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The KEY to lexical semantic representations[1]

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It is widely accepted that the semantic content of a lexical entry determines to a large extent its syntactic subcategorization or other contexts of occurrence. However, clarifying the precise extent to which this hypothesis holds has proven difficult and on occasion controversial. To maintain this hypothesis, scholars have in many difficult cases introduced syntactic diacritics in their lexical semantic representations, thereby running the risk of rendering it vacuous. Our answer to this challenge is two-fold. First, on the substantive side, we argue that the problem lies in the assumption that the semantic content of lexical entries consists of a recursive predicate-argument structure. In contrast, we claim that the semantic content of lexical entries can consist of a *set* of such structures, thus eschewing semantically unmotivated predicates that merely ensure the correct semantic geometry. Second, on the structural side, we suggest that the semantic content of words can idiosyncratically select one of those predicate-argument structures for the purposes of direct grammatical function assignment. We show that this hypothesis, which builds on independently motivated proposals regarding the form of underspecified natural language semantic representations, provides a clean account of linking phenomena related to several classes of predicators: verbs whose denotata require the presence of an instrument, the semantic role of French 'adjunct' clitics, commercial event verbs, the *spray/load* alternations, and lexical subordination constructions.

Theories of the general principles governing the mapping of the semantic arguments of predicators onto syntactic functions or their subcategorization are often referred to as linking theories or mapping theories.[2] It is now

[1] The order of the authors' names is random; each contributed equally to this paper. This paper expands on Davis & Koenig (2000a). We gratefully acknowledge John Beavers, Emily Bender, Bob Borsley, Manfred Sailer, and two anonymous *JL* referees for their generous comments on a previous version of this paper. All remaining errors are ours.

[2] We use the term 'predicator' in this paper to label verbs or other relation-denoting expressions.

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widely believed that the semantic content of a lexical entry determines to a large extent its syntactic contexts of occurrence or subcategorization properties (Baker 1988, Pinker 1989, Jackendoff 1990, Van Valin 1993, Goldberg 1995, Levin & Rappaport Hovav 1995, Wechsler 1995b, Davis & Koenig 2000b, Koenig & Davis 2001). We will refer to this general hypothesis, developed in many variants by these authors and others, as the Semantic Basis Hypothesis (hereafter, SBH). One should not overstate the intended predictive power of the SBH. It does not allow one to predict the syntactic contexts of occurrence of verbs given just the denotation of the verb. At a mininum, the predictions should be conditionally restricted by the language to which the verb belongs and by any syntactic irregularity the verb may have. The syntactic predictive power of the SBH can be expressed as follows:

> HYPOTHESIS 1 (SEMANTIC BASIS HYPOTHESIS) If you know a language and you are presented with a new verb, you can predict a fair amount of its subcategorization (possibly all of it, if the verb is not syntactically irregular).

Technically, we can view the SBH as making the claim that true implicational statements of the following form can be provided for a large portion of the verbal lexicon of a wide variety of languages (where *isa* is a standard subclass-superclass predicate):

(1) $(\text{verb}(v) \text{ and } \text{meaning}(v, w) \text{ and } \text{isa}(w, t) \text{ and } \text{regular}(v)) \Rightarrow \text{subcat}(v, s)$

In other words, given the meaning of a verb, the semantic class of its meaning and the fact that the verb is syntactically regular, the syntactic subcategorization of the verb follows. This semantic underpinning of a large portion of subcategorization has greatly reduced the need to stipulate the syntactic properties of individual lexical entries, devolving the explanation for the surface behavior of predicators to its most plausible source, the meanings of words (see Davis & Koenig 2000b, Davis 2001 for details on how the SBH can alleviate the burden of specifying the subcategorization of individual entries in a hierarchical lexicon). Reciprocally, the SBH might also be used by children as a heuristic for learning the meanings of new verbs (see Landau & Gleitman 1985).

Unfortunately, despite these successes, this program has shortcomings. A major one, on which this paper focuses, is that in order to state linking regularities, researchers – including us – have often resorted to otherwise unmotivated predicates or an *ad hoc* feature geometry for the representation of the semantic content of predicators. In other words, some of the proposed

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semantic basis of subcategorization is disguised syntax. Our first goal in this paper is to distinguish those aspects of linking that are model-theoretically motivated (i.e. motivated by the properties of the denoted situation-types), those that may be semantically motivated, but are not motivated by the properties of the denoted situation-types, and those that must be lexically stipulated.

The source of the inclusion of what are, in effect, syntactic diacritics in the semantic representation of verbs lies, we believe, in a common tacit assumption, namely that the semantic content of lexical entries consists of a *single* semantic unit. Because such a unit can be abstractly viewed as a single-rooted tree (or, possibly, a connected directed acyclic graph), we call this hypothesis the *semantic tree hypothesis*. Drawing on work on underspecified semantic representations, we argue here that the semantic content of lexical entries consists instead of a set of semantic units. We call this hypothesis the *semantic set hypothesis*. We show that this hypothesis not only solves several outstanding issues in semantically-based linking theories, but also provides for a more restrictive linking theory, continuing the program of Pinker (1989), Grimshaw (1993), Wechsler (1995a), and Wunderlich (1997) to reduce linking to a few simple constraints. Our second goal, like that of those authors, is to determine those aspects of linking that are semantically motivated. In a previous paper (Koenig & Davis 2001) we have argued that the semantic content of lexical entries can be divided into a relational component, which describes types of relations among participants, and a modal component, which evaluates those relations at different worlds, and that only the relational component is relevant to the linking of arguments to direct grammatical functions. We go further in this paper and claim that the meaning of lexical entries can consist of a set of such relations and their associated modal modifiers, but that only *one* of these is relevant to the linking of arguments to direct grammatical functions. If correct, this claim suggests that even though there seems to be no limit to the complexity of the semantic information encoded in a single morpheme, the portion of this information targeted by linking constraints must be fairly limited. Somewhat more negatively, we argue that the selection of the semantic information targeted for linking is partly arbitrary; it cannot be predicted completely from properties of the situations denoted by the set of units that define a lexical entry's meaning, and therefore must be noted as one of the idiosyncrasies of lexical entries.

