (e.g., “What book did he read?”). Expressions like “What stays and what goes?” suggest that “what” encodes a singular number feature even though it can occur with both a singular or plural noun (e.g., “What book did he read?” vs. “What books did he read”). When “what” occurs with a noun head, the number feature of the noun overrides the number feature of “what”. Note that other demonstrative pronouns do not allow overriding since they come in distinct singular and plural forms (e.g., “this” vs. “these”). Further, unlike other demonstrative pronouns, “what” does not provide an indication of distance (compare to the demonstrative pronouns “this” and “that”). Since it is not marked for number or distance, it behaves more like a determiner in this respect. But determiners like “the” and “no” cannot occur alone as nominals. The wh-word “whose” is very special. In addition to being a wh-word, it is also a possessive determiner. Since the category possessive determiner is itself a complex POS category that combines the categories possessive and determiner, “whose” combines three distinct POS categories: wh-word, possessive, and determiner.

The other wh-words—where, when, why and how—are not typical elements of nominals, and are not discussed in this paper. However, it should be noted that “how much” and “how many” behave like nominals in encoding a number feature.

Processing Considerations

There is extensive psycholinguistic evidence that human language processing is essentially incremental and interactive (Gibson & Pearlmutter, 1998; Altmann, 1998; Tanenhaus et al., 1995; Trueswell, Tanenhaus & Garnsey, 1994; Ball, 1992; Altmann & Steedman, 1988). Further, garden-path effects, although infrequent, strongly suggest that

processing is essentially serial at the level of phrasal and clausal analysis (Bever, 1970)—although lower level processes of word recognition suggest parallel, activation-based processing mechanisms (McClelland & Rumelhart, 1981; Paap et al., 1982). At the level of phrasal and clausal analysis, humans appear to deterministically pursue a single analysis which is only occasionally disrupted, requiring reanalysis. One of the great challenges of psycholinguistic research is to explain how humans can process language effortlessly and accurately given the complexity and ambiguity that is attested (Crocker, 2005). As Boden (2006, p. 407) notes, deterministic processing “would explain the introspective ease and speed of speech understanding”, but a purely deterministic, incremental processing mechanism would more frequently make incorrect local choices requiring reanalysis than is evident in human language processing. Marcus (1980) proposed a lookahead mechanism to improve the performance of a deterministic, yet monotonic, processor, bringing it into closer alignment with human performance. However, there is little evidence that humans make use of lookahead (cf. Kim, Srinivas & Trueswell, 2002). Later in this paper, a limited form of lookahead based on the perceptual span for visual input which can exceed the space delimited word in the fovea, providing parafoveal information to the right of the foveated word, will be discussed.

To capture the essentially incremental nature of human language processing, we propose a serial, pseudo-deterministic processor that builds linguistic representations by integrating compatible elements, relying on a non-monotonic mechanism of context accommodation to handle cases where some incompatibility that complicates integration manifests itself. Context accommodation makes use of the full context to make modest adjustments to the evolving representation or to construe the current input in a way that allows for its integration into the representation. Context accommodation need not be computationally expensive (i.e., a single production may effect the accommodation, just as a single production may effect integration without accommodation). In this respect, context accommodation is not a reanalysis mechanism that disrupts normal processing; rather, it is part and parcel of normal processing. Reanalysis mechanisms need only kick in when context accommodation fails and larger adjustment is needed. Further, as will be shown below, context accommodation can give the appearance of parallel processing in a serial processing mechanism, blurring the distinction between serial and parallel processing.

The mechanism of context accommodation is most closely related to the limited repair parsing of Lewis (1998). Lewis describes limited repair parsing as a form of reanalysis and contrasts it with reanalysis by backtracking, reanalysis by selection from parallel alternatives, and reanalysis by refining commitments (i.e., underspecification). Lewis’s use of the term reanalysis to describe these different mechanisms is quite liberal. In this paper, we will limit use of the term reanalysis to reanalysis by backtracking. However, we accept Lewis’s arguments against the other mechanisms and in favor of repair mechanisms. Context accommodation may be viewed as a very modest form of repair, but since context accommodation need not take any more time than normal processing, the use of the term repair is somewhat inappropriate.

To capture the essentially interactive nature of human language processing, we propose a probabilistic, context-sensitive mechanism for activating alternatives in parallel and selecting the most highly activated alternative. This parallel, probabilistic mechanism selects between competing alternatives, but does not build any structure—building structure is the function of the incremental integration mechanism. At each choice point, the parallel, probabilistic mechanism uses all available information to activate and select the preferred alternative, and the serial, pseudo-deterministic mechanism integrates the preferred alternative into the evolving representation. Use of the full local context supports selection of alternatives that are likely to be correct, allowing the serial integration mechanism to be largely deterministic. However, the local context is not always consistent with the global context and locally preferred choices sometimes turn out to be globally dispreferred. The mechanism of context accommodation allows the processor to adjust the evolving representation to accommodate the subsequent context, without lookahead, backtracking or reanalysis. Only when the context accommodation mechanism breaks down do more disruptive reanalysis processes become necessary. The use of the term *pseudo-deterministic* reflects the integration of parallel, probabilistic activation and selection mechanisms and context accommodation with what is otherwise a serial, deterministic processor.

The primary alternatives to this approach are constraint-based approaches which rely on some kind of settling out mechanism to make choices rather than having an explicit selection mechanism. This settling out mechanism may be based on inhibition between competing alternatives (cf. Vosse & Kempen, 2000) which may or may not result in a single choice at each choice point; by unification of linguistic structures such that the result is a selection of compatible linguistic structures—such structures might be feature structures as in HPSG (cf. Sag, Wasow & Bender, 2003) or trees as in Tree Adjoining Grammar (Joshi, 1988); or by probabilistic computation of alternatives which allows for the possibility of ranking and bounding alternatives without requiring selection of a single alternative—at least not until the end of the input is determined (Kim, Srinivas & Trueswell, 2002). It may be difficult to provide empirical evidence which can decide between parallel, constraint-based approaches and a serial approach which allows for non-monotonic adjustment of the evolving representation. For example, probabilistic reranking of alternatives—which is essentially non-monotonic—is computationally similar to context accommodation. Both are presumably less disruptive than reanalysis. On the other hand, an inhibition or unification-based approach which leads to a single choice at each choice point, would still require some mechanism capable of making minor adjustments without reanalysis. Constraint-based approaches often overlook the implications of having to build multiple structures at each choice point—it is not unusual for such approaches to focus on a particular choice point of interest (e.g., the noun phrase following an NP vs. clause bias verb) and simply ignore the existence of other choice points. If multiple structures must be built and carried forward at each choice point, the computational system will slow down with the length of the input as more and more structures are built and carried forward, but humans do not exhibit this behavior. It follows that the number of structures built at each choice point must be highly constrained, and the building of structures extremely limited. Kim, Srinivas & Trueswell (2002) avoid the building of structure by incorporating pre-compiled trees into their

constraint-based system. Instead of building up structures from lexical items, lexical items are associated with a collection of pre-compiled trees and the constraint-based mechanism need only determine which pre-compiled tree is appropriate for each lexical item in a given context. Kim, Srinivas & Trueswell (2002) call the process of determining the pre-compiled tree for each lexical item “supertagging”, in comparison to part of speech taggers which label words with part of speech tags, but don’t build any structure. The selected trees must still be integrated, but in the simplest case, there is a single point of integration for each pair of trees. From a localist perspective, the pre-compiled trees provide an extended notion of locality (Joshi, 2004).

At the processing of each word in a linguistic input, humans typically succeed in determining the correct grammatical function of the word, and also succeed in integrating the word into the evolving linguistic representation. The likely way this is accomplished is by using all available information—be it lexical, syntactic, semantic or pragmatic—to make the correct grammatical choice. This implies a highly context sensitive, parallel determination of the grammatical function of the current word (consistent with constraint-based theories), followed by the serial and deterministic integration into (or projection of) the evolving representation (an aspect of processing ignored—or at least de-emphasized—by most constraint-based theories). At each choice point (typically at the processing of a word), all information is considered in parallel in making the best choice, but once a choice is made, processing proceeds serially and deterministically forward until the next choice point.

In the processing of nominals, this means that the processing of each word leads to determination of the appropriate phrase internal grammatical function of the word, projection of a higher level phrasal unit or integration of the grammatical function into an existing higher level phrasal unit, and projection of grammatical features from the grammatical function to the higher level unit. For example, in the processing of “the man”, the processing of the word “the” leads to determination of its grammatical function as a specifier, projection of a nominal construction, and projection of the grammatical feature *definite* to the nominal construction. The subsequent processing of “man” leads to determination of its grammatical function as a head, integration of the head into the nominal construction projected by “the” and projection of the grammatical features *singular* (number), *human* (animacy) and *male* (gender) to the nominal construction. It is important to note that the determiner “the” projects a nominal construction in this example. Not only do determiners project grammatical features, but they project nominal constructions and determine the category of the construction (functioning like a head in this respect). On the other hand, in the absence of a determiner (and projected nominal) a *plural* or *mass* noun can also project a nominal construction. For example, in “rice is good for you”, the mass noun “rice” projects a head which in turns projects a nominal construction (in the absence of a nominal construction projected by a determiner), and projects the grammatical features *indefinite* (definiteness), *singular* (number), and *inanimate* (animacy) to the nominal.

When the projection of grammatical features results in a conflict, blocking or overriding mechanisms—specific instances of context accommodation—come into play. The

blocking and overriding mechanisms occur within the current context, making full use of the context to determine the appropriate projection of grammatical features.

