The Lexical Semantic Framework for Morphology

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Summary and Keywords

The Lexical Semantic Framework (LSF, Lieber, 2004) is concerned with the study of the semantics of word-formation processes. The central goal of LSF is to characterize the meaning of simple lexemes and affixes and to show how these meanings can be integrated in the creation of complex words. LSF offers a systematic treatment of issues that figure prominently in the study of word formation:

(a) The polysemy question: why do derivational affixes often exhibit polysemy (e.g. agent, instrument, experiencer, stimulus, patient/theme nouns in *-er*, as in *driver*, *opener*, *hearer*, *pleaser*, *keeper*)?

(b) The multiple-affix question: why are there affixes that create the same kind of derived words (i.e. both *-er* and *-ant* create agent nouns, e.g. *writer*, *accountant*)?

(c) The zero-derivation question: how do we account for zero-affixation, that is, semantic change with no (overt) formal change (i.e. "conversion")?

(d) The form and meaning mismatches question: why are there instances where the form and meaning correlation is often not one-to-one?

LSF has its source in a confluence of research approaches that follow a decompositional approach to meaning and, thus, defines simple lexemes and affixes by way of a systematic representation that is achieved via a constrained formal language that enforces consistency of annotation. Lexical-semantic representations in LSF consist of two parts: the Semantic/Grammatical Skeleton and the Semantic/Pragmatic Body (henceforth 'skeleton' and 'body' respectively). The skeleton is comprised of features that are of relevance to the syntax. These features act as functions and may take arguments. Functions and arguments of a skeleton are hierarchically arranged. The body encodes all those aspects of meaning that are perceptual, cultural, and encyclopedic.

Features in LSF are used in (a) a cross-categorial, (b) an equipolent, and (c) a privative way. This means that they are used to account for the distinction between the major ontological categories, may have a binary (i.e. positive or negative) value and may or may not form part of the skeleton of a given lexeme. In order to account for the fact that several distinct parts integrate into a single referential unit that projects its arguments to the syntax, LSF makes use of the Principle of Co-indexation. Co-indexation is a device needed in order to tie together the arguments that come with different parts of a complex word to yield only those arguments that are syntactically active.

LSF has an important impact on the study of the morphology-lexical semantics interface and provides a unitary theory of meaning in word formation.

Keywords: morphology, lexical semantics, semantic features, decomposition, co-indexation

1 Introduction[1]

The Lexical Semantic Framework (LSF, Lieber, 2004) is concerned with the study of the semantics of word-formation processes. Its central goal is to characterize the meaning of simple lexemes and affixes and to show how these meanings can be integrated in the creation of complex words.

LSF offers a systematic treatment of issues that figure prominently in the study of word formation:

(a) The polysemy question: why do derivational affixes often exhibit polysemy? Affixation of *-er*, for instance, creates nouns that have several interpretations: (i) agent (*driver*), (ii) instrument (*opener*), (iii) experiencer (*hearer*), (iv) stimulus (*pleaser*), (v) measure (*fiver*), (vi) denominal noun (*villager*), (vii) patient/theme (*keeper*), and (viii) location (*diner*).

(b) The multiple-affix question: why are there affixes that create the same kind of derived words (i.e. both *-er* and *-ant* create agent nouns, e.g. *writer*, *driver*, *servant*, *accountant*)?

(c) The zero-derivation question: how do we account for zero-affixation, that is, semantic change with no (overt) formal change (i.e. "conversion")?

(d) The form and meaning mismatches question: why are there instances where the form and meaning correlation is often not one-to-one?

In order to tackle these issues, LSF is characterized by four general features. First, it is decompositional. Thus, it makes use of primitives (atoms) of the right "grain size" (Lieber, 2004, 4). These primitives are features which make up the lexical-semantic representation of both simplex and complex lexemes. Second, it is lexical by nature. Thus, it is designed in a way that allows a treatment of the semantic properties of words (lexical-semantic properties) as opposed to semantic properties of other levels (e.g. phrases and discourses). Third, it is cross-categorial enough, in order to allow an in-depth analysis of all categories, such as nominals and verbs. Finally, given that word-formation processes serve to extend the simplex lexicon, LSF covers both simplex and complex words. Thus, LSF allows one to deal with the semantics of simplex and complex words in a parallel way.

In the following, we delve more deeply into the way LSF accounts for the semantic properties of both simplex and complex words. Section 2 presents the basic architecture of LSF. It introduces the semantic features used in LSF, and the way these features are distributed amongst the Grammatical Skeleton and the Pragmatic Body. Section 3 focuses on the two major ontological classes, namely SUBSTANCES/THINGS/ESSENCES and SITUATIONS.

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The remaining sections present the lexical-semantic properties of morphologically complex formations. Section 4 introduces the principle of co-indexation that ties together the arguments of morphological building blocks. Section 5 focuses on derivation, and Section 6 on compounding. Section 7 offers a treatment of form and meaning mismatches.

2 Semantic features: skeleton and body

LSF has its source in a confluence of research approaches that follow a decompositional approach to meaning (Jackendoff, 1990; Pustejovsky, 1995; Szymanek, 1988; Wierzbicka, 1996). In this respect, LSF defines simple lexemes and affixes by way of a systematic representation that is achieved via a constrained representation language that enforces consistency of annotation.

Given that LSF applies a decompositional approach to meaning, it makes use of a repository of universal semantic features to which every particular language has access. The following eighteen features form part of the set of universal semantic features (Lieber, 2009, 85-86): *material*, *dynamic*, *I(nferable) E(ventual) P(osition) of S(tate)*, *C(omposed) of I(ndividuals)*, *B(ounded)*, *Loc(ation)*, *scalar*, *animate*, *human*, *female*, *age*, *artifact*, *n dimension*, *orientation*, *consistency*, *function*, *contact*, and *motion with respect to focal point*. These features make up the lexical-semantic representation of lexemes in a compositional manner.