The paper is organized as follows. The first section presents several instances in which proponents of semantically-based linking have resorted to unmotivated semantic analyses to ensure that the semantic arguments of a predicator 'link correctly'. Section 2 presents our solution to these problems, while section 3 provides examples of additional benefits of our approach to the lexical semantics of predicators.

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1. *Ad hoc* LEXICAL SEMANTIC REPRESENTATIONS

The gist of the problem faced by the SBH is exemplified by the verbs *borrow* and *lend*, exemplified in sentences (2). Despite their similar meanings, the linking of the two verbs' arguments differs (see Fillmore 1977 and Gawron 1983 for early discussions of some of the issues we raise here).

(2) (a) Jill borrowed a pen from Sandy.
(b) Sandy lent a pen to Jill.

In this section, we detail this and several other cases that challenge the SBH and which have led some researchers to propose *ad hoc* lexical semantic representations.

The problems the SBH faces are best understood by exemplifying its consequences for the statement of linking constraints, so we first briefly present linking constraints for the direct arguments of English predicators. We take our constraints from the Head-driven Phrase-Structure Grammar (henceforth, HPSG, Pollard & Sag (1994)) linking theory presented in Davis & Koenig (2000b) and Koenig & Davis (2001). Nothing significant hinges on this choice, however; similar difficulties would arise for linking rules or constraints proposed by most scholars who adopt the SBH. But, since we present our solution within the framework developed in our previous work, exemplifying HPSG-style linking constraints for direct arguments makes future comparisons easier. Similarly, although we use typed feature structures to encode the lexical semantics of words, our arguments and analysis do not depend on this choice. They translate straightforwardly into any predicate calculus, term logic, or conceptual structure representations.

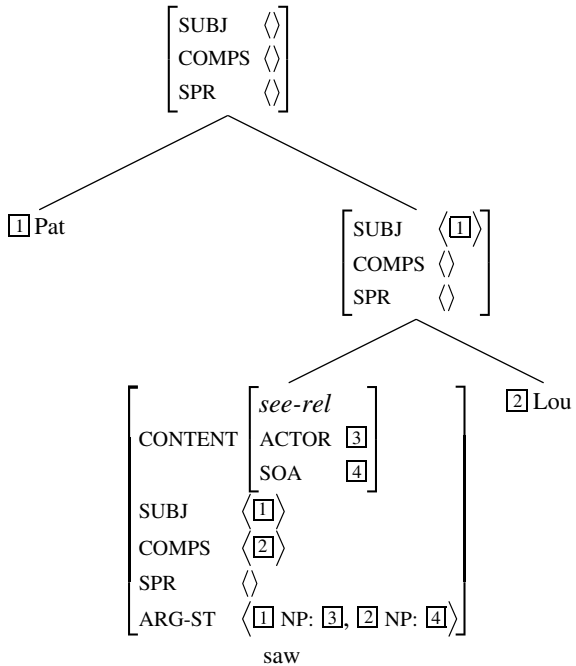
1.1 *Linking in HPSG*

As in other lexically-oriented approaches to syntax, the phrase structure of sentences in HPSG derives from the subcategorization of lexical entries. The manner in which lexical information is projected into constituent structure is exemplified in (3). This figure describes sentences such as *Pat saw Lou*.[3]

[3] HPSG-savvy readers will notice that the attributes shown in figure (3) are actually not attributes of *word* or *phrase*, but of the local portion of the *synsem* (syntax and semantics information) within each word or phrase. We omit these additional attributes for clarity. The terms ACTOR and UNDERGOER are not traditional semantic roles. They are defined as cover terms for disjunctions of entailed properties of situational participants, see Davis & Koenig (2000b) and Davis (2001). In fact, they are dispensable, as Koenig & Davis (2003) argue.

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(3)



Each lexical head specifies, in its ARG-ST (argument structure) attribute, a list of syntactic dependents (in (3), the head's ARG-ST contains two NPs). Each member of this ARG-ST list consists of the syntactic and semantic information of the head's syntactic dependents. Furthermore, the semantics of each of these dependents is appropriately identified with the value of a semantic argument of the head. The tags 3 and 4 following colons in the figure represent this shared semantic information. (Roughly speaking, tags are variables, with identically numbered tags indicating identical pieces of structure; here, identity between the semantics of the first and second NP on the ARG-ST list and the values of the ACTOR and SOA (or State-Of-Affairs) attributes, respectively.) Whereas the ARG-ST list comprises information about the possible dependents of the head, information about the actual subject, specifier, and complements for which a head subcategorizes is recorded on the SUBJ, SPR, and COMPS valence lists. In the typical case, these three lists taken together constitute the head's syntactic dependents, i.e. the ARG-ST list. This identity is indicated in (3) by the tags 1 and 2. The subject subcategorization requirement is identical to the first dependent on the ARG-ST list of the head verb, while the first complement subcategorization requirement is identical to the second dependent on the ARG-ST list.

The projection of phrases from the valence information contained in lexical entries is accomplished by identifying the syntactic and semantic

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information of members of the valence lists of heads with the syntactic and semantic information of non-head daughters. The tag 2 in (3), for example, identifies the syntax and semantics of the direct object with that of the first element of the COMPS list. Once realized, a valence requirement is cancelled from the relevant valence requirements of the projected phrase. As indicated in the figure, the COMPS list of the mother of the lexical head is that of the head-daughter node minus the subcategorized elements realized as complements. Hence the object requirement marked by tag 2 is removed from the COMPS list: the VP node does not subcategorize for a direct object complement. This process is regulated by a general principle of HPSG, the valence principle (see Pollard & Sag 1994 for more details).