Determination of the grammatical function of a word has important representational and processing implications. For example, in the processing of “that” in “that man”, if “that” functions as a specifier and projects a nominal, then when “man” is processed, “man” can simply be integrated as the head of the nominal. In this case, “that” behaves like a typical determiner. However, if “that” functions as the head—behaving instead like a typical pronoun, then when “man” is processed, “man” must be accommodated by shifting “that” into the specifier function to allow “man” to function as the head. Whether or not “that” is encoded in the mental lexicon as a determiner, a pronoun (including relative pronoun), or both, is likely to depend on the history of use of the word. Regardless of which form is retrieved, the language processor must be capable of accommodating the alternative use. Given that the function of “that” cannot be fully determined until the subsequent input is processed (assuming an incremental processor without lookahead), retrieval mechanisms are likely to retrieve the most frequent form (unless the prior context is somehow able to bias retrieval of the alternative form). This basic fact is often overlooked in grammatical treatments which ignore processing considerations. Thus, it is often suggested that “that” in “that man” is a (demonstrative) determiner, whereas, “that” in “that is nice” is a (demonstrative) pronoun. For this to be the case, determining the part of speech of “that” would need to be delayed until after the subsequent input is processed, or ignoring processing, given the syntactic context surrounding “that”. Based on related analyses, at least one researcher (Borer, 2003) has suggested that words are encoded in the mental lexicon without part of speech information. We reject this suggestion which goes against the basic lexicalist/constructionist framework which motivates this research (cf. Ball, 2007a, b). It is not linguistic structure which determines the basic grammatical category and features of words, top-down (except in exceptional cases like nonce expressions and unknown words), it is words which determine basic linguistic structure, bottom-up, based on their grammatical category and features. Lacking lexically specified grammatical (including morphological) information, language processing would soon break down. Even in the case of the well-known poem “The Jabberwocky” (e.g., “’Twas brillig and the slithy toves did gyre and gimble in the wabe...”) (Carroll, 1872) the function words and morphological endings on the nonce words, along with associations between the nonce words and real words (e.g. “brillig” → “bright”), provide sufficient cues to support some level of comprehension.

Like demonstrative pronouns/determiners, a similar mechanism is needed in the incremental processing of noun-noun combinations. For example, in the processing of “the altitude restriction”, when “altitude” is processed it can be integrated as the head of the nominal projected by “the”, but when “restriction” is subsequently processed, “altitude” must be shifted into a modifier function to allow “restriction” to function as the head. Most grammatical treatments refrain from calling nouns like “altitude” adjectives when they function as modifiers in expressions like “the altitude restriction”. However, if “altitude” is not encoded as a noun in the mental lexicon, then it might very well be categorized as an adjective based purely on the syntactic context.

The need for non-monotonic mechanisms like overriding and function shifting is not widely accepted. From a psycholinguistic perspective, Lewis (1998) provides a strong defense of non-monotonic processing without backtracking in his exposition of limited repair parsing. According to Lewis (1998, p. 262) “The putative theoretical advantage of repair parsers depends in large part on finding simple candidate repair operations”. The mechanisms of context accommodation proposed in this paper provide support for this theoretical advantage. From a linguistic perspective, Sag (2009) argues that a monotonic constraint-based approach to grammatical feature projection is to be preferred over non-monotonic mechanisms like overriding in his description of Sign Based Construction Grammar (SBCG)—a variant of HPSG. Purver, Cann & Kempson (2006) put forward a description of Dynamic Syntax which they claim captures the incremental, serial and context-dependent nature of language processing without abandoning monotonicity.

It is a basic claim of this paper that **an incremental, serial, pseudo-deterministic language processing mechanism—which I take the human language processor to be—is necessarily non-monotonic**. Given the incremental nature of the human language processor, it is not possible to always make the globally correct choice at each choice point based on local information. In particular, the non-availability of the right context makes local choices subject to revision. The simple example “the altitude restriction” is intended to make this point. The more complex example “pressure value adjustment screw fastener part number” suggests that carrying forward in parallel the possibility of a noun functioning as either a head or a modifier at each choice point is just not feasible. There are 2^7 possibilities in this nominal. At a minimum, the occurrence of a subsequent noun must disambiguate the function of the preceding noun. But what if the subsequent noun can also be a verb (e.g., “screw”, “part” and “number”), or an adjective, or the POS isn’t even determined? These mundane examples differ from the disruptive garden-path examples which are typically used in psycholinguistic studies of reanalysis (e.g., the famous “the horse raced past the barn fell” from Bever, 1970). Context accommodation is not capable of handling such disruptive inputs, but it is capable of handling the more mundane examples.

As noted above, non-monotonic processes like overriding are often criticized by proponents of constraint-based theories like HPSG (cf. Sag, 2009) and monotonic approaches are often touted as superior to non-monotonic approaches (cf. Dynamic Syntax as described in Purver, Cann & Kempson, 2006). But such theories are missing a key point—incremental processors do not have the full input that is needed for a constraint-based model to be able to monotonically settle in on the appropriate global representation. Local choices must be made that may later turn out to be globally incorrect. There is simply no viable alternative to non-monotonic adjustment of the evolving representation—although there may be alternative mechanisms which can reduce the amount of non-monotonicity. The alternative of having a non-deterministic processing mechanism with some form of backtracking is inadequate on several grounds: 1) it’s computationally explosive, 2) it typically assumes retraction of structure, and 3) it requires knowing when you’ve reached a dead end and need to backtrack. The alternative of full parallelism is also computationally explosive—there is just too much ambiguity to be able to carry forward all possible alternatives and it is clear that humans are not doing

so (Ball, in preparation, provides a more detailed discussion). Some form of ranked and bounded parallelism is often put forward as a viable alternative. But any amount of parallelism will of necessity be isolated and temporary. In this respect it is important to note that non-monotonic processes give the appearance of parallelism in a serial processing mechanism. In adjusting an evolving representation, it appears that the resulting alternative was carried along in parallel. For example, in “the airspeed restriction” when the processing of “restriction” causes “airspeed” to be shifted into a modifier function, it appears that the treatment of “airspeed” as a modifier was carried along in parallel with the treatment of “airspeed” as the head. Serial, non-monotonic processing gives the appearance of parallelism without the computational expense of carrying forward multiple representations. Finally, mechanisms of lookahead, delay and underspecification can only go some way towards supporting monotonic processing. If used extensively, they create more processing problems than they resolve.

In an early and influential deterministic parser, Marcus (1980) relied on a lookahead mechanism to allow the right context to influence local parsing decisions in order to maintain monotonicity. Unfortunately, there are two basic problems with lookahead mechanisms: 1) the processor can't predict how far it needs to look ahead to make a correct choice (e.g., how much lookahead is needed to find the head of the nominal “pressure value adjustment screw fastener part number”, and 2) lookahead mechanisms are inconsistent with psycholinguistic evidence on human language processing (cf. Kim, Srinivas, & Trueswell, 2002).

Besides the mechanism of lookahead, alternative mechanisms of delay and underspecification have also often been proposed to support incremental, yet monotonic processing. For example, Purver, Cann & Kempson's description of a Dynamic Syntax based parser (2006) relies on underspecification to delay decisions until the needed context is available. However, mechanisms of delay and underspecification suffer from problems similar to lookahead. In the case of delay, it is undetermined how long a delay is sufficient. In the case of both delay and underspecification, the failure to determine the grammatical function of an expression degrades the context for making subsequent decisions. Delaying determination of structure or underspecification, if used extensively, is a non-solution. Without that determination, subsequent ambiguity cannot effectively be resolved and the result is an explosion of different possible structures. Further, as Lewis (1998) notes, delay and underspecification (or minimal commitment) is inconsistent with the incremental and immediate determination of meaning which is characteristic of human language processing. Even in the case of prepositional phrase attachment—the poster child for underspecification—there is good evidence that humans make immediate attachment decisions when sufficient context is available (cf. Novick, Thomson-Schill & Trueswell, 2008), although there is some evidence that attachment decisions are delayed when sufficient context is unavailable (Swets, et al., 2008). Overall, the evidence suggests that only a limited amount of delay and/or underspecification is viable, necessitating some form of non-monotonic processing.

Computational Implementation

The processing of nominals has been implemented as a subcomponent of a computational cognitive model of reading comprehension (Ball, Heiberg & Silber, 2007) developed using the ACT-R Cognitive Architecture (Anderson et al, 2004; Anderson, 2007). ACT-R combines a production system for modeling proceduralized behavior with a declarative memory (DM) system for modeling declarative knowledge. Declarative knowledge is encoded in the form of DM chunks (or frames) which are named and typed slot/value lists. DM chunks are organized into a single inheritance hierarchy. The production system, which can only execute a single production at a time, is the locus for incremental processing. The production system interacts with the DM system via productions which retrieve chunks from DM. These retrieval productions provide a retrieval specification (e.g. retrieve a word chunk) which combines with the parallel, spreading activation mechanism of DM to determine which chunk gets retrieved—the single most active chunk which is consistent with the retrieval specification is retrieved. The parallel, spreading activation mechanism of DM is the locus of interactive processing.

DM chunks which have been retrieved from memory, encoded from the environment and constructed during processing constitute the current context or short-term working memory (Ericsson & Kintsch, 1995). The slot values of these short-term working memory (ST-WM) chunks spread activation to matching chunks in DM, providing the context for further DM retrievals. The production system constructs a single representation given the sequence of DM chunks that are retrieved from DM. Declarative memory encodes chunks at varying levels of representation from letter, to trigram, to word, to multi-word unit, to phrase, to clause. These chunks capture explicit knowledge of language. The procedural system uses the DM chunks that are retrieved to build larger representations which may be stored in DM for subsequent use. The procedural system captures implicit knowledge of language.