Lexical-semantic representations in LSF consist of two parts: the *Semantic/Grammatical Skeleton* and the *Semantic/Pragmatic Body* (for similar claims in the literature see Rappaport Hovav and Levin (1996, 1998) and Mohanan and Mohanan (1999)). Depending on their syntactic relevance, the universal semantic features can be part of the skeleton or the body of a lexeme in a given language.

The distinction between skeleton and body is a key aspect of the organization of lexical-semantic representations in LSF. The skeleton is fully formalizable, decompositional, hierarchically arranged, contains those aspects of meaning relevant to syntax, and is stable from speaker to speaker. All speakers, for example, are expected to share the same skeletal information for particular lexemes.

The body is partially formalizable and systematic, and consists of two parts (Lieber, 2009, 83). The first featural part of the body comprises the universal features that are semantically but not syntactically active in a given language. The second part of the body encodes all those aspects of meaning that are perceptual, cultural, and encyclopedic, such as colour, function, and dimension. The first part of the body is largely stable from one speaker to the other, whereas the information encoded in the second part diverges.

In order to better understand the make up of lexical-semantic representations in LSF, consider, for example, the lexeme *piston*. All speakers share the skeletal information that *piston* is a common noun (i.e. a SUBSTANCE/THING/ESSENCE). Speakers also share the featural bodily information that *piston* is human made (i.e. an artifact) and that it has a function. The second part of the body of the lexical-semantic representation of *piston*, however, is the locus of specialized user knowledge and, thus, it diverges from one speaker to the other. Some speakers, for instance, may know that *pistons* have something to do with cars, others may know that *pistons* are parts of engines, and others may even know that *pistons* are parts of reciprocating engines, are located in cylinders etc.

As far as English is concerned, there are at least seven semantic features relevant to

syntax and necessary for word formation. As illustrated in (1), features that are encoded into the skeleton are presented in square brackets. Features that are part of the body are enclosed in angle brackets (from Lieber, 2009, 85):

(1) [material]
[dynamic]
[IEPS]
[CI]
[B]
[Loc]
[scalar]
<animate>
<human>
<female>
<age>
<artifact>
<n dimension>
<orientation>
<consistency>
<function>
<contact>
<motion with respect to focal point>

The seven syntactically active features of English which are needed for the analysis of lexical meaning are defined as follows (from Lieber, 2009, 80):

(2) [± **material**]: The presence of this feature defines the conceptual category of SUBSTANCES/THINGS/ESSENCES, the notional correspondent of the syntactic category noun. The positive value denotes the presence of materiality, characterizing concrete nouns. Correspondingly, the negative value denotes the absence of materiality; it defines abstract nouns.

[± **dynamic**]: The presence of this feature signals an eventive or situational meaning, and by itself signals the conceptual category of SITUATIONS. The positive value corresponds to an EVENT or Process, the negative value to a STATE.

[± **IEPS**]: This feature stands for 'Inferable Eventual Position or State'. Informally, we might say that the addition of [IEPS] to a skeleton signals the addition of a path. The positive value implies a directed path, and the negative value a random or undirected path.

[± **Loc**]: Lexical items that bear the feature [Loc] for 'Location' are those for which position or place in time or space is relevant. For those items which lack the feature [Loc], the notion of position or place is irrelevant. Further, those which bear the feature [+Loc] will pertain to position or place. [-Loc] items will be those for which the explicit lack of position or place is asserted.

[± **B**]: This feature stands for 'Bounded'. It signals the relevance of intrinsic spatial

or temporal boundaries in a SITUATION or SUBSTANCE/THING/ESSENCE. If the feature [B] is absent, the item may be ontologically bounded or not, but its boundaries are conceptually and/or linguistically irrelevant. If the item bears the feature [+B], it is limited spatially or temporally. If it is [-B], it is without intrinsic limits in time or space.

[± **CI**]: This feature stands for 'Composed of Individuals'. The feature [CI] signals the relevance of spatial or temporal units implied in the meaning of a lexical item. If an item is [+CI], it is conceived of as being composed of separable similar internal units. If an item is [-CI], then it denotes something which is spatially or temporally homogeneous or internally undifferentiated.

[± **scalar**]: This feature signals the relevance of a range of values to a conceptual category. With respect to [-dynamic] SITUATIONS it signals the relevance of gradability. Those SITUATIONS for which a scale is conceptually possible will have the feature [+scalar]. Those SITUATIONS for which a scale is impossible will be [-scalar]. With respect to SUBSTANCES/THINGS/ESSENCES the feature [scalar] will signal the relevance of size or evaluation (i.e. this will be the feature which characterizes augmentative/diminutive morphology in those languages which display such morphology).

Features in LSF are used in (a) a cross-categorial, (b) an equipolent, and (c) a privative way. This means that they are used to account for the distinction between the major ontological categories, may have a positive or a negative value (binary value), and may or may not form part of the skeleton of a given lexeme. With respect to the privative use of these features, consider for example the feature [material]. This feature may be used in the lexical-semantic representation of nouns, but it is not relevant to the discussion of the semantics of verbs or adjectives. Thus, verbs and adjectives should not be characterized by this feature in their lexical-semantic representation.

3 Major ontological classes

3.1 SUBSTANCES/THINGS/ESSENCES *and* SITUATIONS

The features [material] and [dynamic] classify items into the two major ontological classes as SUBSTANCES/THINGS/ESSENCES and SITUATIONS. Items with the feature [material] as the outermost function of their skeleton belong to the class of SUBSTANCES/THINGS/ESSENCES and items with the feature [dynamic] as their outermost function are SITUATIONS.