The role of linking constraints within this approach is to associate members of the ARG-ST list with values of role attributes of the semantic relations associated with predicators. Figures (4) and (5) provide examples of such constraints.[4] In this representation, argument positions are represented as values of attributes, ACTOR, and SOA, for instance. The name of the predicate is written in italics at the top left of the relevant Attribute-Value Matrix, and the predicate's semantic roles and their fillers are represented through attribute and value pairs below its name. The *act-vb* verb class represented in figure (4a) states that verbs describing situations that include a participant bearing actor-properties[5] map this argument to the semantic representation of the first NP member of the ARG-ST list (i.e. potential subcategorization requirements). The type *und-vb* represented in figure (4b) states that verbs describing situations that include a participant bearing undergoer-properties[6] map this argument to the semantic representation of the last NP member of the ARG-ST list.

(4) The *act-vb* and *und-vb* linking classes

(a) The type *act-vb*

$$\begin{bmatrix} \textit{act-vb} \\ \text{CONTENT} \begin{bmatrix} \textit{act-rel} \\ \text{ACTOR} \quad \boxed{1} \end{bmatrix} \\ \text{ARG-ST} \quad \langle \text{NP: } \boxed{1}, \ldots \rangle \end{bmatrix}$$

(b) The type *und-vb*

$$\begin{bmatrix} \textit{und-vb} \\ \text{CONTENT} \begin{bmatrix} \textit{und-rel} \\ \text{UNDERGOER } \boxed{1} \end{bmatrix} \\ \text{ARG-ST} \quad \langle \ldots, \text{NP:} \boxed{1} \ (, \text{XP} \ldots) \rangle \end{bmatrix}$$

[4] This presentation does not adopt the more semantically motivated attribute names argued for in Koenig & Davis (2003), since our point is orthogonal to the issues discussed in that paper.

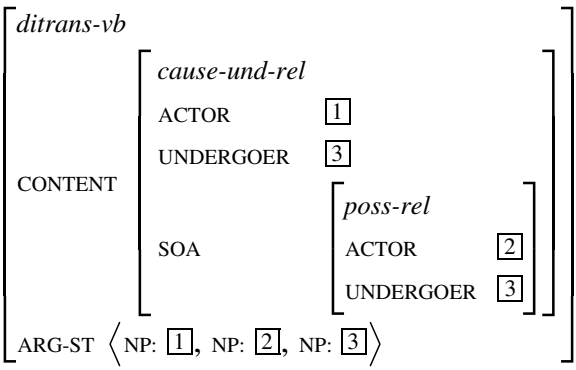
[5] These properties are somewhat similar to the Proto-Agent properties of Dowty 1991 and the notion of Actor within Role and Reference Grammar (Van Valin 1993).

[6] These properties are somewhat similar to the Proto-Patient properties of Dowty 1991 and the notion of Undergoer within Role and Reference Grammar (Van Valin 1993).

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Finally, the type *ditrans-vb* represented in figure (5) states that English verbs describing situations of transfer of possession map the embedded ACTOR argument to the second NP member of the ARG-ST list. Although the linking of the other two members of the ARG-ST lists is represented in the figure for completeness, this need not be stipulated as part of this linking class. It follows from the fact that the *ditrans-vb* class is a subclass of both the *act-vb* and the *und-vb* classes and therefore inherits the constraints stated in figure (4).[7]

(5) The ditransitive English verb class



We cannot go into the details of the linking of non-direct arguments, as it involves many different subcases, and would detract from the main issue of this paper. Suffice it to say that prepositional phrases whose preposition carries semantic content target a subpart of the semantic content of predicators (more details on this below).

The ditransitive linking class exemplifies a property of most theories of linking with wide coverage (i.e. that cover, at least in principle, the linking behavior of all verbs, from intransitives to ditransitives), namely their partial reliance on the 'geometry' of lexical semantic representations to model how semantic arguments are realized. Thus, the ACTOR argument embedded within the value of the SOA argument in the ditransitive class is realized differently from the ACTOR argument which is not embedded. That arguments belonging to identical lexical participant role categories, but which differ in their relative embedding with respect to the root of the semantic representations (the outermost brackets in the value of the CONTENT attribute in our figures), do not link identically is an hypothesis which many proponents of the SBH endorse, explicitly or implicitly (see Pinker 1989, Jackendoff 1990,

[7] The linking constraint *ditrans-vb* is language-particular. The range of ditransitive verbs in other languages may be broader, narrower, or even nonexistent. The linking types in (4), in contrast, apply to most languages (see Foley & Van Valin 1984 and Manning 1996 on some of the complexities of the linking of syntactically ergative languages).

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Alsina 1992, Van Valin 1993, among others).[8] This is because linking rules or constraints that researchers have proposed are often sensitive to the structure of lexical semantic representations and in particular their geometry or to an ordering of semantic roles (through a so-called semantic hierarchy, see Fillmore 1968, Jackendoff 1972, Bresnan & Kanerva 1989 among many others). In many cases, such as our representation of the ditransitive verb class, the embeddedness of a particular semantic argument is independently semantically motivated. The possessor participant of a transfer of possession verb is indeed part of a *sub*situation of the transfer of possession, namely the resulting state. It is therefore semantically plausible to mirror the participation of an entity in a sub-situation in the embeddedness of the semantic attribute whose value denotes such a participant. Unfortunately, this sensitivity of linking constraints to the geometry of lexical semantic representations has also led to embeddings that are not semantically motivated – i.e. to a geometrical arrangement that does not mirror the subsituation/embedding situation relation among described situations. We exemplify such problems and other problems with the SBH in the rest of this section.