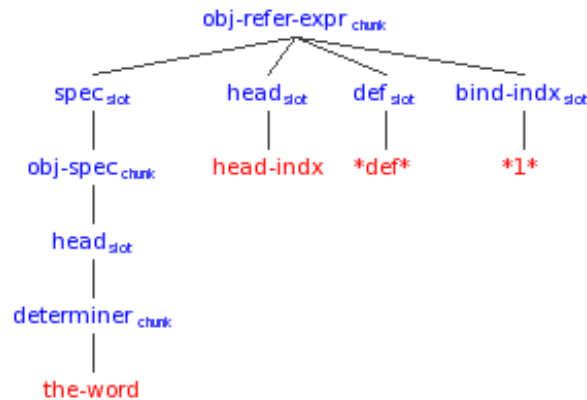
The word recognition subcomponent of the model uses ACT-R's spreading activation mechanism in conjunction with word retrieval productions to retrieve the word or multi-word unit which is most consistent with the perceptual input. Retrieval involves an interaction of the perceptual form of input with declarative knowledge (Freiman & Ball, 2008), allowing the model to recognize misspelled words, variations in word form, and multi-word expressions. Perceptual input is not pre-segmented into words, but arrives in the form of a perceptual span of letters, spaces and punctuation. The perceptual span extends beyond the space delimited word in the fovea, providing parafoveal information to the right of the foveated word. The perceptual information in the parafovea provides a limited form of lookahead to support the recognition of multi-word units, but this lookahead does not otherwise participate in processing (i.e. the parafoveal information is used in DM retrievals, but is not used by the serial integration mechanism).

The model contains a capability to display the representations that are generated from the linguistic input in a tree format (Heiberg, Harris & Ball, 2007). In the model, nominals are called object referring expressions (abbreviated obj-refer-expr). The use of the term

“object referring **expression**” indicates that the representations are linguistic, but not purely syntactic. The terminal nodes may contain words, but do not contain anything like abstract concepts or word senses. To more fully represent the meaning of the object referring expression, it must be mapped to a non-linguistic representation of the object to which it refers (within the context of a situation model). This mapping will not be discussed in this paper, but it is noted that the mapping is simplified by the nature of the linguistic representations as compared to typical syntactic representations.

The processing of the nominal “the man” is shown below:

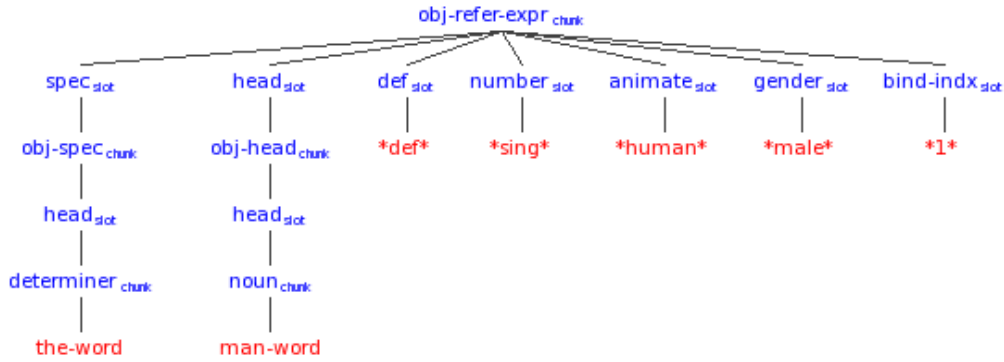
“the” →



The word “the” is identified as a determiner chunk via execution of a POS retrieval production. This determiner chunk is the lexical entry for “the” (grammatical feature slots associated with the determiner chunk are not displayed). Then a production which constructs an object specifier chunk (abbreviated “obj-spec”) executes and integrates the determiner chunk as the value of the head slot of the object specifier chunk. Next, a production which constructs an object referring expression chunk executes and integrates the object specifier chunk as the value of the specifier slot (abbreviated “spec”). The object referring expression chunk also has a head slot. The value “head-idx” indicates that this slot does not yet have a value. The object referring expression chunk also has a definiteness slot (abbreviated “def”) which has the value *definite* (abbreviated “*def*”). This value was projected from the lexical entry for “the”. Finally, the object referring expression has a “bind-idx” slot which contains the index *1*. This index supports the binding of traces and anaphors in more complex linguistic expressions. It should be noted that the tree representations are simplified in various respects. In particular, the grammatical feature slots of the individual lexical items are not displayed. Further, only some slots without values are displayed. For example, the head slot is displayed even if it doesn’t have a value, but grammatical feature slots and modifier slots (pre and post-head) without values are not displayed.

Henceforth processing descriptions will abstract away from references to production execution, chunks and slots.

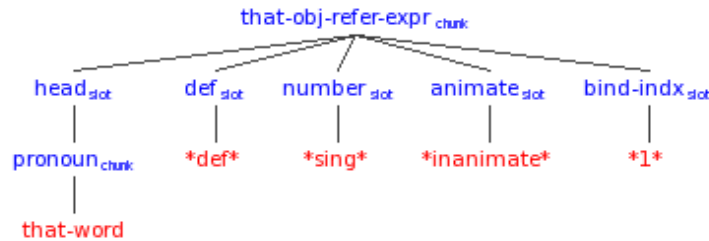
“the man” →



The processing of the word “man” projects an object head construction with “man” functioning as the head. The object head is integrated as the head of the object referring expression projected by “the”, and “man” projects the grammatical features number, animate (i.e., animacy), and gender with the values *singular*, *human*, and *male*. The animate feature has the possible values *human*, *animate* and *inanimate*.

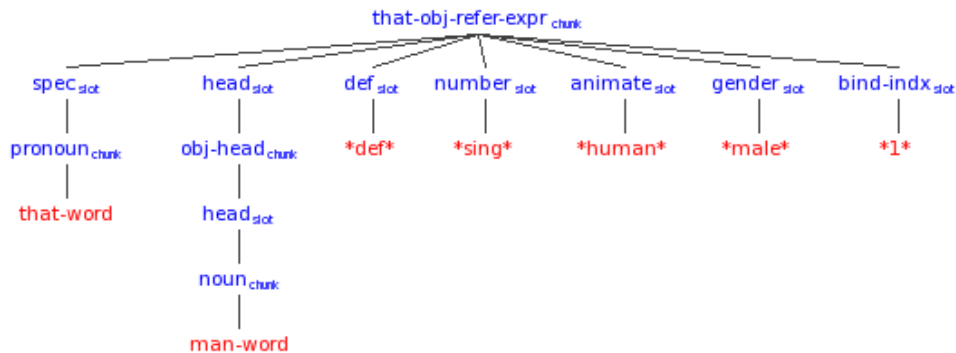
The processing of “that man” proceeds as follows:

“that” →



The word “that” is determined to be a pronoun which projects a special “that” object referring expression with “that” functioning as the head rather than the specifier as was the case for “the”. That-obj-refer-expr is a subtype of obj-refer-expr. “That” also projects the features def, number and animate with the values *definite*, *singular* and *inanimate*.

“that man” →

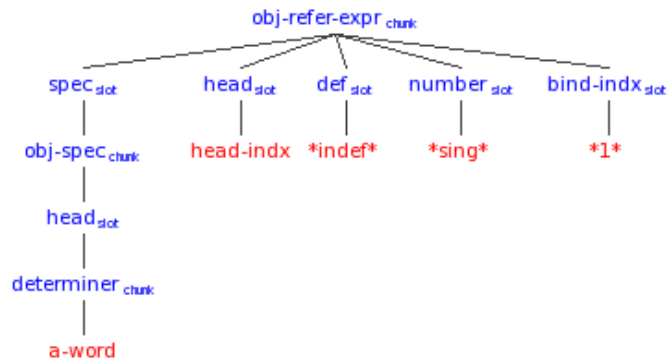


The processing of “man” following “that” leads to its identification as a noun which projects an object head. The object head is integrated as the head of the that-obj-refer-

expr with “that” shifted to the specifier function. Note that “that” is still categorized as a pronoun when it functions as a specifier. “Man” overrides the animacy feature of “that” changing it to *human* and projects the gender feature *male*.

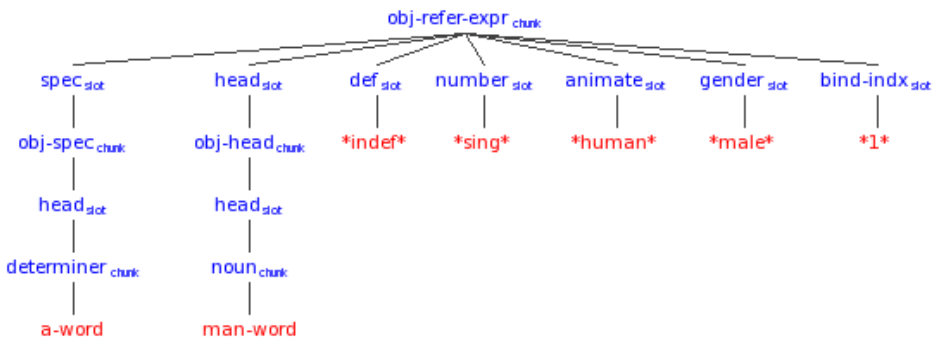
The processing of “a man” proceeds as follows:

“a” →



The word “a” is similar to “the” except that it projects the def feature *indefinite* (abbreviated *indef*) rather than *definite*, and it also projects the number feature *singular*.