The binary use of these features captures further distinctions that manifest themselves in these two classes. The presence of a positive or a negative value of the feature [material] derives the distinction between concrete and abstract nouns as shown in Figure 1:

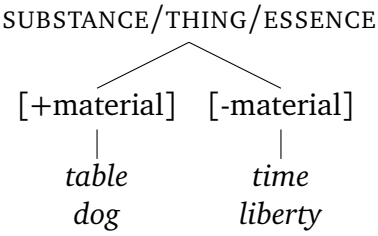

Figure 1: SUBSTANCES/THINGS/ESSENCES in LSF

The positive value of the feature [dynamic] characterizes the sub-class of EVENTS or PROCESSES and the negative value flags the sub-class of STATES, as illustrated in Figure 2:

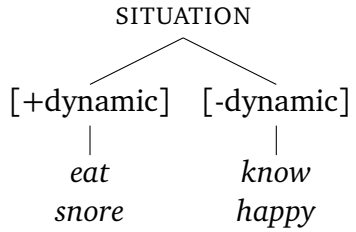

Figure 2: SITUATIONS in LSF

Figure 2 informs us that, in LSF, *happy* belongs to the class of SITUATIONS. In particular, adjectives in LSF are characterized by the features [-dynamic] and [scalar]. Thus, they are instantiations of the major ontological class of SITUATIONS and, more specifically, of the sub-class of STATES since they are characterized as [-dynamic]. They differ from stative verbs in that they bear the feature [scalar]. As shown in Figure 3, gradable adjectives such as *red* are characterized as [+scalar] and non-gradable adjectives, e.g. *dead*, are [-scalar].

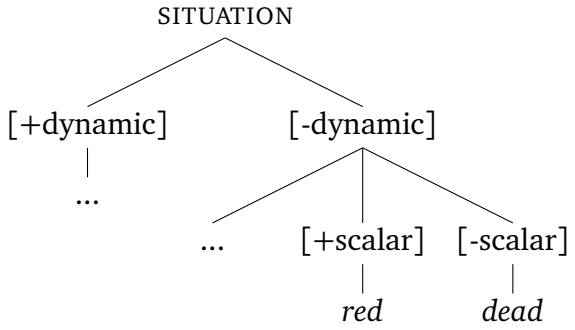

Figure 3: [+scalar] and [-scalar] STATES in LSF

The features [material] and [dynamic] are not mutually exclusive since there are SUBSTANCES/THINGS/ESSENCES that are "processual in flavor, denoting states, events, actions, or even relations of some sort, and also those which lack a processual flavor" (Lieber, 2004, 26). The difference between the processual *mother* that involves having or caring for a child, and *money* that lacks this processual aspect is given in (3) (adapted from Lieber, 2004, 27):

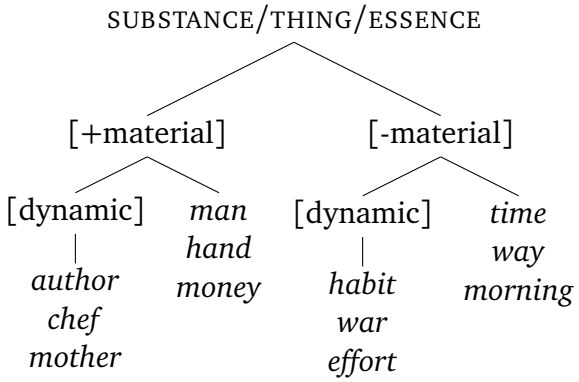

Figure 4: Processual SUBSTANCES/THINGS/ESSENCES in LSF

3.2 Formalizing lexical-semantic representations

In this section, we focus on the inner structure of the lexical-semantic representation of lexemes in LSF and present some of the major characteristics (i.e. aspectual and quantitative characteristics) of SUBSTANCES/THINGS/ESSENCES and SITUATIONS.

Features in LSF act as functions and may take arguments. In particular, the skeleton comprises a function and one or more arguments predicated of that function (3a). Like Jackendoff's (1990) Lexical Conceptual Structures, functions and arguments of a skeleton are hierarchically arranged as illustrated in (3b):

(3) a. $[F_1$ ([argument])]

b. $[F_2$ ([argument], $[F_1$ ([argument])])]

Let us apply this general format to SUBSTANCES/THINGS/ESSENCES and SITUATIONS.

3.2.1 SUBSTANCES/THINGS/ESSENCES

The skeletal part of lexemes denoting SUBSTANCES/THINGS/ESSENCES is characterized by at least one feature, namely [material], and the so-called "R" argument. This argument suggests "referential" and is involved in referential uses of NPs (Williams, 1981, 86). It is an external argument and it is called referential, for it is at the same time an argument of the predicate and its referent. In this respect, the concrete *table* and the abstract *time* are treated as one-place predicates that carry the "R" argument. Their skeletal representations are given in (4a) and (4b) respectively:

(4) a. *table* [+material ([R])][2]

b. *time* [-material ([R])]

Relational SUBSTANCES/THINGS/ESSENCES are treated as two-place predicates.[3] Thus, *leg* (e.g. the leg of X) and *friend* (e.g. the friend of X) in (5) carry two arguments in their

[2]Although in Lieber (2004), the referential argument "R" is not marked, in this chapter we will explicitly mark this argument in the structure of SUBSTANCES/THINGS/ESSENCES for ease of exposition.