1.2 *Identical semantics but different syntax*

1.2.1 *Instruments*

We begin our foray into the difficulties in semantically-based linking theories with several cases in which two arguments or adjuncts contribute the same apparent semantic content, but are not realized the same way syntactically. Such cases undermine the claim that lexical semantics wholly determine the subcategorization of predicators, since two predicators realize an argument fulfilling the same participant role differently. Consider examples (6) and (7).

(6) (a) They poked the body with a stick.
(b) They eat ice-cream with a knife.

(7) (a) They used a stick to poke the body.
(b) They use a knife to eat ice-cream.

(6a) and (7a) describe the same event-type (see Lakoff (1968) for the earliest observation that *with*-PPs can be adequately paraphrased by the verb *use*).[9]

[8] As a referee points out, we need not represent the cause–effect dyad within the structure of the CONTENT of lexical entries. Davis & Koenig (2000b) and Davis (2001) present some arguments why it is useful to do so. What is important to us is not whether lexical decomposition is needed, but whether whatever semantic structures linking rules depend on can be model-theoretically motivated or not.

[9] Some readers might question the synonymy of sentences (6a) and (7a). The latter sentence seems to allow for a reading where the stick is not itself in contact with the body but serves to establish contact between a fourth object and the body, a reading which is either absent or significantly harder to assign to the former sentence. We see such potential differences

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In particular, any event of poking requires the use of an object to serve as a poking instrument (at least when the subject is an animate being, as in (6a)). The stick in both sentences thus plays the same participant role, that of an instrument. The semantic basis hypothesis therefore would lead us to expect this argument of the semantic predicate(s) which describe(s) this event-type to be consistently linked to their surface form. How can we explain the fact that the instrument used to poke the body surfaces as the object of the preposition *with* in one case and as the direct object *use* in another?[10] One obvious possibility is to assume that the content of the verb *use* and the preposition *with* are similar in relevant respects. The instrument participant would then be realized identically, as an object in both cases (the object of the verb *use* and the object of the preposition *with*, respectively). But this analysis makes it difficult to model the parallel semantic contribution of *with* in (6a) and (6b). More precisely, an analysis which espouses the SBH does not seem to be able to represent uniformly the paraphrase relations that exist between (6a)–(7a) and (6b)–(7b) while respecting the differences in entailment between *poke* and *eat* (only *poke* lexically entails the presence of an instrument participant). See Koenig et al. (2003) for a more detailed discussion of the contrast between verbs such as *poke* whose denotata require the presence of an instrument – a.k.a. obligatory instrument verbs – and verbs such as *eat* whose denotata merely allow their presence – a.k.a. optional instrument verbs.

We can represent the semantic content shared by *use* and *with* as in figure (8).

(8) The semantic content of *use*

$$\begin{bmatrix} \textit{use-rel} & \\ \text{ACTOR} & x \\ \text{UNDERGOER} & y \\ \text{SOA} & z \end{bmatrix}$$

Figure (8) says that the words *with* or *use* as used in sentences (6b) and (7b), respectively, describe a situation in which an entity x (the unspecified value of the ACTOR attribute represented as x in the figure) acts on an instrument y

as parallels to the well-known 'directness' distinction between lexical and periphrastic causatives (see McCawley 1978 and Jackendoff 1990 for arguments that such differences do not necessarily undermine postulating a similar semantic representation for the two kinds of causatives, and Fodor 1970, contra). We leave exploration of this complex issue to another venue.

[10] Our argument does not depend on the assumption that the word *use* is truly equivalent to *with* (there might be differences due to the well-known effects of lexical packaging, see Fodor 1970 or Jackendoff 1990). Nor does it assume that *use* is the *only* verb that can paraphrase the semantics of *with* in sentences (6). All our analysis requires is that this use of *with* encodes some primitive concept of instrumentality à la Talmy (2000), i.e. where the instrument is both the acted-upon entity of one part of a causal chain and the 'cause' of another part of the causal chain.

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(the unspecified value of the UNDERGOER attribute represented as *y* in the figure) so that an event *z* occurs (the unspecified value of the SOA attribute represented as *z* in the figure).

Now, since the semantic content of *eat* does not require an instrument role, the contribution of *with* is not part of the lexical semantic representation of *eat*. Rather, as the paraphrase in (7b) would suggest, the semantic content of *eat* serves as an argument of the semantic relation encoded by *with*. The referent of the object of the preposition is the instrument used to perform the eating. The semantic contribution of the infinitive VP complement of *use* in (7b) (or the verb that takes the *with* PP in (6b)) is then embedded as the value of the SOA attribute (i.e. is substituted for *z* in the figure), as shown in figure (9).

(9) The lexical semantic representation of *eat with*

$$\begin{bmatrix} \textit{use-rel} & \\ \text{ACTOR} & x \\ \text{UNDERGOER} & y \\ \text{SOA} & \begin{bmatrix} \textit{eat-rel} & \\ \text{ACTOR} & x \\ \text{UNDERGOER} & t \end{bmatrix} \end{bmatrix}$$

Unfortunately, this analysis will not account for *poke* as used in (6a), since a poking situation requires the use of an instrument, as we suggested earlier. figure (10), which parallels figure (9), illustrates. Since *poke* entails the presence of a user and an instrument, embedding the semantic content of *poke* as the value of the SOA argument of a *use-rel* relation yields a feature structure with an infinite regress, or with a cycle. The embedded *poke-rel* in figure (10) must include a SOA attribute whose values would itself be a *poke-rel*.

