Anna Maria Di Sciullo and Naoko Tomioka
www.interfaceasymmetry.uqam.ca

Compound Representation at the Interface*

Introduction

In Asymmetry Theory morphologically complex predicates are formed in $D_{morphology}$ and are then mapped to D_{syntax} (Di Sciullo 2003, 2005a). This mapping is subject to the interface conditions between the two domains, and the representations that pass through this interface provide a novel notion of "lexical representation" which connects the morpho-phonological and syntactic-semantic information. We argue that complex predicates such as compounds count as units of linguistic computation by virtue of the interface representation between $D_{morphology}$ and D_{syntax}, and the use of this representation is necessary in light of our experimental finding.

The $D_{morphology}/D_{syntax}$ interface provides a novel notion of "lexical representation" which connects the morpho-phonological and syntactic-semantic information. Crucially, the same configurational representation is used for semantic scope properties and for linear precedence relations.

Three types of morpho-logical affixes are distinguished in this theory: Operator, Modifier, and Predicate affixes, and each type ramifies in two sub-types. The scope properties of affixes is provided by the morpho-logical derivations, where affixes asymmetrically c-command the elements within their scope, independently from their linear precedence relations, e.g., [*re* [*en close*]], [*post* [*post revolutionary*]], [*un* [*able deny*]] (*undeniable*), [*able* [*ize computer*]] (*computerizable*), [*ity* [*al form*]] (*formality*).

The linear order of the affixes is derived in the morpho-phonology and is legible at PF. While affixes that occupy the specifier position remain in situ, affixes that occupy the head position are ordered to the right of the root by M-Flip applying at PF.[1]

(1)   a.   b.   c. Mod -af   d. Op af

pred-af   pred--af   F   F

root   root   root   root

The theory correctly predicts the linear order of affixes with respect to roots for languages such as English, but also for languages with very different properties, such as African languages and Turkish, as shown in Di Sciullo (2005c). In the case of English, the theory correctly predicts that Predicate affixes follow the root, e.g., *domestic-**ate**, edit-**ion**, valu-**able***, Modifier affixes and Spec-Operator-affixes precede the root, e.g., ***un**-fold, **re**-wind, **en**-large, **th**-is, **th**-at*, while head-Operator follow the root, e.g., *cat-**s**, wash-**ed***.

---

[1] See also Williams (2003) and Wurmbrand (2003) for independent motivations for the operation Flip.

This distinction, formed on the basis of different types of affixes also applies to types of compounds. We argue that complex predicates such as N-V compounds are formed in $D_{morphology}$ and, hence subject to the same derivational constrains as affixes. Moreover, they pass the interface between $D_{morphology}$ and D_{syntax}, as structured representation and the use of this representation plays a key role in the linguistic processing.

In English, in certain noun-verb compounds, the noun saturates the internal argument of the verb, see (2) which includes –*ing* suffix. In other noun-verb compounds, the noun is interpreted as the modifier of the event and hence the verb remains unsaturated. The compound, being unsaturated predicate, deverbalizes with –*ed* suffix (3).

(2) The meat-cut**ing** knife (N_{obj}-V)
(3) The finger-paint**ed** portrait. (N_{mod}-V)

This relation between the correlation between the choice of the suffix and the interpretation of the nominal constituent of the compound is more direct than the above description might suggest. Given our hypothesis, the constituents [N_{arg}-V] and [N_{mod}-V] pass through the interface, and are represented as the lexical unit, to which other systems might access.

To test this hypothesis, we investigated the acceptability of novel noun-verb compounds with tense/aspect morphemes which are homophonous with the participle forms – i.e. –*ed* and –*ing* morphemes. If the interface representations play a role in determining the acceptability of the new compounds, the forms that contain the homophonous tense/ aspect morpheme should be more acceptable than the forms that contain the other morphemes.

In another framework, in which syntax is the sole module of concatenation (e.g., Distributed Morphology of Hale & Marantz 1993), the morphological complexity arises simply at PF, and not at LF. In Minimalism (Chomsky 1996), PF and LF do not interface, and hence, the notion of "word" plays no role outside of the phonological computations. The presence of a direct link between the semantic and phonological representations of a complex predicate, thus, supports the Asymmetry Theory type architecture of the grammar over that of Distributed Morphology. Hence, we report a connection between a phonological representation and the syntactic structure of compound verbs, and argue that the presence of this connection suggests that the computational system must contain such lexical representations as $noun_{arg}$-verb compound and $noun_{mod}$-verb compound.