[3]On relational nouns see Löbner (1985, 2011).

skeleton. In these cases, the highest argument of a relational noun is the "R" argument, and the second argument is the possessor argument:

(5) a. *leg* [+material ([R], [ ])]
b. *friend* [+material ([R], [ ])]

Consider now the lexical-semantic representation of the SUBSTANCE/THING/ESSENCE lexeme *mother* in (6):

(6) *mother* [+material, dynamic ([R], [ ])]

The skeleton in (6) reads as follows: *mother* is a concrete (i.e. [+material]) processual (i.e. [dynamic]) SUBSTANCE/THING/ESSENCE. In addition, it is a functional two-place predicate (i.e. mother of X). Thus, it carries two arguments (an "R" argument and a possessor argument).

So far, we have seen how the semantic features of the skeleton can be described in this framework but as we said, the representation of a lexical item consists of two parts, the skeleton and the body. In the following schemata I give the partial lexical-semantic representations of the words *author* and *bed* (adapted from Lieber, 2009, 86):

(7) a. *author* [+material, dynamic ([R], [ ]) SKELETON
<+animate> BODY
<+human>
<function>
{writes for publication,...}

b. *bed* [+material ([R]) SKELETON
<-animate> BODY
<+artifact>
<3 dimension>
<horizontal>
<function>
{for sleeping, contains comfortable surface,...}

The examples in (7) illustrate that the complete lexical-semantic representation of a lexeme in LSF consists of three parts. The first part is the skeleton. The skeleton of *author* consists of the features [+material] and [dynamic] and two arguments (e.g. author of a book). Thus, *author* is a concrete processual SUBSTANCE/THING/ESSENCE. The skeleton of *bed* is characterized by the feature [+material] and one argument, i.e. the 'R' argument. The second part of the representation is the systematic part of the body and consists of those semantically active features which are, nevertheless, syntactically inactive. This part informs us that *author* is <+animate>,<+human>, and has a <function>. In a similar vein, *bed* is <-animate>, <+artifact>, <3 dimension>, <horizontal>, and has a <function>. The third part of the representation is the part of the body in which encyclopedic information about the lexical item is provided. Thus *author* {writes for publication,...} and *bed* is {for sleeping...}.

3.2.2 SITUATIONS

SITUATIONS are those items that carry the feature [dynamic] as the outermost function of their skeleton. (8a) provides the skeleton of the EVENT *snore* and (8b) gives the skeleton of the STATE *know*:

(8) a. *snore* [+dynamic ([ ])]

b. *know* [-dynamic ([ ], [ ])]

Observe that *snore* has one argument in its skeleton since it is an one-place predicate. The skeleton for *know* comes with two arguments since this verb is a two-place predicate. It has both an internal and an external argument (e.g. *I know the answer*.).

The addition of the feature [I(nferable) E(ventual) P(osition) or S(tate)] to the skeleton of a verb captures further distinctions as illustrated in Table 1:

[+dynamic ([ ], [ ])]	simple activity verb	*do*
[+dynamic, +IEPS ([ ], [ ])]	change of state	*brake*
[+dynamic, +IEPS ([ ], [ ])]	change of place	*ascend*
[+dynamic, -IEPS ([ ])]	manner of change	*walk*

Table 1: Aspectual classification of verbs

[IEPS] accounts for the major aspectual classes of verbs and signals the addition of a sequence of Places or States. That is, it adds a Path component of meaning. In particular, the presence of this feature with a positive value means that the path is directed. Consider, for example, that the [+IEPS] verbs *brake* and *ascend*, imply a Path in which there is progression from one point to the other but the initial and final points are not the same. A negative value signals a random path. This state of affairs is exemplified by *walk* in which we can make no inference with respect to the relationship between the initial and final points (they might be the same).

As presented in the previous section, adjectives belong to the class of SITUATIONS, and, in particular, to the class of STATES. (9) provides the skeletal part of the adjectives *red*, *dead*, and *fond*. Gradable adjectives are characterized as [+scalar], and non-gradable adjectives are flagged by the feature [-scalar].

(9) a. *red* [-dynamic, +scalar ([ ])]

b. *dead* [-dynamic, -scalar ([ ])]

c. *fond* [-dynamic, +scalar ([ ], [ ])]

Like verbs and nouns, adjectives can be either one-place predicates or two-place predicates. The adjectives *red* (10a) and *dead* (10b) are one-place predicates, and *fond* is a two-place predicate (e.g. *fond of music*), respectively.

3.3 Quantity

An important aspect of the semantics of both SUBSTANCES/THINGS/ESSENCES and SITUATIONS is quantity. In LSF, quantitative semantics, that is, duration, internal individuation,

and boundaries of SUBSTANCES/THINGS/ESSENCES and SITUATIONS can be characterized by the same features, namely, [B(ounded)] and [C(omposed of) I(nividuals)]. The use of the same set of features for both classes follows from the cross-categorial characteristic of LSF since semantic features can be used for the discussion of various categories. It should be mentioned that [B] and [CI] are meant to handle only those quantitative characteristics of meaning that manifest themselves at the lexical level.

In more detail, as far as SUBSTANCES/THINGS/ESSENCES are concerned, the feature [B] can be used to distinguish between count [+B] and mass [-B] nouns. In addition, the feature [CI] is used for the distinction between nouns that are not composed of discernible replicable parts, i.e. [-CI], and aggregates which are characterized as [+CI]. Consider the following from Lieber (2004, 137):

[+B, -CI]	singular count nouns	*apple*
[-B, -CI]	mass nouns	*luggage*
[+B, +CI]	group nouns	*flock*
[-B, +CI]	plural nouns	*sheep*

Table 2: Classification of nouns based on quantitative semantics

The noun *person*, for example, is characterized as [+B, -CI] because it is an individual noun (count noun) and at the same time, is not composed of discernible replicable parts. The word *luggage* bears the specification [-B, -CI] in its skeleton since it is a mass noun composed of discernible replicable parts. *flock* as a group noun is characterized by the features [+B, +CI]. Finally, the plural noun *sheep* is a conglomeration of similar individuals and is, therefore, characterized by the features [-B, +CI] in its skeleton.