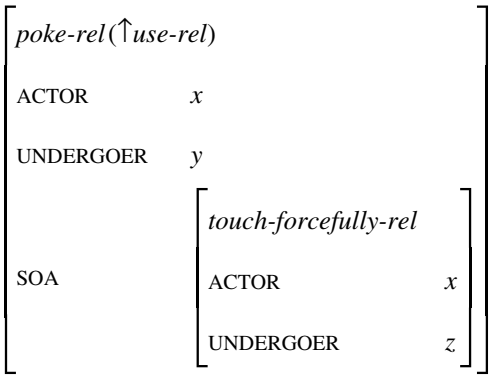
(10) The lexical semantic representation of *poke with* (option 1)

$$\begin{bmatrix} \textit{use-rel} & \\ \text{ACTOR} & x \\ \text{UNDERGOER} & y \\ \text{SOA} & \begin{bmatrix} \textit{poke-rel} & \\ \text{ACTOR} & x \\ \text{UNDERGOER} & z \end{bmatrix} \end{bmatrix}$$

An alternative analysis would reflect the fact that *poke* requires an instrument, and modify the semantic representation for *poke* in figure (10). Under this analysis, *poke* would be a specialized version of *use*, as shown in figure (11). (The type in parentheses after the upward arrow ↑ is an informal indication of the supertype(s) of which the type represented in the figure is an instance, i.e. *use-rel* in this case.)

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(11) The lexical semantic representation of *poke with* (option 2)



This kind of analysis does not run the risk of an infinite regress or circular feature structure, since the value of the SOA argument does not denote a situation that requires the presence of an instrument participant. But we are now faced with another problem: a parallel representation cannot be given to *eat* as used in sentence (6b), since in this instance, the content paraphrasable as *use an object to perform an act* is not part of the intrinsic meaning of the verb, and cannot therefore be part of the value of the CONTENT attribute of *eat*. Rather, the *use-rel* is added by *with*. Unfortunately, the lexical semantic representations of *poke* and *eat* now look quite different (in one case, the *with* PP adds to the content of the verb, and in the other, it only redundantly marks meaning already included in the verb's lexical semantic representation). Such differences in lexical semantic representations make it difficult to explain their similar linking patterns, if the SBH is correct. Either the linking constraints must be complicated or the SBH weakened. We conclude that neither of the solutions we have explored – making the meaning of *eat* the value of the SOA attribute or making the meaning of *poke* a specialized version of the meaning of *use* – solves the difficulty posed by sentences (6)–(7).

1.2.2 *Adjunct causes*

The French sentences in (12) illustrate a second example of the kinds of difficulties encountered by the hypothesis that semantically similar participant roles are *ceteris paribus* expressed similarly.

(12) (a) Il en est mort.
he from.it is dead
'He died from it.'
(b) Ça l' a tué.
it him has killed
'It killed him.'

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Since so-called French object clitics are in fact verbal affixes (see Miller 1991 for persuasive arguments to that effect), *en mourir* in (12a) is a derived word – however the notion of lexical derivation or its equivalent is implemented in one's preferred framework – at least if we adopt the Lexical Integrity Hypothesis (see Bresnan & Mchombo 1995). This means that *en mourir* is subject to linking constraints. The question, then, is what is its semantic representation? Since *en* in sentence (12a) encodes the cause of death, the question reduces to determining how the cause of death is represented in the semantic content of *en mourir*. One possibility would be to represent it as in figure (13).

(13) The lexical semantic representation of *en mourir* (option 1)

$$\begin{bmatrix} \textit{cause-rel} & \\ \text{ACTOR} & x \\ \text{SOA} & \begin{bmatrix} \textit{die-rel} & \\ \text{UNDERGOER} & y \end{bmatrix} \end{bmatrix}$$

In other words, the derived word *en mourir* is semantically paraphrasable as *cause to die*. Unfortunately, this analysis predicts the wrong surface realization of the derived word's argument: the referent of *en* – which expresses the cause of death – should be the subject, since it represents the instigator of the event and causes are systematically realized as subjects of active forms of verbs in nominative/accusative languages.

An alternative possibility would be to assume the semantic content of *en mourir* to be as represented in figure (14). In this analysis, following the approach to English valence alternations proposed in Pinker (1989), the cause of death is the value of an additional MEANS argument position. This analysis of the lexical semantics of *en mourir* permits the appropriate surface realization of its arguments, since the cause of death is not denoted by the value of an ACTOR attribute. But it does so at a prohibitive semantic cost. The proposed lexical semantic representation of *en mourir* is no longer semantically motivated. In particular, the event-semantics equivalence of sentences (12a) and (12b) is not reflected in our semantic metalanguage.[11] Despite the mutual entailment of the two sentences, the meaning of *en mourir* is claimed to be something like *die* (*x, by-means* (*y*)) whereas the meaning of *tuer* is claimed to be something like *cause* (*x, die* (*y*)). The semantic arbitrariness of this metalanguage difference is reflected in the absence of independent semantic motivation for the new attribute MEANS. It is introduced solely to ensure the right 'geometry', for linking purposes, in our lexical semantic representations.

[11] John Beavers, p.c., correctly points out that *en* in *en mourir* must be an inanimate cause, something which is not required of *tuer* 'kill'. But since animacy is a property of fillers of causal roles rather than a property of causal roles themselves, and *tuer* allows inanimate causes, as sentence (12b) shows, our point stands. There is no model-theoretic motivation for distinguishing the two causes, as the use of the predicate/keyword MEANS would imply.

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In other words, our semantic representations now include what is in effect a syntactic diacritic. The attribute MEANS serves to encode the syntactic fact that the cause argument of *en mourir* is realized as an oblique affix.