This paper unfolds as follows. First we discuss argument/modifier asymmetries in compounds, and we show how they follow from Asymmetry Theory. Second, we present experimental results on the processing of novel compounds which support our hypothesis that the morpho-conceptual interface is perceived on the basis of configurational asymmetry between arguments and modifiers. In the last section, we summarize our results, and draw some consequences for interface processing.

1. Compounds: Background
1.1. Internal argument/modifier asymmetry

The argument/modifier asymmetry with respect to precedence relation is observed in English compounds.

(4) a.   b.

        Arg1   Mod
              V   Arg2   F
                                                              Agr1
                                                                    V   Agr2
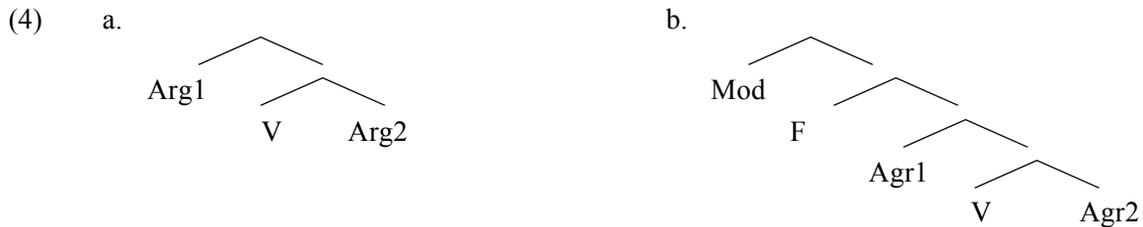
The asymmetry between arguments/objects and modifiers/adjuncts has received much attention in works on compound formation. A major puzzle concerning compounds is that even though Head-movement captures the compound formation of argument/object type (Baker 1988), it cannot account for the presence of modifier/adjunct-compounds (Rosen 1989, Rivero 1992, Spencer 1995). The existence of modifier/adjunct compounds, hence, casts doubt on the uniform, purely syntactic account of compound formation. We thus argue that the formation of compounds take place in the $D_{morphology}$.

The derivation of compounds, be they object-verb or adjunct-verb compounds, follows from the application of the operations of the grammar. English verbal compounds provide direct empirical evidence of the argument/modifier compound internal asymmetry. In English verbal compounds, the dependent of the verb is either its logical object, (5a), or an adjunct, (5b), or both, (5c). Interestingly, in the latter case, the adjunct must precede the object, (5d).

 (5)   a. blood testing
        b. clinical testing
        c. clinical blood testing
        d. *blood clinical testing

The strict ordering of the constituents of a compound follows from the properties of the operations of the grammar, which apply under asymmetric Agree. Consequently, modifiers are generated higher than the predicates and their arguments. Object/adjunct asymmetries, such as the one in (6), are preserved through the derivations.

(6)   [$_F$ clinical F [$_{NV}$ blood testing]]

Assuming as in Chomsky (1995-2007) that subjects (external arguments) are not adjuncts (contra Kayne 1994), the fact that subjects do not generally Merge with verbs in the derivation of compounds brings additional support to the view that the object/adjunct asymmetry, and not another sort of asymmetry, e.g., the syntactic complement/non-complement asymmetry (Huang 1982, Rizzi 1980, Chomsky 1981, 1995, 2001), is the crucial asymmetry in the derivation of compounds.

Interestingly, finer-grained linear precedence asymmetries between different sorts of adjuncts are observed in English compounds, suggesting further that asymmetric relations are hard-wired in morphology. The examples in (7) show that an agentive adjunct must follow a spatial/locational adjunct. The examples in (8) illustrate that a sequential/temporal modifier must precede a spatial/locational modifier, (9). Thus we have the morphological configurations in (10). Syntactic adjuncts do not show the restrictions on linear precedence relations observed in compounds. Compare (7)-(9) to (10). This also indicates that morphological asymmetries cannot be equated to syntactic asymmetries.