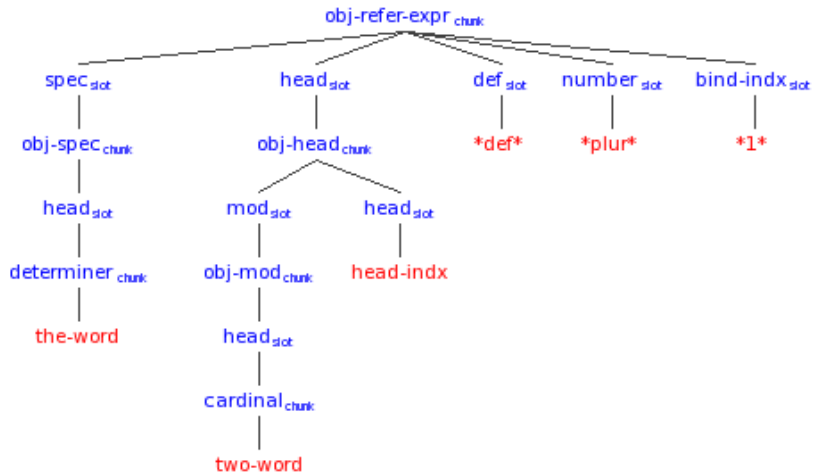
“a man” →



The processing of “man” following “a” is very similar to its processing following “the”.

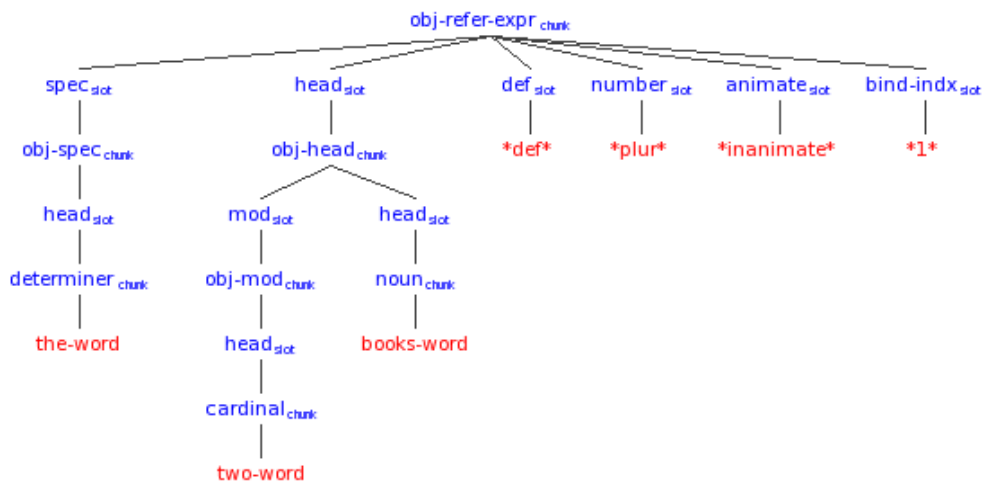
The processing of “the two books” proceeds as follows:

“the two” →



The processing of “two” following “the” leads to its identification as a cardinal number (a subtype of quantifier) which projects an object modifier. The object modifier in turn projects an object head with the object modifier functioning as a modifier of the head. The object head is integrated as the head of the object referring expression, even though the object head does not actually contain a head at this point. The object modifier projects the feature *plural* to the object referring expression.

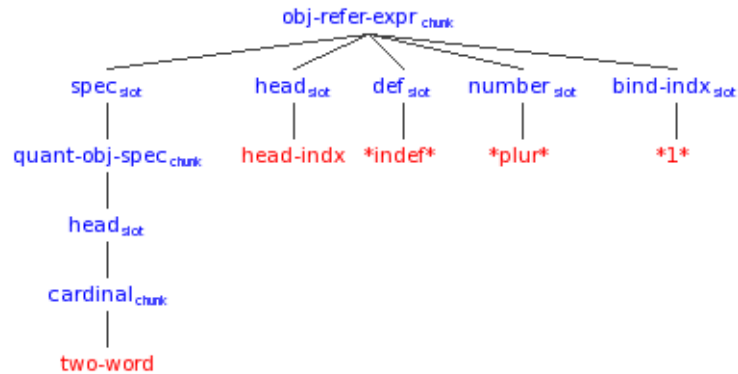
“the two books” →



“books” is integrated as the head of the object head and projects the features *plural* and *inanimate*, overriding the *plural* feature projected by “two” with the same value. “Books” does not project a gender feature since it is *inanimate*. The projection of the *indefinite* feature of “books” is blocked by “the”.

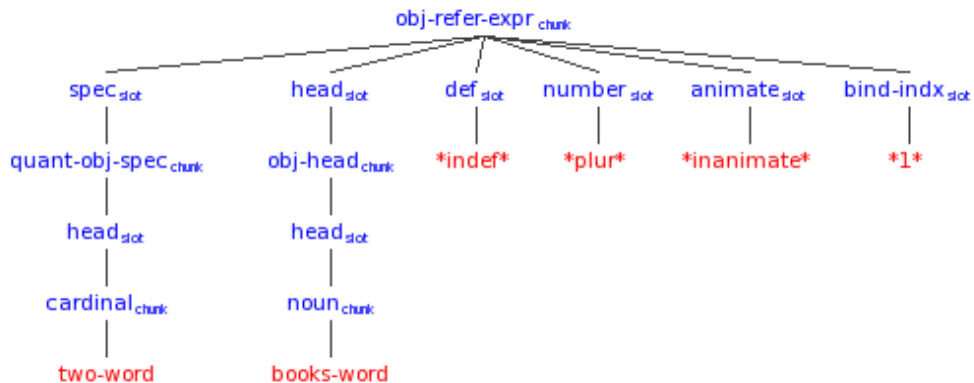
The processing of “two books” differs in important respects from “the two books”. In particular, in the absence of a determiner, the quantifier “two” functions as a specifier and projects an object referring expression as shown below:

“two” →



Note that “two” projects a quantified object specifier (abbreviated “quant-obj-spec”), rather than an object modifier, in this example. Determining the function of a lexical item is context dependent. Quantifiers can function as specifiers or modifiers, and perhaps even heads under some conditions. “Two” also projects the grammatical features *indefinite* and *plural*.

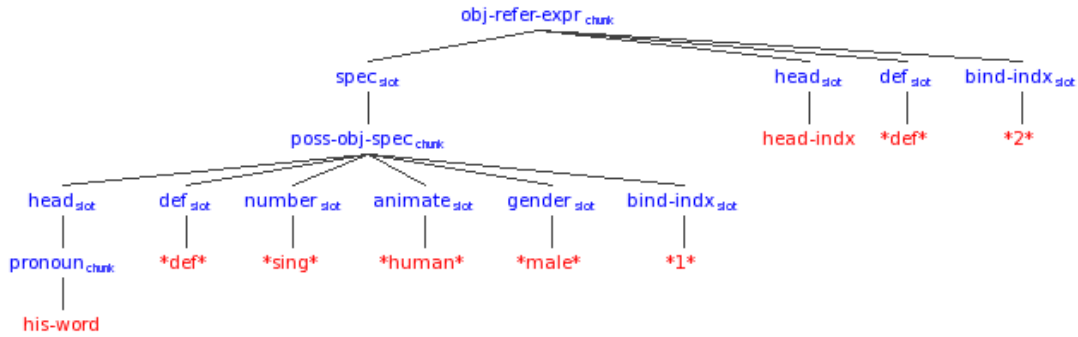
“two books” →



The processing of “books” projects an object head which functions as the head of the nominal. “Books” also projects the grammatical features *inanimate* and *plural*, overriding the *plural* feature projected by “two”. The *indefinite* feature of “books” is blocked by the corresponding feature for “two”.

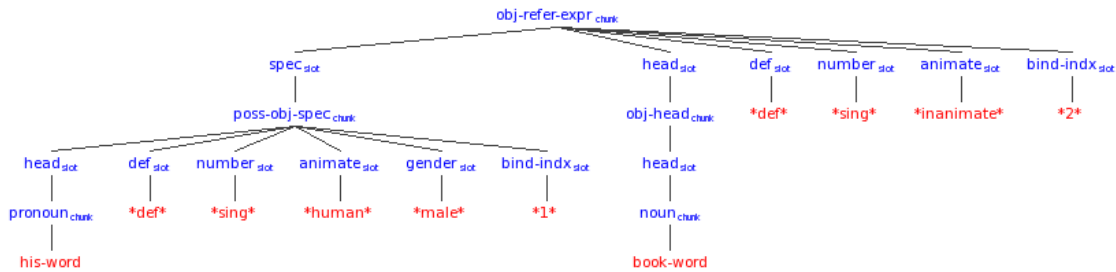
The processing of “his book” proceeds as follows:

“his” →



The possessive determiner “his”—treated as a pronoun by the model, but with a slot value (not shown) that indicates its possessive function—projects a possessive object specifier (abbreviated “poss-obj-spec”) which is a special type of object referring expression that functions as a specifier. The possessive object specifier projects a higher level object referring expression and functions as the specifier. The *definite* feature of the possessive object specifier is projected to the higher level object referring expression. Note that there are two distinct bind indexes to support co-reference to either object referring expression.