(14) The lexical semantic representation of *en mourir* (option 2)

$$\begin{bmatrix} \textit{die-rel} & \\ \text{UNDERGOER} & y \\ \text{MEANS} & x \end{bmatrix}$$

Sentences that include extended datives such as (15) (see Leclère 1975) show that this difficulty is widespread.

(15) Il leur a sali notre voiture.
he to.them has dirtied our car
'He dirties our car (on them (*sic*)).'

Again, the dative clitic is an affix and the derived word *leur salir* must be derived 'in the lexicon', at least within approaches that respect the Lexical Integrity Hypothesis. Since the extended dative affix encodes that its referent is an entity affected by the dirtying event, the referent of *leur* should link like the patient of *affecter* 'to affect', i.e. as a direct object affix (*leur*), contrary to fact. Introducing yet another attribute to distinguish the affected participant to which *leur* refers from the one to which a direct object of *affecter* 'to affect' refers – say, $\text{AFFECTED}_{\text{DAT}}$ – would amount to introducing yet another covert syntactic diacritic into our lexical semantic representations.

All the examples we have discussed in this section have the same flavor. At times, participants which are not lexically entailed by the base entry of a verb, but are part of its extended argument structure, bear properties which should make them direct arguments, if the SBH is correct. But, in fact, they are realized as obliques, as expected from their 'adjunct' status. In the next section, we discuss difficulties the SBH faces when dealing with valence alternations, that is, instances in which a single word realizes its arguments in two different ways.

1.3 *Valence alternations*

Many researchers have argued, consistent with the SBH, that valence alternations have a semantic basis. Words occur in various syntactic frames and these syntactic variations often correlate with semantic differences (see Pinker 1989, among many others, for a detailed study advocating this point of view).[12] In fact, the assumption that alternants of a verb have different

[12] Although we discuss the issue of valence alternations in terms of verb meanings rather than in terms of the meaning of constructions as Goldberg (1995) does, nothing crucial hinges on this choice. In a constructional approach, it is constructional meanings or semantic construction links that must be posited without independent semantic motivation.

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meanings is critical to maintaining the SBH. If the semantic content of lexical entries determines to a large extent subcategorization properties, we would expect verbs in different syntactic alternants to have different semantic contents in each of them, at least if the syntactic difference is not idiosyncratically listed in the relevant lexical entries. Thus, to account for the contrast between syntactic contexts in which *spray* occurs in sentences (16a) and (16b), Pinker and others have claimed that the two sentences do not mean the same thing, a hypothesis we concur with. The formulas in (17), adapted from Pinker, are meant to express this semantic difference.

(16) (a) $spray_{loc}$: Joan sprayed the paint onto the statue.
(b) $spray_{with}$: Joan sprayed the statue with paint.

(17) (a) CAUSE (JOAN, GO (PAINT, TO (STATUE)))
(b) ACT-ON (JOAN, STATUE, BY (CAUSE (JOAN, GO (PAINT, TO (STATUE)))))

Roughly speaking, *spray* as used in sentence (16a) can be paraphrased as *moving paint onto the statue* (*in a* '*spraying*' *manner*), whereas when it is used as in sentence (16b), it can be paraphrased as *affecting the statue by moving paint onto it* (see Anderson 1971, Rappaport & Levin 1988, Pinker 1989, and others). These paraphrases express the intuition that the meaning of $spray_{loc}$ is somehow included in that of $spray_{with}$. Although we agree with the hypothesis that sentences (16a) and (16b) differ semantically, we question the representation of this semantic difference in the formulas in (17). This is because we lack independent semantic motivation for the new metalanguage predicate/keyword BY. As far as we can see, this predicate means the same as our attribute MEANS in figure (13), and it is equally semantically unmotivated. The only motivation of which we are aware for introducing this predicate is that it provides the right geometric configuration for the application of linking rules. By insuring that *paint* is embedded one level deeper than either *Joan* or *the statue*, it guarantees that rules mapping arguments to the subject and object grammatical functions target *Joan* and *the statue* rather than *paint*. Linking the two alternants of verbs that exhibit a valence alternation, as *spray* does, thus runs into the same difficulty that lexically encoded adjuncts face. Getting linking 'right' requires us to encumber our semantic metalanguage with syntactic diacritics.

1.4 *Model-theoretic and lexical semantic representation mismatches*

For the SBH to have some semantic bite, not only should the properties of lexical semantic representations determine the mapping of direct arguments, but also *ceteris paribus* lexical semantic representations should reflect model-theoretic properties of the described situations. Otherwise, these

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representations depart from the truly semantic and contain arbitrary or vague elements. Note that we do not require the lexical semantic representations to be *determined* by model-theoretic properties, as (i) there are many model-theoretic properties that are of no significance to linking and might be 'bundled' in the atomic label of the relation type associated with lexical entries,[13] and (ii) there are, of course, many distinct ways of representing within a lexical entry the various model-theoretic properties of its denotation. What we require is that properties of lexical semantic representations (names of predicates involved, number of relations included in the semantic content of lexical entries, what kinds of sub-situations the denoted eventuality-type includes) correspond to a well-defined model-theoretic property and, conversely, that this model-theoretic property is represented in a unique manner within the semantic content of lexical entries. For the SBH to have semantic teeth, we need not further assume that we can simply deterministically infer linking from properties of situations (relative to the vocabulary and syntax of our lexical semantic representations in the manner alluded to above, of course). Situations in the model can be described in various ways (see Krifka 1989 for a good discussion of this issue) and a verb's linking might differ depending on how a situation is described. More precisely, the SBH only commits us to saying that those aspects of linking that are semantically motivated follow from properties of the situation as described by the verb. We therefore expect that verbs that *describe* the same class of situations would link their semantic arguments in the same manner, to the extent that their linking is not irregular and need not be lexically stipulated. Unfortunately, in some well-known cases, this does not seem to be the case. Some verbs appear to describe identical situation types, yet they differ in their linking behavior. Verbs such as *buy* and *sell*, probably *pay* and possibly *charge*, and, more generally, verbs that evoke the commercial exchange frame of Fillmore (1977) are a case in point. Each verb intuitively describes the same set of situations, but each maps different participants onto the subject and object positions of its active form.[14] In addressing the issue of varying subject and object selection among these verbs, Jackendoff (1990) proposes a difference in their lexical semantic representations (see the simplified representations in (18)).