(7) a. expert-tested drug
     b. hospital-expert-tested drug
     c. *expert-hospital-tested drug

(8) a. hospital expert tested drug
     b. bi-annual hospital expert tested drug.
     c. *hospital bi-annual expert tested drug

(9) a. [$_F$ hospital F [$_F$ expert   F [$_{NV}$ tested]]]
     b. [$_F$ bi-annual F [$_F$ hospital F [$_F$ expert F [$_{NV}$ tested]]]]

(10) a. This drug has been tested by experts in a hospital.
      b. This drug has been tested in a hospital by experts.
      c. Since 1984, this drug has been tested by experts in a hospital twice a year.
      d. Since 1984, this drug has been tested by experts twice a year in a hospital

The facts above provide evidence for compound-internal argument/modifier asymmetry.

Given the architecture of the language faculty adopted here, where the D$_{morphology}$/D$_{syntax}$ interface provides a novel notion of lexical representation which connects the morpho-phonological and syntactic-semantic information, the same configurational representation is used for semantic scope properties and for linear precedence relations. Consequently, a difference in linear order between arguments and modifiers, as well as between modifiers (asymmetric linear precedence relation) relates to a difference in hierarchical structure (asymmetric c-command relation).

1.2. Compounding and derivation

The configurational asymmetries observed in English compounds pattern with the ones observed in affixed forms.

First, the argument/modifier asymmetry attested in compounds follows from the fact that elements in the domain of secondary predicates (adjectival and adverbial modification) asymmetrically c-command the elements in the domain of the primary predicates (primary predicates and their arguments).

(11)   I-Asp

en   F   Pred2

β   coding

(12)   I-Asp

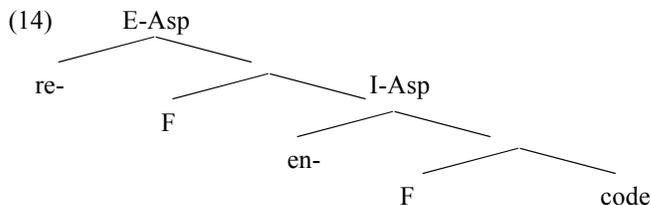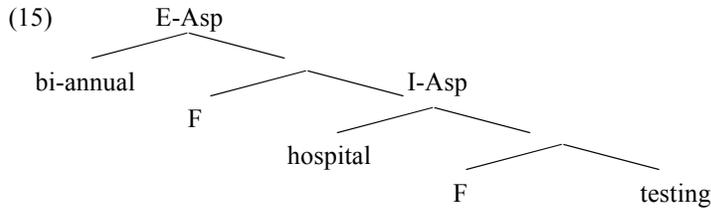clinical   F   Pred2

β   blood   testing
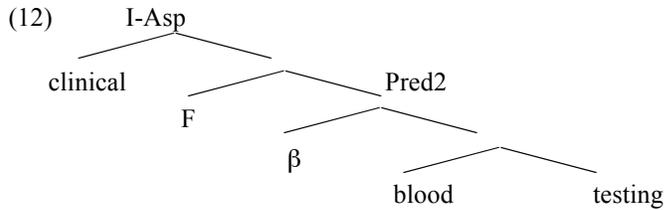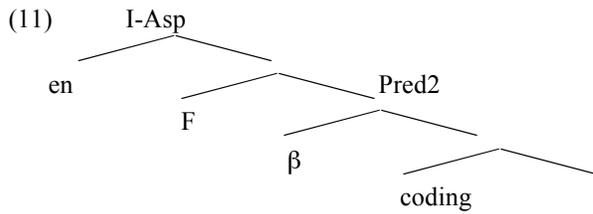
Second, derivational affixes present asymmetries in dominance relations. In particular, affixes modifying the aspectual features of the verbal root to which they apply, such as spatial prefixes, are generated lower in the verbal projection tree than affixes that modify aspectual features, without affecting the argument structure of the verbal root, such as the sequential affixes (see Di Sciullo 1997, 1999, 2005a).