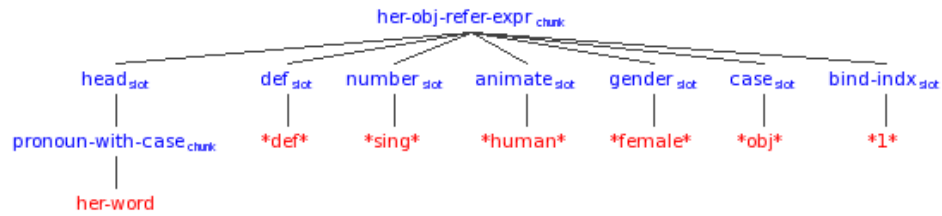
“his book” →



The word “book” projects an object head which is integrated as the head of the higher level object referring expression projected by “his”. The features *singular* and *inanimate* are projected to the higher level object referring expression.

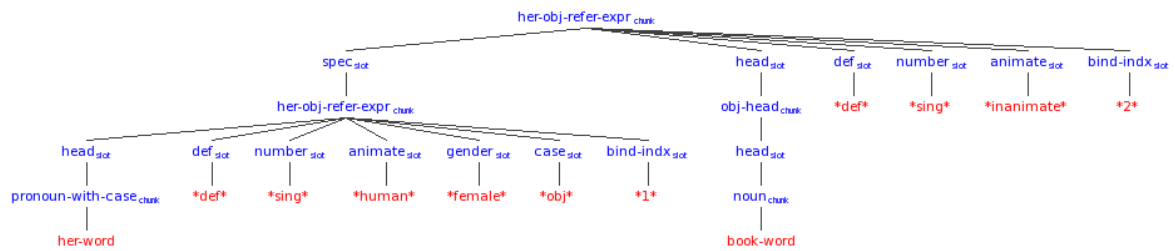
The pronoun “her” differs from “his” in that it is both a personal pronoun and a possessive pronoun (e.g., “I like her” vs. “I like her book”). Whereas “her” alone functions as a personal pronoun, “his” alone does not. In “I like his”, “his” is functioning as a possessive pronoun (or possessive determiner), not a personal pronoun. Note that “his” unlike “her” is both a possessive determiner and possessive pronoun (“hers” is the possessive pronoun form of “her”). At the processing of the word “her”, it is treated as a personal pronoun and functions as the head of the projected object referring expression, but if “her” is followed by “book”, a higher level object referring expression is projected and “her” is shifted into a specifier function, so “book” can function as the higher level head:

“her” →



Note that “her” also projects and objective case feature (abbreviated *obj*) and is subcategorized as a pronoun-with-case.

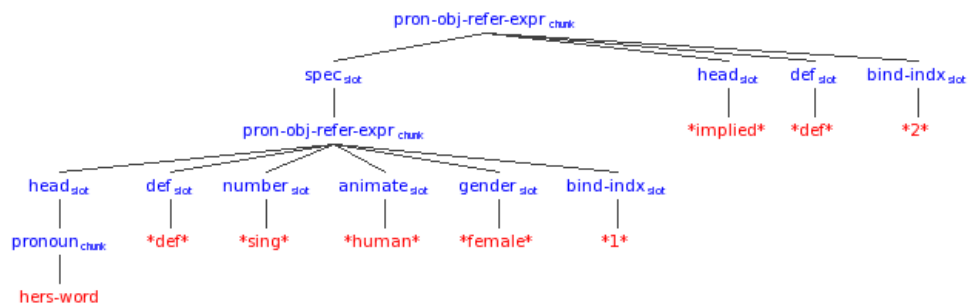
“her book” →



From a processing perspective, the primary difference between “his” and “her” is that “his” immediately projects a higher level object referring expression and functions as a specifier within the higher level expression—setting up the expectation for a head—whereas “her” does not.

The possessive pronoun “hers” also differs from “his” in that there is no expectation for the occurrence of a head in the higher level object referring expression (i.e., “hers” cannot be a possessive determiner). This is indicated by marking the head of the higher level object referring expression as “*implied*” (a similar approach is adopted in the treatment of the implied subject of imperative statements):

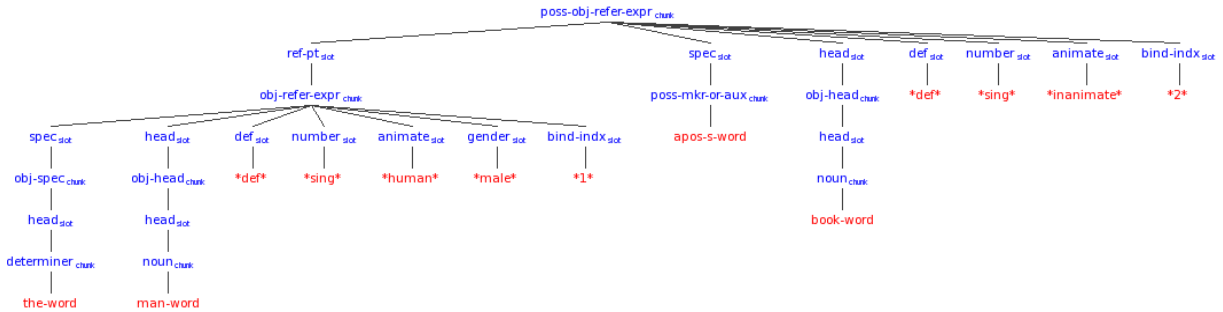
“hers” →



“Hers” is categorized as a pronoun, but has a slot value (not shown) that indicates its subcategorization as a possessive pronoun.

The processing of the possessive object referring expression “the man’s book” leads to the following representation:

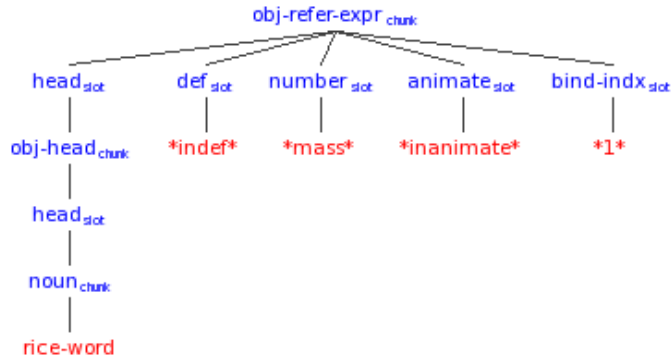
“the man’s book” →



It should be noted that the possessive object referring expression (abbreviated poss-obj-refer-expr) is not projected until the noun “book” is processed due to the ambiguity of “’s” (e.g., “the man’s book” vs. “the man’s going”). At the time it is processed, “’s” (represented as apos-s-word for apostrophe-s) is ambiguously categorized as a possessive marker or auxiliary (abbreviated poss-mkr-or-aux). This is one of the few places in which the model delays determination of the function of a word (or morpheme) until the subsequent context is available—due to the major difference between projecting an object referring expression (i.e., nominal) and projecting a situation referring expression (i.e., clause). However, note the possibility of having to switch back from a clausal to a nominal analysis in “the man’s going was a surprise” (this example is not currently handled by the model). In the processing of “book”, after it projects an object head, the processing of “book” is temporarily interrupted and in the context of a subsequent object head, “the man” + “’s” is determined to be a possessive nominal. A possessive object referring expression is projected in which “the man” functions as a reference point (abbreviated ref-pt) and the genitive marker (i.e., apos-s-word) functions as a specifier. The *definite* feature is projected to the possessive object referring expression. The processing of the object head “book” resumes and it is integrated as the head of the possessive object referring expression and projects the features *singular* and *inanimate*.

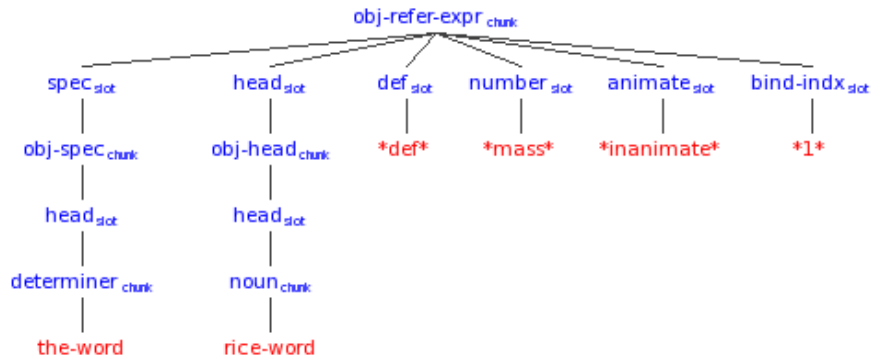
The processing of the mass noun “rice” proceeds as follows:

“rice” →

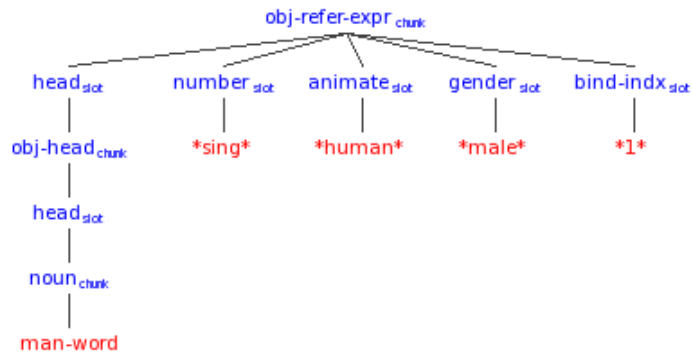


The word “rice” is identified as a noun and projects an object head. In the absence of a specifier and object referring expression, the object head projects an object referring expression. Because “rice” is a mass noun, the def feature is set to the value *indefinite* and number feature is set to the value *mass* which is treated as a subtype of *singular*.

The processing of “the rice” differs in that the *definite* feature of “the” is projected to the nominal, blocking the *indefinite* feature of “rice”.