With respect to SITUATIONS, [B] and [CI] capture quantitative and aspectual characteristics. [+B] events are those verbs which may have duration, but their duration is not linguistically significant, whereas [-B] events are those verbs the duration of which is linguistically significant. A temporally punctual situation, i.e. a [+B] event, such as *explode* and a temporally durative one, i.e. a [-B] event, such as *walk*, behave differently with adverbials as in (10) (from Lieber, 2004, 138):

(10) a. *The bomb exploded for an hour.

b. We walked for an hour.

The examples in (10) show that language makes a distinction between those events that are punctual and those events that are durative; the durative adverbial "for an hour" can be used with the [-B] *walk* but not with the [+B] *explode*.

The use of the feature [CI] with respect to events captures the distinction between iterativity and homogeneity. In more detail, the use of [CI] with a positive value is the equivalent of plurality in nouns. Just as plural nouns are composed of discernible replicable parts, [+CI] events such as *pummel* denote repeated actions of the same sort; *pummel* 'to produce repeated blows'. The use of [CI] with a negative value with respect to events corresponds to non-plural nouns (single individuals or mass nouns). Therefore, [-CI] SITUATIONS are those events which are not composed of multiple, repeated actions of the same sort. The following summarizes the various aspectual event classes:

[+B, -CI]	nonrepetitive punctuals	*explode*
[-B, -CI]	nonrepetitive duratives	*ascend*
[+B, +CI]	<logically impossible>	
[-B, +CI]	repetitive duratives	*pummel*

Table 3: Classification of verbs based on quantitative semantics

A [+B, +CI] SITUATION is not possible since this would mean that an event could be both punctual and composed of multiple, repeated, and identical actions.

4 The Principle of Co-indexation

The previous section was devoted to the study of some salient characteristics of simplex lexical items. In the following sections, we delve more deeply into the study of the way the theoretical apparatus of LSF accounts for the semantics of complex words.

The creation of a morphologically complex word involves not only the combination of two (or more) morphemes on a structural level, but also the integration of distinct morphemes on a semantic level. In order to account for the fact that several distinct parts, an affix and a lexical base in the case of derivation and two lexemes in the case of compounding, integrate into a single referential unit, Lieber (2004) introduces the Principle of Co-indexation. This is "[...] a device we need in order to tie together the arguments that come with different parts of a complex word to yield only those arguments that are syntactically active" (Lieber, 2004, 45). Co-indexation reads as:

(11) Principle of Co-indexation
In a configuration in which semantic skeletons are composed, co-index the highest nonhead argument with the highest (preferably unindexed) head argument. Indexing must be consistent with semantic conditions on the head argument, if any. (Lieber, 2004, 61)

The highest argument of the skeleton is the argument of the outermost lexical function of the head. In order to identify the highest argument of the skeleton in complex formations, consider the schemata below:

(12) Concatenation of functions
[αF1 ([ ])] [βF2 ([ ])]

(13) Subordination of functions

a. [αF1 ([ ], [βF2 ([ ])])]

b. [αF1 ([βF2 ([ ])])]

The schema in (12) illustrates the mechanism of concatenation of functions which accounts for compounding, and the schema in (13) shows the subordination of functions which is evident in affixation. As far as compounding is concerned, the highest argument in (12) is the argument of the lexeme [βF2].

Observe that affixation in (13), is accounted for by two sub-schemata. As we will see in the next section, (13a) accounts for affixes that carry an argument in their skeleton. In these cases, the highest argument of the skeleton in (13a) is the argument of the affix, that is, the argument of [αF1]. Affixation that involves subordination of functions without indexing of arguments is regulated by (13b). In this schema, the highest argument of the skeleton is the argument of the base, that is, the argument of [αF2].[4]

5 Derivation in LSF

The first issue which arises in derivation is how we should treat elements below the level of word, that is, affixes. In LSF, affixes have a skeleton and their semantic contribution can be accounted for by the same semantic features which are needed for the description of the semantics of simplex words. Consider, for example, the affix *-er*:

(14) *-er* [+material, dynamic ([R], <base>)]

The semantic contribution of the affix *-er* can be described as the addition of the features [+material] and [dynamic] to a <base>. More specifically, *-er* creates concrete and processual SUBSTANCES/THINGS/ESSENCES. Notice, however, that although affixes have a skeletal part, the semantic content of an affix is abstract and underdetermined since affixes have no (or little) body. This is a source for polysemy in word formation. That is, the semantic contribution of the affix can be spelled out in several ways when the affix is combined with the more semantically robust base and deployed in context.

5.1 S-selection

The lexical-semantic representation of an affix contains information about the type of lexemes that could serve as bases for the derivation. A basic tenet of LSF is that selection is primarily semantic (s-selection) and not categorial (c-selection) (Lieber, 2007). That is, affixes select for the semantic category rather than the syntactic category of their bases (see Plag, 2004 for a similar proposal).

A comparison between the traditional c-selection hypothesis and the hypothesis that selection is primarily semantic shows that s-selection allows us to capture subtle selectional properties of affixes that are difficult to model in terms of c-selection. In order to best account for the selectional properties of *-ship*, for instance, it does not suffice to merely mention that this affix attaches to nouns (e.g. *stewardship*, *accountantship*). One must specify that *-ship* shows a strong preference for concrete processual nouns, that is, SUBSTANCES/THINGS/ESSENCES that are [+material, dynamic].

LSF allows us to model even more subtle selectional properties as in the lexical-semantic representation of a prefix such as *re-*. In terms of c-selection, *re-* attaches to verbs, but an analysis that takes into consideration the semantic properties of the base can account for the fact that *re-* does not attach to all verbs (e.g. **reknow*, **reexplode*). This prefix only attaches to a well-defined class of SITUATIONS with the skeleton in (15):

[4]For more on subordination of functions and arguments in affixation see Andreou (2015).