French verbs including sequential (iterative and inverse) and spatial (directional and locational) prefixes show asymmetries in linear order, (13a), recursivity, (13b), and locality effects, (13c). Taking af_1 to be external aspect affixes, and af_2 to be internal aspect affixes, E-prefix must precede I-prefix, (13a); E-prefix can be iterated; I-prefix cannot, (13b); I-prefix must be spelled out if E-affix is; when the root does not have I-Asp features (13c), I-prefix affects the structure of the v; E-prefix does not.

(13)   a. $af_1 > af_2 > root$ /   *$af_2 > af_1 > root$ *réemporté/*enréporté*
       b. $af_1^n > af_2 > root$ /   *$af_1 > af_2^n > root$ *réenfermé/*enrefermé*
       c. $af_1 > af_2 > root$ / * $af_1 > af_2 > root$ *réembarqué/*rebarqué*

Given Asymmetry Theory, E-Asp asymmetrically c-commands I-Asp affixes in the aspectual modification domain, (14), and the asymmetry illustrated in (8) follows without requiring movement, (15).

(14)   E-Asp

re-   F   I-Asp

en-   F   code

(15)   E-Asp

bi-annual   I-Asp

          F

               hospital   F   testing

2. Previous study

Experimental results for the configurational asymmetry between E-Asp and I-Asp affixes in French verbs (Tsapkini, Jarema, and Di Sciullo 2004)

Question
Does the asymmetry between E-Asp and I-Asp influence the way in which the verb is processed?
        refermer 'to close again', *enfermer* 'to close in' matched for
        -surface and base form frequency
        - word-length (2-4 syllables)
        -semantic transparency
        -base form consistency (free-standing)

Design
        - 72 critical stimuli divided into 2 experimental lists
        - Each verb appeared only once, either as a prefixed or a base-form
        - Filler words: nouns, adjectives, and verbs (Density 75%)
        - Nonwords: created by changing the first, middle,
         or final consonant of randomly selected words matched for frequency.
        - The total of 394 items in each list were randomized and divided in four blocks for
          each subject.
        - 30 training items were also used in the beginning of each session.

Participants
        24 native French speakers
        university students, normal-to-corrected vision, no reading disorders

Results
Mean RTs and SDs for prefixed and stem forms

6
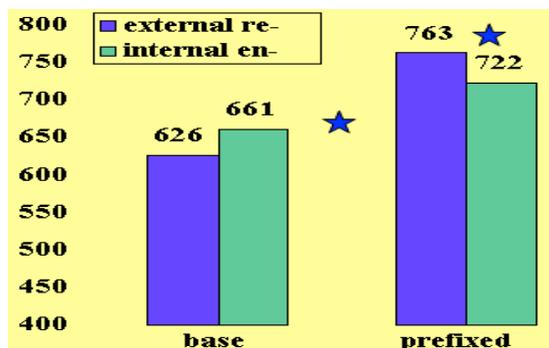
Statistically significant effect of form (base forms show faster latencies than prefixed
        forms)
Significant interaction between the type of prefix and the form of the verb
        - Latencies for base forms for both types of prefixes are not different from each
        other.
        - However, forms with external prefixes show significantly longer latencies
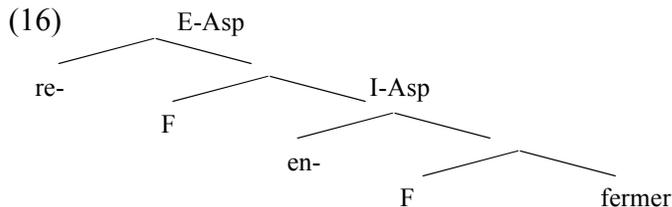   than forms with internal prefixes.

Mean RTs and SDs for prefixed and stem forms

	Mean RTs	SDs
En stem	648	95
Re stem	628	80
En prefixed	724	97
Re prefixed	766	140

This difference cannot be accounted for by any difference in stem frequencies or surface
frequencies or by any other distributional factor, e.g., syllable length, affixal homonymy,
etc., it can only be attributed to the particular configurational properties of the prefixes.

Conclusion

There is a difference in accessing internally vs. externally prefixed verbs.