The processing of the isolated singular count noun “man” leads to the following:

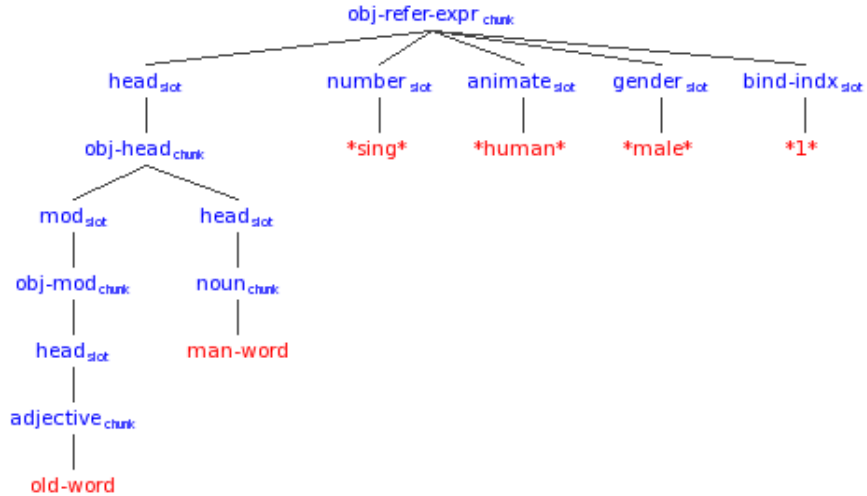


The word “man” projects an object head and in the absence of an object referring expression in which it can be integrated, it also projects an object referring expression. However, note that the nominal lacks a def feature which is normally required. Construal

processes operating over this object referring expression might add additional grammatical features like *indefinite* and *mass* in the case of the universal grinder as in “there is man all over the rug” (Pelletier, 1975).

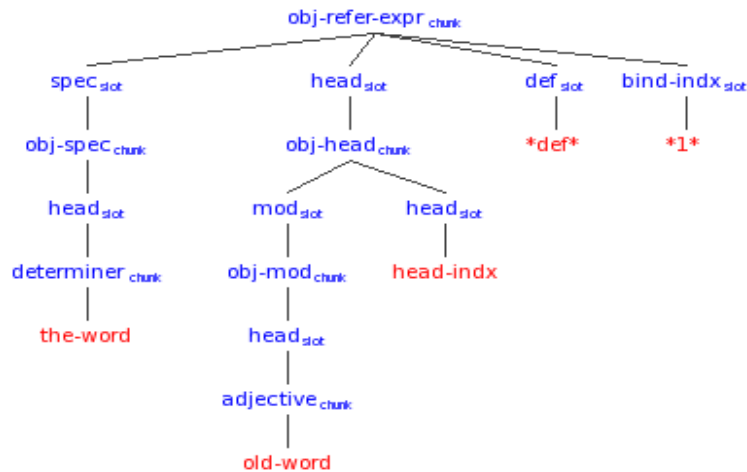
If adjectives functioning as modifiers do not project grammatical features, then the expression “old man” also lacks a marking for definiteness. Consider

“old man” →



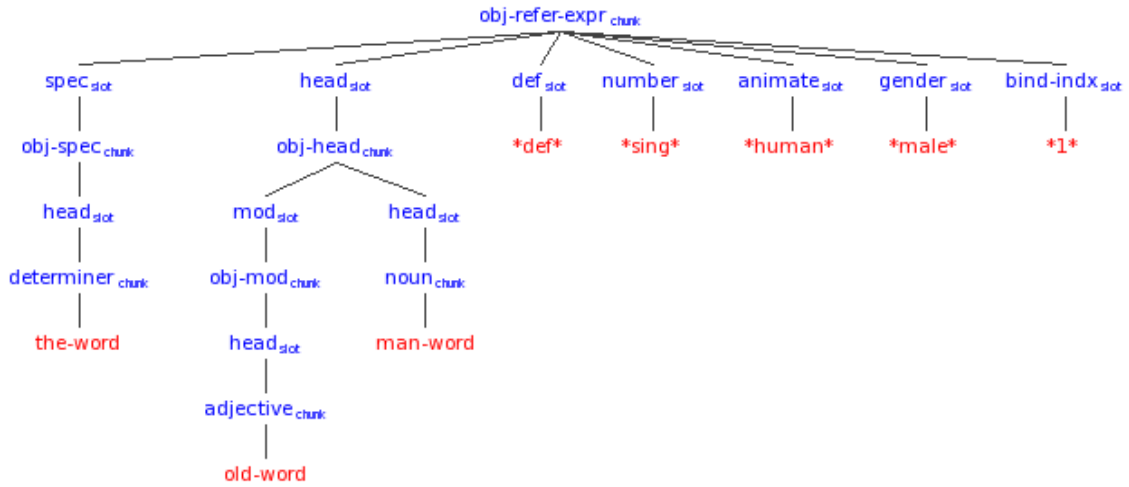
Again, an object referring expression is projected, but it lacks a definiteness feature. On the other hand, if the input is “the old”, the object referring expression is marked as *definite*, but it lacks a number feature as well as a head.

“the old” →

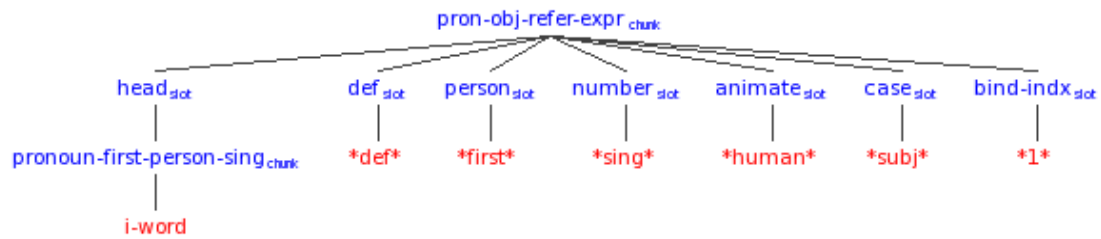


If we add a head as in “the old man” we finally get a fully specified object referring expression.

“the old man” →



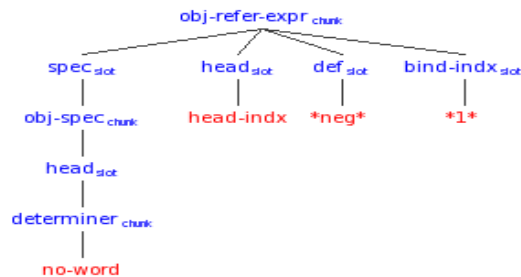
The special case of “I”:



Note the projection of the *first-person* feature from “I”. Pronoun-first-person-sing is a subtype of pronoun-with-case.

As a more complex example, consider the processing of the nominal “no airspeed or altitude restrictions”

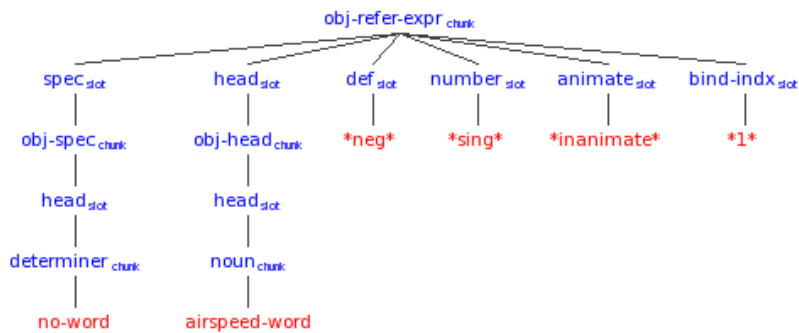
“no” →



The processing of the word “no” leads to its identification as a (negative) determiner which projects an object specifier of which it functions as the head. The object specifier in turn projects an object referring expression of which it functions as the specifier. “No”

is a special determiner that projects the definiteness feature *negative* (abbreviated “*neg*”). The categorization of “no” as a determiner is based on its grammatical behavior. Like the determiner “the”, “no” provides an indication of definiteness. Also like “the”, “no” combines with heads which may be either singular or plural as in “no **one** is here” and “no **books** are on the table”. Based on this, we assume that “no” does not project a number feature. Finally, like “the”, “no” does not occur alone as a nominal—which is related to the fact that “no” does not project a number feature. Overall, the grammatical behavior of “no” is closer to that of the determiner “the” than it is to quantifiers like “all” and “some” (previously “no” was treated as a quantifier). On the other hand, “none” (i.e., “no” + “one”) behaves more like a quantifier in encoding a *plural* number feature and occurring alone as a nominal (e.g., “None are here”). Why “none” is *plural* and not *singular*, whereas “no one” is *singular* (e.g., “No one is here”), is unexplained.

“no airspeed” →

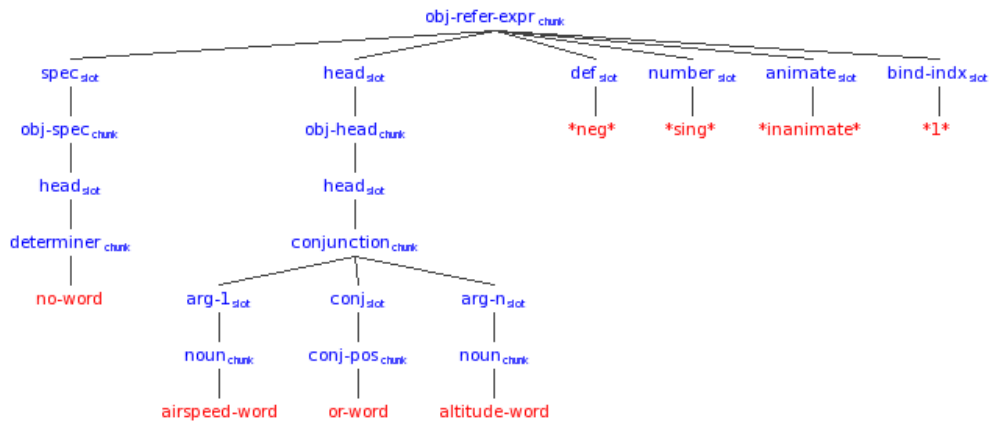


The processing of the noun “airspeed” following “no” leads to projection of an object head construction which is integrated as the head of the object referring expression projected by “no”. “Airspeed” also projects the number feature *singular* and the animacy feature *inanimate*.