(15) Bases for *re-*
<[+dynamic, -CI, +IEPS (..., [$_{\text{Path. State: stage level}}$])]>

The representation in (15) informs us that *re-* attaches to [+dynamic] SITUATIONS, i.e. events, that are not inherently iterative, i.e. [-CI], may be inchoative or unaccusative, i.e. [+IEPS], and have an argument which can be interpreted as a Path or Result that is reversible, i.e. [$_{\text{Path. State: stage level}}$]. The three dots indicate that there may be other arguments in the base as well. According to Lieber (2004, 2007), the distinction between stage- and individual-level items Carlson (1977) captures the difference between permanent and non-permanent results in SITUATIONS. Stage-level results are contemporary and, consequently, reversible, whereas individual-level results cannot be reversed.

The foregoing discussion shows that the theoretical apparatus of LSF allows one to model the selectional properties of affixes in a detailed manner (e.g. prefixation of *re-*) and to take into consideration that even within the same class, an affix may show a strong preference for a specific sub-class of bases to attach to (e.g. *-ship*).

5.2 Co-indexation in derivation

In this section we examine the way the mechanism of co-indexation ties together the arguments of the base and the affix in derived words. Given that affixes have their own skeleton, affixation involves the addition of this skeletal material as the outermost function to the skeleton of a base, thereby subordinating the base in question as schematically shown in (13).

In (13a), both the base [βF2] and the affix [αF1] come with open argument positions in their skeletal part. Thus, the principle of co-indexation is needed in order to regulate the interaction between the arguments of the base and the affix.

The derivation of *driver*, for example, involves the co-indexation of the highest argument of the non-head, which is the verb *drive*, with the only argument of the head, which in this particular case is the affix *-er*. The skeletons of *-er* and *drive*, as well as the application of the principle of co-indexation are illustrated below:

(16) a. *-er* [+material, dynamic ([R], <base>)]
b. *drive* [+dynamic ([ ], [ ])]
c. *driver* [+material, dynamic ([R$_i$], [+dynamic ([$_i$], [ ])])]

Since there are no semantic conditions on the head argument, the highest argument of the nonhead, in this particular case the external argument of the verb *drive*, is co-indexed with the highest (and only) unindexed argument of the head, that is, the 'R' argument of *-er*. Given that co-indexation accounts for the referential properties of complex items, the result of the co-indexation process is that the derived word is interpreted as bearing the role of the external argument of the verb; in this case it is an agent.

As noted in the definition of the principle of co-indexation in (11), indexing must be consistent with semantic conditions on the head argument, if any. Although the combinatorial properties of *-er* do not impose such semantic conditions, other affixes such as *-ee* come with specific semantic requirements in their skeleton. Consider the lexical-semantic representation of *-ee*:

(17) *-ee* [+material, dynamic ([$R_{\text{sentient, nonvolitional}}$], <base>)]

It follows from the representation in (17) that *-ee* places specific semantic conditions on its co-indexed argument. In particular it requires to be co-indexed with a sentient and non-volitional argument (Barker, 1998). Consider now the derivation of the word *employee* (Lieber, 2004, 63):

(18) [+material, dynamic ([$R_{\text{sentient, nonvolitional-i}}$], [+dynamic ([ ], [$_i$])])]
-ee *employ*

Given that the first argument of the verb *employ* is always volitional, the only argument of the affix must be co-indexed with the second argument of the base, namely the patient argument, which is always nonvolitional. From this follows the theme reading of the word *employee*.

The mechanism of subordination of functions, which regulates affixation, does not always involve indexing of arguments. Consider, for example, the negative prefix *in-* on adjectives. This prefix does not carry an argument in its skeleton as shown in (19). Thus, the contribution of *in-* is characterized by the feature [-Loc], which flags negation. The use of the [-Loc] feature in LSF is equivalent to the negation operator "¬".

(19) *in-* [-Loc (<base>)]

Given that the prefix does not carry an argument in its skeleton, the only argument present in the schemata in (20a) and (20b), is the argument of the base, i.e. the adjective. Thus, these cases of derivation are accounted for by the schema in (13b), which regulates subordination of functions without indexing of arguments.

(20) a. Contrary reading
[-Loc ([-dynamic, +scalar ([ ])])]
in- *appropriate*

b. Contradictory reading
[-Loc ([-dynamic, -scalar ([ ])])]
in- *animate*

The schemata in (20) can inform the discussion on a key aspect of word formation, that is, "constructional polysemy" (Copestake & Briscoe, 1996; Pustejovsky & Boguraev, 1996). This is the kind of "[...] polysemy that follows from a single skeleton which is interpreted in a number of ways depending upon the bases with which it combines" (Lieber, 2004, 89). In other words, the different readings of *in-* in (20) do not follow from distinct representations, but from the interaction of the general negative meaning of this prefix with the properties of the bases it attaches to. In particular, the schemata in (20) capture the generalization that *in-* delivers contrary readings with gradable adjectives (e.g. *inappropriate*) and contradictory readings with non-gradable adjectives (e.g. *inanimate*). Whether *in-* results in a contrary or contradictory reading is a matter of the gradability of the base it attaches to. The adjective *appropriate* is gradable, i.e. [+scalar], and thus between *appropriate* and *inappropriate* there can be intermediate states. In addition, both *appropriate*

and *inappropriate* can be false at the same time. The adjective *animate*, however, is non-gradable, i.e. [-scalar] and, as a result, there can be no middle state between *animate* and *inanimate*. From this follows the contradictory reading of *inanimate*.