[13] Situations of spraying, for example, involve a particular kind of motion of a non-solid entity. This kind of information, though, is not relevant to the linking of arguments and can thus be bundled into the atomic relation label *spray-rel* in the lexical semantic representation of the word *spray*.

[14] Some special circumstances seem to contradict this assumption, such as the sign *You break, you buy* seen in stores. If we happen to break a teapot, we still might not be willing to say that we were sold a broken teapot. But this reluctance might be due to the presence of some irony in the warning and thus not truly invalidate the extensional equivalence between acts of buying and selling. Another questionable case is buying from a vending machine, where it seems odd to claim that either the machine or its owner has sold the item to the buyer.

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(18) (a) *buy*: CAUSE(x, $\left[\begin{array}{l} \text{GO}\ (y, \left[\begin{array}{ll}\text{FROM} & z\\ \text{TO} & x\end{array}\right]) \\ \left[\text{EXCH}\left[\text{GO}\ (\textit{money}, \left[\begin{array}{ll}\text{FROM} & x\\ \text{TO} & z\end{array}\right])\right]\right]\end{array}\right]$)

(b) *sell*: CAUSE(z, $\left[\begin{array}{l} \text{GO}\ (y, \left[\begin{array}{ll}\text{FROM} & x\\ \text{TO} & z\end{array}\right]) \\ \left[\text{EXCH}\left[\text{GO}\ (\textit{money}, \left[\begin{array}{ll}\text{FROM} & x\\ \text{TO} & z\end{array}\right])\right]\right]\end{array}\right]$)

Without going into the details of Jackendoff's own linking theory, we note that his linking rules, like the linking constraints we presented earlier, are sensitive to the 'geometric' position of an argument within a predicator's lexical semantic representations. For example, the fact that x, as the argument of CAUSE, is less embedded than z in (18a), while the reverse is true in (18b), ensures that the verbs *buy* and *sell* do not link the two arguments corresponding to x and z in the same way.

We share Jackendoff's view that commercial transfer involves both a transfer and a counter-transfer. But, as we see it, there are two difficulties with Jackendoff's proposal. First, there seems to be no clear semantic motivation for the conceptual structure difference between the two verbs. Given the (near) model-theoretic equivalence between the two verbs, it is hard to see the justification for the claim that each involves *different* causal events. It seems that the difference in conceptual structure is mainly a syntactic diacritic to insure the right linking of arguments to syntactic positions. Second, it is not clear how Jackendoff's analysis would capture the semantic relation between *buy* and *sell* since conceptual structures are the only level at which semantic information is represented. In other words, conceptual structure in Jackendoff's theory is not a metalanguage that needs to be model-theoretically interpreted. It *is* the interpretation and provides the input to inferential mechanisms (Jackendoff 1983). It is therefore hard to see how the mutual entailment relation (modulo the issue raised in footnote 14) between the meaning of *buy* and *sell* can be accounted for. As we will show in section 2, we can maintain an identical semantics for *buy* and *sell*, while weakening the claim that the difference between the linking of these two verbs is model-theoretic in nature.

We have now introduced three classes of cases that challenge the SBH. In some cases, arguments bear semantic properties that, typically, require that they bear a direct grammatical function, but in these cases they do not. In other cases, the relation of semantic inclusion between the meanings of two valence alternants is difficult to model through lexical semantic

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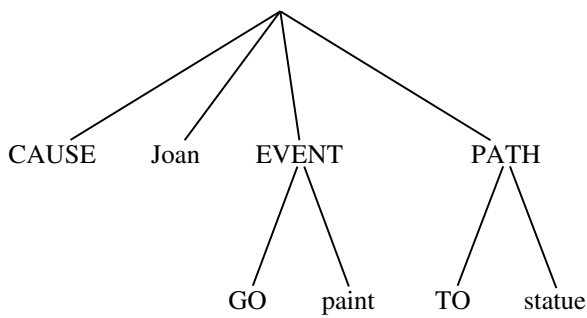
representations that form the input to linking constraints. Finally, in some cases, verbs that are nearly model-theoretic equivalent do not link their corresponding arguments in the same manner. These cases range over a wide set of data, and it is therefore important for proponents of the SBH to answer these challenges. We have discussed what has been the typical answer to these challenges, namely some geometrical rearrangement of lexical semantic representations so that linking constraints apply correctly. But, as we have argued, in all instances of which we are aware, the rearrangements are not motivated semantically. In effect, they amount to introducing syntactic diacritics in the lexical semantic representations.

A possible avenue of research, in light of these difficulties, is to abandon our reliance on structured lexical semantic representations to model linking altogether, following the lead of Dowty (1991). Dowty (1991) states linking constraints directly over bundles of entailments rather than on reified lexical semantic representations. But such an approach restricts the purview of a linking theory and leads to a weaker hypothesis for linking (see Davis 1996, 2001; Koenig & Davis 2001 for discussions of this point). In the next section we therefore propose another solution to these challenges. This solution maintains the hypothesis that linking constraints are best stated over lexical semantic representations, but it challenges a typical assumption about the structure of lexical semantic representations.