“no airspeed or” →

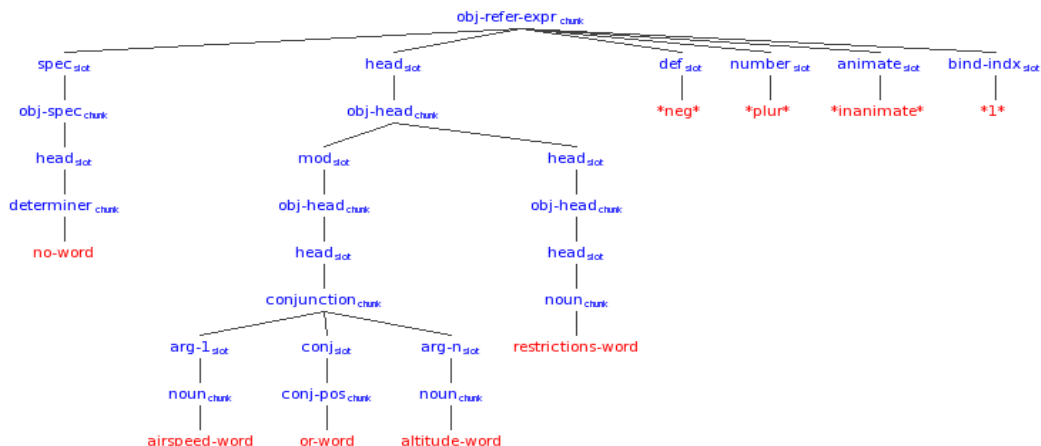
The processing of the disjunction “or” leads to its addition to short-term working memory (cf., Ericsson & Kintsch, 1995)—which corresponds to a collection of buffers in the ACT-R based model—since the category of the first conjunct of a conjunction cannot be effectively determined until the linguistic element after the conjunction is processed—due to rampant ambiguity associated with conjunctions (compare “the man and woman” vs. “the man and the woman” vs. “the red and blue ball” vs. “the red and the blue ball” vs. “the high and the mighty”, etc.). This is another example of delay in processing and it can cause processing problems (e.g., overloading of short-term working memory which has a very limited capacity) if the status of the conjuncts is not quickly resolved.

“no airspeed or altitude” →



The processing of the noun “altitude” in the context of the disjunction “or” and the nominal “no airspeed” with head noun “airspeed” results in the accommodation of “altitude” such that the head of the nominal is modified to reflect the disjunction of the nouns “airspeed” and “altitude”. Although “airspeed or altitude” is labeled a conjunction, it projects the number feature *singular* not *plural* because it contains the disjunction “or” (e.g., “no airspeed **or** altitude **is** specified”). If the input had been “airspeed and altitude” the *plural* number feature would have been projected by the conjunction “and” (e.g., “no airspeed **and** altitude **are** specified”). Further, if either of the disjuncts is *plural* (e.g., “apples **or** pears **are** available”), then the overall nominal is *plural* despite the disjunct. Overall, the *singular* feature of the disjunction “or” is (or, at least, may be) blocked by the *plural* feature of any preceding disjuncts and overridden by the *plural* feature of the last disjunct (compare “rice, barley **or** wheat **is** available” vs. “beans, rice **or** barley **are** available” vs. “rice, barley **or** beans **are** available”), whereas the *plural* feature of the conjunction “and” overrides the *singular* feature of any preceding conjuncts and blocks the *singular* feature of the last conjunct (e.g., “rice, barley **and** wheat **are** available”).

“no airspeed or altitude restrictions” →



The processing of the noun “restrictions” in the context of the nominal “no airspeed or altitude” results in the accommodation of “restrictions” such that the current head “airspeed or altitude” is shifted into a modifier function to allow “restrictions” to become the head. In the current implementation, an object head is a construction which contains three slots: 1) a pre-head modifier (labeled “mod” above), 2) a head, and 3) a post-head modifier (labeled “post-mod”, but not shown in the diagram since it is empty). The existence of the pre-head modifier slot supports function shifting at no additional cost relative to normal integration. There is no need to adjoin a modifier tree as in Tree Adjoining Grammar, or modify the existing structure above the modifier slot. A production which both shifts the existing head into the modifier slot and integrates the new head competes with a production which merely integrates the new head into the empty head slot. The *plural* number feature of restrictions is also projected to the nominal, overriding the previous *singular* number feature.

Conclusion

A localist theory of the representation and projection of grammatical features in nominals was presented in which words and phrases functioning as specifiers, heads, and modifiers project grammatical features to encompassing nominals. Grammatical features may be redundantly encoded in words and phrases fulfilling different grammatical functions within the nominal, and these redundantly encoded grammatical features may occasionally conflict. Non-monotonic mechanisms of blocking and overriding of features were presented for handling conflicts. Blocking occurs when a grammatical feature projected by a preceding functional unit is primary, whereas overriding occurs when a grammatical feature projected by a subsequent functional unit is primary. Blocking and overriding are basic non-monotonic processes which are deemed necessary in a serial, incremental language processing mechanism. These mechanisms are inconsistent with unification based approaches to grammatical analysis (e.g. HPSG) since they involve conflicts which would lead to unification failure. These non-monotonic mechanisms are exemplars of a more general context accommodation capability for dealing with expectations in processing which are not realized, resulting in accommodation via adjustment of the evolving representation or construal of the **to be integrated** linguistic element as being of the appropriate functional type—as in construal of the infinitive phrase “to be integrated” as a modifier of the nominal head “linguistic element” in this sentence. The mechanisms described in this paper are part and parcel of normal processing and are not viewed as exceptional.

The grammatical features described in this paper and implemented in the computational cognitive model were largely motivated by functional considerations—i.e., by the need to be able to generate a representation of the linguistic input which facilitates the mapping into a representation of the situation described by the linguistic input—what is called a **situation model** (Kintsch, 1998) or **mental model** (Johnson-Laird, 1983). For example, the definiteness feature is crucial to determining the referent of a nominal. If the nominal is *definite*, then either a referent has already been introduced into the situation model, or the referent is somehow salient in the context. If the nominal is *indefinite*, then a new referent may need to be introduced into the situation model. The number, animacy and gender features are crucial to determining co-reference, especially with respect to the use

of pronouns and trace elements. Subjective and objective case features may be useful for identifying the subject and object of a clause. Number agreement is also helpful in identifying the subject. For example, in “There are some books on the table”, the number agreement between “are” and “some books” indicates that “some books” is the subject—despite its non-canonical position in this sentence. In the model “there” is treated as a focus element, but is not the subject of the sentence. The genitive marker establishes a reference point with respect to which a secondary referent can be identified. The person feature which is least relevant to meaning determination (in English)—although it may help to identify the third-person subject—has all but been eliminated. Although grammatical features do not always map neatly to the corresponding conceptual features of referents, they provide useful information for establishing reference and determining meaning.

The larger context for this research is a focus on the development of a language comprehension system that is at once cognitively plausible and functional (Ball, Heiberg & Silber, 2007). Despite the fact that the only existing exemplar of a functional language comprehension capability is the human language processor, there is too little research on the relevance and value of cognitive constraints and human language processing within computational linguistics. We are in a phrase of computational linguistic research in which the use of statistical and machine learning techniques which have limited cognitive and linguistic validity, predominate. Such approaches have achieved impressive gains and may ultimately succeed in developing human level language comprehension capabilities, but there is room for more research that is less focused on such techniques and more focused on traditional analysis of linguistic and cognitive phenomena and their utility for language comprehension.

Appendix I contains tables listing basic nominal elements and the grammatical features which they project.

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Appendix I: Projection of Grammatical Features to Nominals

Determiner

The defining features of determiners are that they cannot occur alone as a nominal, they function as the specifier of the nominal they project (not the head), and they project the definiteness feature to the nominal. Given these defining features, there are very few true determiners. The classic determiners are the words “the” and “a” which are also called “articles”. “No” is also treated as a determiner, rather than a quantifier, since it cannot occur alone as a nominal. Further, like “the”, “no” is compatible with both singular and plural head nouns (e.g., “no book” vs. “no books”) indicating that it does not project a number feature. The determiner “a/an” is unique among determiners in projecting a *singular* number feature. Despite projecting both a definiteness and a number feature, “a” cannot occur alone as a nominal.

Word	Def
The	Def
No	Neg

Word	Def	Number
A	Indef	Sing
An	Indef	Sing

Possessive Determiner

Possessive determiners are a complex part of speech which projects an internal nominal known as the reference point. The possessive determiner functions as the head of the reference point. The possessive determiner also projects the grammatical features of the pronoun from which it is derived (i.e., me → my), less the case feature, to the reference point. These features are needed to bind the possessive determiner—which embeds a pronoun as the reference point—to its antecedent. The reference point in turn projects an encompassing nominal and functions as the specifier. Possessive determiners only project the feature *definite* to the encompassing nominal. We have not identified any grammatical evidence that the possessive (or genitive) feature is projected to the encompassing nominal.