To sum up, co-indexation is a mechanism that operates on the arguments of the base and the affix and determines the reference of the derived word. The fact that co-indexation must be consistent with semantic conditions on the head argument accounts for the agentive reading of *driver* and the object-oriented meaning of *employee*. The affix *-er* most productively selects for verbs the external argument of which is volitional and *-ee* has scope over the sentient and non-volitional argument of the verb it combines with. There are affixational processes, nevertheless, that do not involve coindexation of arguments. As illustrated by prefixation of *in-*, in these cases, the affix does not carry an argument in its skeleton. Finally, the underdetermined semantic content of affixes is a source for polysemy in word formation. The different readings of words derived with the same affix do not follow from distinct representations of the affix, but from the interaction of the general meaning of the affix with the properties of the bases it attaches to.

6 Compounding in LSF

Compounds in LSF are formed by concatenation of skeletons with concomitant co-indexing. Thus, compounding involves the composition of bases. In what follows, we present the way co-indexation works in the three compound types, namely, argumental, coordinate, and attributive compounds (Bauer, Lieber, & Plag, 2013).

6.1 Argumental compounds

Argumental compounds in LSF are those compounds in which there is an argumental relation between the head and the non-head. In synthetic compounds, such as *bus driver*, the non-head is interpreted as an argument of the verbal base (i.e. the head). Consider for example the compound *burrito assembler* (from Lieber, 2010, 135):

(21) [+material ([R_j])] [+material, dynamic ([R_i], [+dynamic ([$_i$], [$_j$])])]
burrito *-er* *assemble*

This compound is formed as follows. The first step involves the derivation of the word *assembler*. The affix *-er* has no semantic conditions with respect to the argument it co-indexes with and, as a result, the "R" argument of the affix co-indexes with the highest argument of the verb, i.e. the external argument. The second step is the co-indexing of the "R" argument of the non-head *burrito* with the only unindexed argument of the verb, i.e. the internal argument. From this follows the object-oriented reading of the compound.

6.2 Coordinate compounds

In coordinate compounds, the compound members bear equal semantic weight (Bauer et al., 2013, 479). In order to account for the semantics of coordinate compounds one must take into account the complete lexical-semantic representations of the compound members since the nearly identical features of the compound members allow for the complete identification of reference. Consider, for example, the compound *actor author*:

(22)	*actor*	*author*
	[+material, dynamic ([R_i])	[+material, dynamic ([R_i])
	<+animate>	<+animate>
	<+human>	<+human>
	<function>	<function>
	{performs in a film,...}	{writes for publication,...}

Consider, first, the skeletal part of the two lexemes. In (22), the lexemes *actor* and *author* have identical skeletons. Both are concrete processual SUBSTANCES/THINGS/ESSENCES. In accordance with the principle of co-indexation, the "R" arguments of the two lexemes are co-indexed. Consider now the body part of the two lexemes. Observe that the first featural part of the two lexemes is identical. That is, both lexemes are <+animate>, <+human>, and have a <function>. The information in the second encyclopedic part, however, diverges; *actor* {performs in a film,...}, whereas, *author* {writes for publication,...}.

The analysis shows that the coordinative interpretation is the result of compounding two lexemes that have nearly identical lexical-semantic representations. Only encyclopedic knowledge differs from one lexical item to the other. In particular, co-indexation of the "R" arguments of *actor* and *author*, and the compatibility of the features of the skeleton and the formal part of the body allows for the complete identification of reference.

6.3 Attributive compounds

In atributive compounds there is a modification relation between the head and the non-head. This category of compounding in LSF is the default category since attributive compounds involve neither argumental relation between the head and the non-head (subordinate type) nor identification of reference (coordinate type). Consider, for example, the compound *bamboo bed*:

(23)	*bamboo*	*bed*
	[+material ([R_i])	[+material ([R_i])
	<+animate>	<-animate>
	<-human>	<+artifact>
		<function>
	{tropical plant,...}	{for sleeping,...}

Both *bamboo* and *bed* in (23) carry an "R" argument. Thus, the principle of co-indexation applies in order to tie together the "R" arguments of the two lexemes. Although the skeletons of *bamboo* and *bed* are identical, the body parts of the two lexemes are not compatible. Thus, a coordinative interpretation is ruled out. In addition, there is no relation of subordination between the head and the non-head. This rules out a subordinative interpretation. Thus, the interpretation of *bamboo bed* is a matter of the speaker finding a plausible relationship between the two lexemes. In this example, the relationship between the head and the non-head depends on the encyclopedic knowledge that *bamboo* has a <function>, namely, it can be used as a material for <+artifacts>. From this follows the modification relation "made of" in *bamboo bed*.

6.4 Exocentricity

Exocentric compounds do not introduce any extension to the framework. In particular, the lexical-semantic representation of exocentric compounds is not different in principle from the representation of endocentric compounds. Thus, exocentricity is attributed to general grammatical principles and mechanisms that are not specific to compounding. The exocentric *birdbrain* and the endocentric *bamboo bed*, for example, exhibit the same relationship between their members. That is, the relationship between their members is one of attribution. They differ only with respect to the fact that the exocentic *birdbrain* is interpreted metonymically (Bauer, 2008, 2010). In particular, *birdbrain* is based on the PART FOR WHOLE metonymy, and, thus, a part of a person (i.e. *brain*) is used to denote the person in question.

7 Form and meaning mismatches

Mismatches between form and meaning are evident in conversion (e.g. $hammer_N$ $hammer_V$), derivational redundancy (e.g. *re-rewrite*), semantic subtraction (e.g. *ritualistic*), and in cases of empty morphs (e.g. *orient-at-ion*).