(16)

```
                 E-Asp
        ┌──────────┴──────────┐
      re-              ┌──────┴──────┐
                       F           I-Asp
                              ┌──────┴──────┐
                            en-      ┌──────┴──────┐
                                     F          fermer
```

I-Asp> I-Asp
        - lexical decision tests: longer RTS with E-AspV than with I-AspV

If compounding and derivation in English share basic architectural properties of
the language faculty, we expect asymmetries to be found in compounds. The examples
above, where the sequential modifier must precede the spatial modifier, show that this
prediction is also borne out.
        To summarize, in this section, additional evidence is provided that compounds are
domains where strict asymmetric relations hold.

In the next section, we provide experimental results indicating that humans process compounds in terms of argument and modifier asymmetry. In particular, human perception is sensitive to the asymmetry between the internal components of compounds, namely arguments and modifiers. We formulate the following hypotheses:

    A. If there is no configurational argument/modifier asymmetry in compounds, there should be no difference in acceptability judgments in human processing.
    B. A difference in acceptability judgment would indicate configurational asymmetry between the two sorts of compounds.

3. Current experiment

Evidence from the effect of a configurational argument/modifier asymmetry in novel compounds.

(17) a.   Sunday vegetable shopping   vs. *vegetable Sunday shopping
     b.   cold-water shoe washer   vs.   * shoe cold-water washer

Parallelism between the internal/external affixes and the compounds:
Prefix ordering: external – internal – root   and   Compound: modifier- object –verb

Empirical observation
The relations between the two constituents of N-V compounds, unlike those of N-N compounds are strictly predictable.
N-V compounds are productive in deverbal contexts, but less so in a verbal form (Mithum 1986).

(18)   the cat-catch**er**
       the paw-paint**ed** portrait
       the tail-chew**ing** pig

(19)   ?John cat-caught yesterday.
       ? Fido paw-painted the portrait.
       ? Jerry tail-chewed.

The reduced acceptability of the novel compounds and the scarcity of existing tokens make these compounds unsuited for lexical-decision-task based experiments.

→ Acceptability rating and the effect of homophony

General Design and the hypothesis
- N_{obj}-V compounds take the participle morpheme *–ing*, in contrast, N_{adj}-V compounds take the *-ed* morpheme.
- The effect of homophony is expected between the participle morphology (*ed* and *ing*) and the tense/aspect suffix (*-ed* and *-ing*) on the acceptability of novel compounds.

- The presence of N_{obj}-V compound, N_{adj}-V compound representation in the mental representation will form the basis for the effect of homophony.

Stimuli
- Mono-transitive verbs and a noun forming 20 novel N-V compounds (10 in each class)
- All the constituents (nouns and verbs) of the compounds come from the most frequent word lists.
- The compounds are presented in a sentence to help disambiguate the classification of the compound.
- Three contexts for each compound
- 60 fillers

Participants
20 native speakers of English

Experiment procedure
Block 1 – experimental sentences mixed with fillers in random order
Block 2 – control sentences with fillers in random order

All the compounds were rated for acceptability: 1 =good to 5 = bad

	N_{obj}-V	N_{adj}-V
Control Context	*-ing* (participle)	*-ed* (participle)
Experimental Context1 (favoured)	*-ing* (progressive)	*-ed* (past)
Experimental Context 2(non-favoured)	*-ed* (past)	*-ing* (progressive)

Result

With N_{obj}-V compounds, the subjects rated the *–ing* forms significantly more acceptable than the *–ed* forms.
With Nadj-V compounds, the subjects showed preference for the *–ed* form over the *–ing* form.

→ The tendencies in opposing direction
The result indicates that there is an effect of homophony.
The observed pattern cannot be due to the nature of the suffixes alone.
The effectof homophony/increased acceptability differentiate N_{obj}-V compounds from N_{adj}-V compound categorically.