Word	Def
My	Def
Our	Def
Your	Def
His	Def
Her	Def
Their	Def
Its	Def

The wh-word “whose” is special in being both a possessive determiner (which is itself a complex POS category) and a wh-word. It projects both a wh-feature and a definiteness feature, but does not project a number feature (e.g., “whose book” vs. “whose books”)

Word	Wh	Def
Whose	Wh	Def

Pronoun

The defining feature of pronouns is that they can occur alone as nominals. Note that this does not distinguish pronouns from proper nouns or mass nouns. To occur alone as a nominal, a pronoun must project both a definiteness and a number feature.

We assume that only *first* and *second-person* pronouns are marked for person, with *third-person* treated as an unmarked default.

Word	Def	Person	Number	Animacy	Case
I	Def	1 st	Sing	Human	Subj
Me	Def	1 st	Sing	Human	Obj
We	Def	1 st	Plur	Human	Subj
Us	Def	1 st	Plur	Human	Obj

Word	Def	Person	Number	Animacy
You	Def	2 nd	Plur	Human

The best evidence that pronouns are marked for the feature *third-person* has to do with the binding of reflexive pronouns (cf. Radford, 1997). However, establishing the compatibility of the reflexive pronoun with its antecedent may rely instead on a default mechanism. For example, in “they like themselves” it could be that third-person marking on “they” and “themselves”—along with plural marking—could determine the agreement of “they” with “themselves”. However, in “the men like themselves” or “the woman likes herself”, in order to use person marking to determine the correct reflexive pronoun, all nouns would have to be marked as *third-person*. Instead we will assume special handling of *first* and *second-person*, with a default, unmarked person agreement for *third-person* pronouns, nouns and proper nouns.

Word	Def	Number	Animacy
It	Def	Sing	Inanimate

Word	Def	Number	Animacy	Case
They	Def	Plur	Human	Subj
Them	Def	Plur	Human	Obj

Word	Def	Number	Animacy	Gender	Case
He	Def	Sing	Human	Male	Subj
Him	Def	Sing	Human	Male	Obj

She	Def	Sing	Human	Female	Subj
Her	Def	Sing	Human	Female	Obj

The wh-words “who” and “whom” are special in that they encode the features of both a pronoun and a wh-word. However, they do not appear to be marked for number since they are compatible with singular and plural subjects (e.g., “who is he”, “who are they”, and “whom did he meet” where “whom” can refer to one or many people). The wh-words “whoever” and “whomever” differ from “who” and “whom” in that they are *indefinite* rather than *definite*.

Word	Wh	Def	Number	Animate	Case
Who	Wh	Def	Sing	Human	Subj
Whom	Wh	Def	Sing	Human	Obj
Whoever	Wh	Indef	Sing	Human	Subj
Whomever	Wh	Indef	Sing	Human	Obj

Possessive Pronoun

Possessive pronouns are unique among pronouns in not projecting a number feature to the encompassing nominal. Instead the number feature is inferred from the referent of the possessive pronoun (e.g., “mine is nice” vs. “mine are nice”). Possessive pronouns differ from the possessive determiners from which they are derived (my → mine) in not allowing a head in the encompassing nominal (e.g., “*mine book is nice” vs. “my book is nice”). The head of the encompassing nominal is an implicit trace element that binds to the referent, thereby acquiring the number feature of the referent. This implicit trace element is projected from the possessive pronoun.

Word	Def	Number
Mine	Def	Depends on referent
Ours	Def	Depends on referent
Yours	Def	Depends on referent
His	Def	Depends on referent
Hers	Def	Depends on referent
Theirs	Def	Depends on referent

Possessive Nominal

Possessive nominals (e.g., “John’s” in “John’s book”) collapse across possessive pronouns and possessive determiners, preferring to occur with a noun head, but allowing for its absence (e.g., “John’s book is red” vs. “John’s is red”). The preference for a noun head suggests that the possessive nominal functions as the specifier of the projected nominal, not the head. In functioning as a specifier, the possessive nominal behaves like a determiner, but in not requiring a noun head it behaves like a pronoun.

Word	Def	Number
John’s <i>book</i>	Def	Depends on <i>book</i>
John’s	Def	Depends on referent

Reflexive Pronoun

Word	Def	Number	Animacy
Myself	Def	Sing	Human
Yourself	Def	Sing	Human
Yourselves	Def	Plur	Human
Itself	Def	Sing	Inanimate
Ourselves	Def	Plur	Human
Themselves	Def	Plur	Human

Word	Def	Number	Animacy	Gender
Himself	Def	Sing	Human	Male
Herself	Def	Sing	Human	Female

Demonstrative Pronoun

The defining feature of demonstrative pronouns is that they are marked for distance. Since this feature helps in determining the referent of the pronoun, it is projected to the nominal. Although demonstrative pronouns can function alone as nominals, they can also be combined with a noun head as in “this book”. In combining with noun heads they behave like determiners rather than pronouns. For this reason, they are sometimes cross classified as demonstrative determiners (cf. Biber, Conrad & Leech, 2002). However, from a processing perspective, when the demonstrative pronoun is processed, it projects a nominal and functions as the head, just like other pronouns. However, unlike other pronouns, if a noun head occurs subsequently, the demonstrative pronoun is shifted into a specifier function.

Word	Def	Number	Distance
This	Def	Sing	Near
That	Def	Sing	Far
These	Def	Plur	Near
Those	Def	Plur	Far

The wh-word “what” is special in that it behaves like a demonstrative pronoun in both occurring alone as a nominal and combining with a noun head (e.g., “what did he read?” vs. “what book did he read?”). However, unlike demonstrative pronouns it does not encode for distance. If the distance feature is considered definitional for demonstrative pronouns, then “what” is not technically speaking a demonstrative pronoun, but neither is it technically an ordinary pronoun since it can combine with a noun head. Expressions like “What stays and what goes?” suggest that “what” encodes a singular number feature even though it can occur with both a singular or plural noun (e.g., “What book did he read?” vs. “What books did he read?”). When “what” occurs with a noun head, the number feature of the noun overrides the number feature of “what”. To capture the ability of demonstrative pronouns and “what” to occur with and without a noun head, we could introduce a superordinate part of speech called something like “determiner-pronoun” or

using multiple inheritance, we could have demonstrative pronouns and “what” inherit from both determiners and pronouns.

Word	Wh	Def	Number
What	Wh	Def	Sing
Which	Wh	Def	Sing
Whatever	Wh	Indef	Sing
Whichever	Wh	Indef	Sing

Quantifier

The quantifier “some” is interesting in that it appears to encode the number feature plural (e.g., “some are missing”), yet it can occur with a singular noun head (e.g., “some book is on the table”). We will assume that the latter is a case of number overriding by “book” which is suggested by the stress placed on “some” in spoken language in such expressions (compare “some books are on the table” vs. “**some** book is on the table”).

Word	Def	Number
Some	Indef	Plur
Many	Indef	Plur
Much	Indef	Mass/Sing
More	Indef	Plur
Most	Indef	Plur
All	Def?	Plur
Both	Def?	Plur
Each	Def?	Sing
Each Other	Def?	Sing
Either	Def?	Sing
Neither	Neg	Sing
Every	Indef	Sing
Few	Indef	Plur
None	Neg	Plur
No one	Neg	Sing
One	Indef	Sing
Two	Indef	Plur

Word	Def	Number	Polarity
Any	Indef	Plur	Neg

Quantified Pronoun

Word	Def	Number	Animacy
Somebody	Indef	Sing	Human
Everybody	Indef	Sing	Human
Nobody	Neg	Sing	Human
Someone	Indef	Sing	Human

Everyone	Indef	Sing	Human
No one	Neg	Sing	Human
Something	Indef	Sing	Inanimate
Everything	Indef	Sing	Inanimate
Nothing	Neg	Sing	Inanimate

Word	Def	Number	Animacy	Polarity
Anybody	Indef	Sing	Human	Neg
Anyone	Indef	Sing	Human	Neg
Anything	Indef	Sing	Inanimate	Neg

Wh-words

Besides the wh-words “who” and “what” which are categorizable as pronouns, and “whose” which is categorizable as a possessive determiner, the expressions “how much” and “how many” behave like nominals in their inclusion of a definiteness and number feature. Of course, the definiteness and number features are projected by the quantifier and not the wh-word, but the inclusion of these features allows the expression to function as a nominal. For example, in “how many went?”, even if “how many” isn’t the subject of this clause, it is presumably bound to the implicit subject similar to the treatment of “who” in “Who went?”

who_i t_i went?
 how many_i t_i went?

Word	Wh	Def	Number
How much	Wh	Indef	Mass/Sing
How many	Wh	Indef	Plur

Noun

Word	Number	Animacy
Dog	Sing	Animate

Word	Number	Animacy	Gender
Man	Sing	Human	Male
Woman	Sing	Human	Female

Word	Def	Number	Animacy
Dogs	Indef	Plur	Animate
People	Indef	Plur	Human
Cattle	Indef	Plur	Animate

Word	Def	Number	Animacy	Gender
Men	Indef	Plur	Human	Male
Women	Indef	Plur	Human	Female

Word	Def	Number	Animacy
Rice	Indef	Mass/Sing	Inanimate

Proper Noun

Word	Def	Number	Animacy
IBM	Def	Sing	Inanimate
The Fillmores	Def	Plur	Human

Word	Def	Number	Animacy	Gender
Tom	Def	Sing	Human	Male
Mary	Def	Sing	Human	Female