Conversion is defined as semantic change without concomitant formal change. In English, there is Noun-to-Verb conversion (e.g. $hammer_N$ $hammer_V$), Verb-to-Noun conversion (e.g. $throw_V$ $throw_N$), and Adjective-to-Verb conversion (e.g. $cool_A$ $cool_V$). English conversion in LSF is best analyzed as "relisting in the lexicon" (Lieber, 1992, 159) rather than the addition of phonologically null affixal material (Don, 1993; Hale & Keyser, 2002). A comparison between the products of the highly productive *-ize* and conversion reveals that converted items show a greater semantic diversity. Consider, for example, *hammer* and *bark* (from Plag, 1999, 220). The verb *to hammer* belongs to the instrumental category, and the verb *to bark* belongs to the privative category. These categories, crucially, are never expressed by the affix *-ize* and its neologisms. Given the broad range of meanings expressed by conversion in English, we should not collapse conversion and affixation. Thus, a conversion verb such as *hammer* in LSF is analyzed as a noun that gets relisted in the mental lexicon as verb.

Let us turn to derivational redundancy. In LSF there is no principled constraint on the recursive attachment of affixes with the same meaning. Expressing the same content more than once in the same word is possible when useful and meaningful. Thus, derivational redundancy is both useful and meaningful in *re-rewrite*, for example, in which the iterative meaning of *rewrite* is intensified by the "redundant" prefixation of the same prefix, i.e. *re-*.

In cases of semantic subtraction, a derivational affix attaches to an already affixed word, but the meaning of the affix closest to the base does not contribute to the meaning of the whole. Consider, for instance, [[ritual] ist] ic]. Although the affix *-ic* creates relational nouns, the meaning of *ritualistic* is not 'pertaining to a ritualist' but rather 'pertaining to ritual'. The meaning of *-ist*, is in a way canceled as a result of affixation of *-ic*. In LSF, cases of semantic subtraction are accounted for by allomorphy. Thus, *-istic* in *ritualistic* is considered an allomorph of *-ic*.

In a similar vein, empty morphs, that is, forms that lack semantic content, are also amenable to treatment as cases of allomorphy. Consider, for example, that *-at-* in *orientation* adds no meaning to the whole. In LSF, forms such as *-at-* are analyzed as cases of

allomorphic variation of either the base or the affix (for more on this issue see Bauer et al., 2013, 181).

8 Conclusions

The focus of generative morphological theory has long been on examining the formal rather than the semantic properties of lexical items. LSF is a framework of meaning in word formation and offers a systematic treatment of the way meanings can be integrated in the creation of complex words.

LSF is decompositional, lexical by nature, cross-categorial, and focuses on both morphologically simplex and complex words. Thus, LSF allows one to analyze in a parallel and decompositional manner the meaning properties of both morphologically simplex and complex words.

A key aspect of the organization of lexical-semantic representations in LSF is the distinction between skeleton and body. Semantic features that are syntactically active belong to the skeleton and the remaining semantic features are relegated to the body.

The integration of distinct representations on a semantic level is regulated by the Principle of Coindexation. This principle account for the way the distinct parts of complex words (e.g. derived and compound words) integrate into a single referential unit.

Affixation is LSF is accounted for by subordination of functions. The apparatus of LSF allows one to offer a detailed account of the selectional properties of affixes and to take into consideration that even within the same class, an affix may show a strong preference for a specific sub-class of bases to attach to.

As fas as polysemy in affixation is concerned, the different readings of words derived with the same affix do not follow from distinct representations of the affix, but from the interaction of the general meaning of the affix with the properties of the bases it attaches to. Thus, the underdetermined semantic content of affixes is a source for polysemy in word formation.

Compounding in LSF is accounted for by concatenation of functions with concomitant co-indexing. The interpretation of subordinate compounds (e.g. *burrito assembler*) follows from the argumental relation between the head and the non-head. The coordinate interpretation of a compound such as *actor author*, is the result of compounding two lexemes that have nearly identical lexical-semantic representations. Only encyclopedic knowledge differs from one lexical item to the other. The category of attributive compounds is the default category in LSF since attributive compounds involve neither argumental relation between the head and the non-head (subordinate type) nor identification of reference (coordinate type). The interpretation of attributive compounds, such as *bamboo bed*, depends on establishing a plausible relationship between the two lexemes. This relationship follows from encyclopedic knowledge. Finally, exocentricity is attributed to general mechanisms such as metonymy that are not specific to compounding.

LSF offers a treatment of issues pertaining to form and meaning mismatches. Semantic change with no (overt) formal change (i.e. conversion) is analyzed as relisting in the lexicon. In LSF there is no principled constraint on the recursive attachment of affixes with the same meaning (i.e. derivational redundancy). Thus, expressing the same content more than once in the same word is possible when useful and meaningful. Finally, empty morphs and cases of semantic subtraction are amenable to treatment as cases of allomorphy.

Work in LSF has inaugurated a new research program in the morphology-lexical semantics interface and has shown that meaning is essential for a proper treatment of word formation. Following Lieber's (2004) seminal monograph, a number of publications that deal with the interface between morphology and lexical-semantics have appeared. With respect to affixation, these include studies on event and result nominals (Lieber, in press-a; Melloni, 2011), transposition and conversion (Lieber, 2015), historical examination of affixes (Trips, 2009), analysis of the selectional properties of affixes in Optimality Theory (Lieber, 2010b), and evaluative affixation (Andreou, 2015). As far as compounding is concerned, Lieber (2010) discusses non-affixal (de)verbal compounds (e.g. *dog attack*, *attack dog*), Lieber (in press-c) examines synthetic compounds, and Lieber (in press-b) and Andreou (2014) offer a more detailed survey of exocentricity. Lieber (in press-a) introduces further mechanisms that account for semantic properties of derived words in context.

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