The mean of the acceptability rating for each type and context is as follows:

	N_{obj}-Verb	N_{adj}-Verb
past tense (*-ed*)	3,43	2,74
progressive(*-ing*)	2,72	3,45
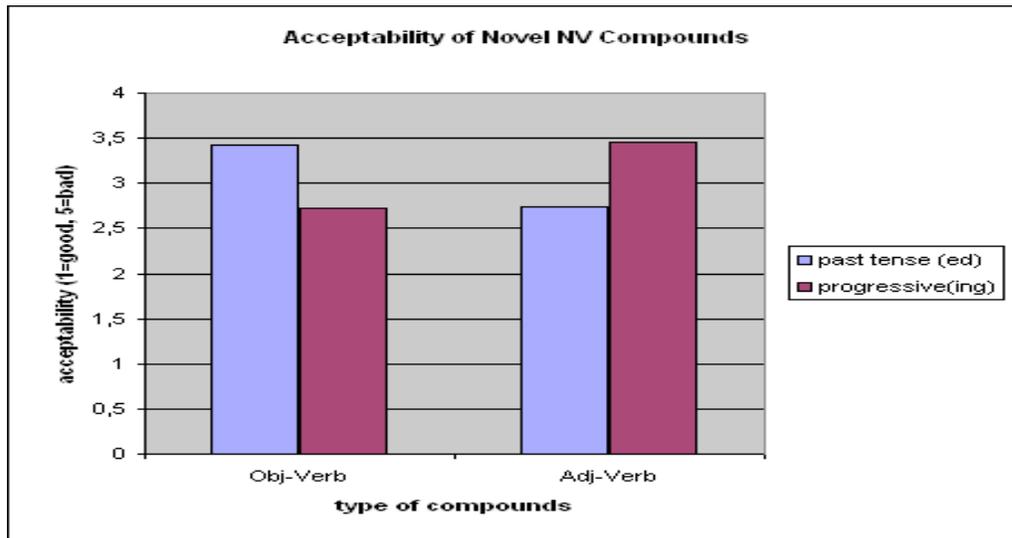
Discussion

This study provides additional experimental evidence to the findings of (Tsapkini, Jarema, and Di Sciullo 2004) where priming showed a significant difference in reaction time between internal vs. external prefixed verbs in French.

Finally, the sharp differences in acceptability between novel $N_{argument}$ vs. $N_{modifier}$ compounds cannot be attributed to frequency, since the compounds as wholes are novel. Moreover, the parts of the compounds are drawn from most frequent word lists.

This study brings forth a novel type of evidence to shed light on the issue concerning the notion of lexical representation. Productivity is a feature of morphology that is often argued to be part of linguistic performance, rather than competence (Mohanen 1986). Recently, productivity is measured over individual lexical items (e.g. Baayen 1992), which pushes the notion of productivity even further from theories of linguistic competence. However, we show that productivity should be defined over the units defined at the linguistic interface. We examined a type of productivity in English which cannot be measured over individual lexical items, and show that the pattern of productivity suggests the presence of certain units in the linguistic representation. This study thus provides a novel synthesis of performance-based evidence and the theory of linguistic representation.

4. Conclusion

According to Asymmetry Theory, the mental representation of complex words includes configurational information, which distinguishes arguments from modifiers.

The result of the experiment provides evidence of a configurational asymmetry between 'argument of' and 'modifier of' in English compounds. The asymmetry manifested itself compound internally by:

> A. Strict precedence relations: the modifier precedes the argument.
> B. Asymmetries in compounds and in derivational affixes pattern alike.

We draw the following consequences for interface properties:

(20) a. Human processing of complex words accesses asymmetric relations, such as the argument/modifier, and the E-Asp/I-Asp asymmetries.
  b. Interface representations provide the asymmetrical bases for legibility, which include configurational asymmetry, and are not limited to linear precedence relations or frequency effects.

The compound internal argument-modifier asymmetry is legible at the interface between $D_{morphology}$ and D_{syntax}. The results of our experiment show a sharp difference in acceptability judgment. We take this as indicating that humans perceive and interpret compound indicates configurational asymmetry between $N_{argument}$ vs. $N_{modifier}$ with compounds.

References

Baayen, R. 1992. Quantitative Aspects of Mophological Productivity. *Yearbook of Morphology* 1991. 109-150.

Baker, M. (1988). *Incorporation: A Theory of Grammatical Function Changing*. Chicago, Illinois: University of Chicago Press.

Bickerton, D. (1990). *Language and Species*. Chicago: University of Chicago Press.

Chomsky, N. (2004). Three Factors in Language Design, *Linguistic Inquiry* 36(1), 1-22.

Chomsky, N. (2001). Derivation by Phase, in M. Kenstowicz (ed.), *Ken Hale: A Life in Language*. Cambridge, MA: MIT Press, 1-52.

Chomsky, N. (2000). Minimalist Inquiries: The Framework', in R. Martin, D. Michaels, and J. Uriagereka (eds.), *Step by Step. Essays on Minimalist Syntax in Honour of Howard Lasnik*. Cambridge, MA: MIT Press, 1-59.

Chomsky, N. (1995). *The Minimalist Program*. Cambridge, MA: MIT Press.

Deprez, V., (2007). Grammaticalizing Number and Definiteness in French-Based Creoles. Ms. Rutgers University.

Delfito, D. & Paradisi, P. (2007). Prepositionless Genitive and N+N Compounding in (Old) French and Italian. Ms.

Clark, E. V., and Barron, B. J. S. (1998). 'A Thrower Button or a Button Thrower? Children's Judgements of Grammatical and Ungrammatical Compound Nouns', *Linguistics* 26:3-19.

Collins, C. (2002). 'Eliminating Labels', in S. D. Epstein and T. D. Seely (eds.), *Derivation and Explanation in the Minimalist Program*. Oxford: Blackwell, 42-64.

Di Sciullo, A.M. (forthcoming). 'Why are Compounds part of Natural Languages'. In Lieber, R. and P. Stekauser (eds.) *The Handbook of Compounds*. Oxford: Oxford University Perss.

Di Sciullo, A.M. (2005c). 'Affixes at the Edge', *Canadian Journal of Linguistics, Special 50th anniversary issue*: 83-117.

Di Sciullo, A. M. (2005b). 'Decomposing Compounds'*, SKASE Journal of Theoretical Linguistics*: 14-33.

Di Sciullo, A. M. (2005a). *Asymmetry in Morphology*. Cambridge, MA: MIT Press.

Di Sciullo, A.M. & D. Isac (2007). Asymmetric Merge. Ms. UQAM.

Di Sciullo, A. M. & Williams, E. (1987). *On the Definition of Word*., Cambridge, MA: MIT Press.

Dowing, P. A. (1977). 'On the Creation and Use of English Compound Nouns', *Language* 53.: 810-842.

Fiorentino R., and Poeppel, D. (2007). 'Compound Words and Structure in the Lexicon', *Language and Cognitive Process* 22(7): 1-48.

Jackendoff, R. (2002). *Foundations of Language: Brain, Meaning, Grammar, Evolution*. Oxford: Oxford University Press.

Gil, D. (2005). 'Isolating-Monocategorial-Associational Language', in H. Cohen and C. Lefebvre (eds.), *Handbook of Categorization in Cognitive Science*. Amsterdam: Elsevier.

Hauser, M. D., Chomsky, N. and Fitch, W. T. (2002). 'The Faculty of Language: What Is It, Who Has It, and How Did It Evolve? ', *Science* 298: 1569-1579.

Hale, K., and Keyser, J. (2002). *Prolegomena to a Theory of Argument Structure*. Cambridge, MA: MIT Press.

Mohanan, K. 1986. *The Theory of Lexical Phonology*. Reidel. Dordrecht.

Pinker, S. and P. Bloom (1990). Natural Language and Natural Selection. *Behavioral and Brain Sciences* 13: 707-784.

Roeper, T., Snyder, W, and Kazuko Hiramatsu (2002). 'Learnability in a Minimalist Framework: Root Compounds, Merger, and the Syntax-Morphology Interface', in I. Lasser (ed.), *The Process of Language Acquisition.* Frankfurt: Peter Lang Verlag.

Rosen, S. T. (1989). 'Two Types of Noun Incorporation', *Language* 65: 294-317.

Spencer, A. (1995). 'Incorporation in Chukchi', *Language* 71: 439-489.

Tsapkini, K,, G. Jarema and A. M. Di Sciullo. 2004. The role of configurational asymmetry in the lexical access of prefixed verbs: Evidence from French. *Brain and Language*, 90, 143-150 .

Wurmbrand, S. 2003. Syntactic and post-syntactic movement. Ms. U. of Connecticut.