2. A LESS RECURSIVE APPROACH TO LEXICAL SEMANTIC REPRESENTATIONS

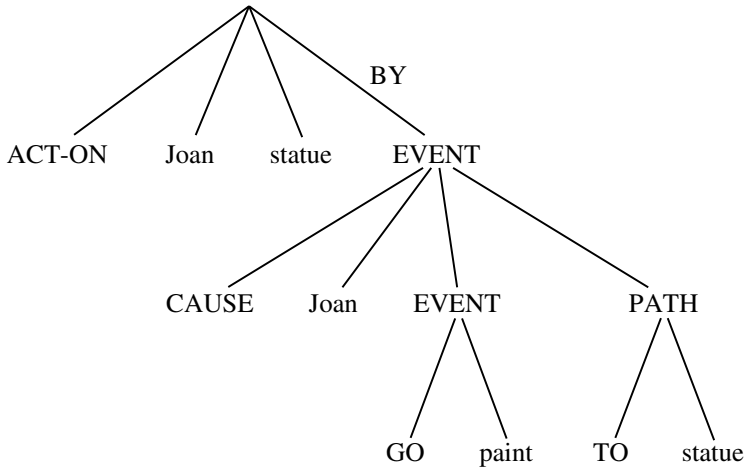
The difficulties we have just presented arise, we believe, from a common cause, namely the assumption that the lexical semantic representation of a word forms a singly-rooted semantic tree, in which daughter subtrees correspond to arguments of the predicate associated with the mother node. We illustrate this point with Pinker's proposal for the semantic representations associated with $spray_{loc}$ and $spray_{with}$. The relevant semantic trees are represented in figures (19) and (20), respectively.

(19) The semantic tree for $spray_{loc}$ (after Pinker)



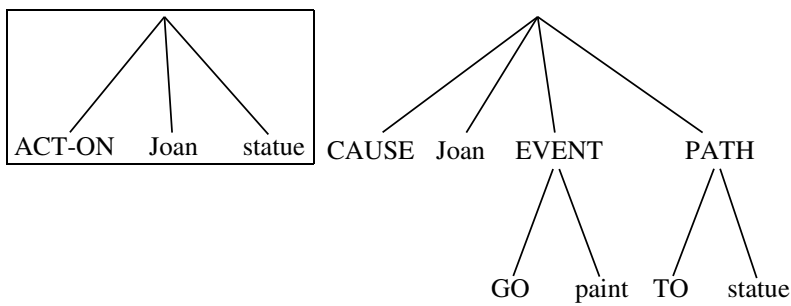
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(20) The semantic trees for $spray_{\text{with}}$ (after Pinker)



If the relative semantic embedding of arguments correlates with the directness of their surface realizations (that is, arguments which are realized less obliquely are less embedded semantically), as many researchers do assume (see Pinker 1989, Jackendoff 1990, Alsina 1996, Van Valin & Lapolla 1997, Davis & Koenig 2000b, among others), the assumption that the lexical semantics of verbs forms a single-rooted tree forces the introduction of unmotivated semantic differences and semantic attributes (such as BY in figure (20)) so as to guarantee the deeper embedding of *paint* relative to either *Joan* or *the statue* in the case of sentence (16b). Our solution is to abandon the semantic tree hypothesis. This is illustrated informally in figure (21), which represents the meaning of $spray_{\text{with}}$. Although the lexical semantic representation we propose contains the same components as in Pinker's proposal, these components do not form a single semantic unit. Moreover, only the boxed component is relevant to linking the verb's direct arguments.

(21) An Elementary Predication List representing the semantics of $spray_{\text{loc}}$



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More generally, we posit the following hypotheses regarding the lexical semantic representation of predicators:

1. The lexical semantic representation of a predicator consists of a set of single-rooted semantic trees.[15]
2. Only one of those trees is relevant for the linking of arguments to direct grammatical functions.

We explain this intuitive description of our solution in the rest of this section. Our semantic representation language is inspired by Minimal Recursion Semantics (hereafter, MRS, see Copestake et al. (1999) and Copestake et al. (2001) for introductions). This representation language accords particularly well with our rejection of the semantic tree hypothesis because MRS is a representation of the meaning of expressions as a flat set of Elementary Predications (or EPs). But our analyses can be recast in any other representation language provided it allows lexical entries to consist of a set of relations. Within MRS, the set of EPs is encoded as values of a RELATIONS attribute, as illustrated in figure (22).[16] (To orient readers, the denotation of this set is typically equivalent to the logical conjunction of its members.)

(22) A MRS-style representation of the meaning of the sentence *Jo loves Pat*

$$\left[\text{RELATIONS}\left\langle \begin{bmatrix} \textit{named-rel} & \\ \text{LBL} & a \\ \text{INSTANCE} & y \\ \text{NAME} & \textit{`Jo'} \end{bmatrix}, \begin{bmatrix} \textit{named-rel} & \\ \text{LBL} & b \\ \text{INSTANCE} & t \\ \text{NAME} & \textit{`Pat'} \end{bmatrix}, \boxed{1} \begin{bmatrix} \textit{love-rel} & \\ \text{LBL} & c \\ \text{EVENT} & r \\ \text{ACTOR} & y \\ \text{UNDERGOER} & t \end{bmatrix} \right\rangle\right]$$

The semantics of this sentence contains three EPs, one for the naming relation relating the name *Jo* to its referent, one for the naming relation relating the name *Pat* to its referent, and finally one for the love relation relating the referents of *Jo* and *Pat*. (Note that MRS adopts a Davidsonian analysis of situations in that the *love-rel* EP contains an event argument.) Each relation has an additional label attribute (or LBL), which is a pointer to the EP itself. MRS was introduced with the explicit goal of allowing underspecification of scope relations in the context of Machine Translation and LBLS are critical to such underspecification. Since scope relations are orthogonal to our point, we

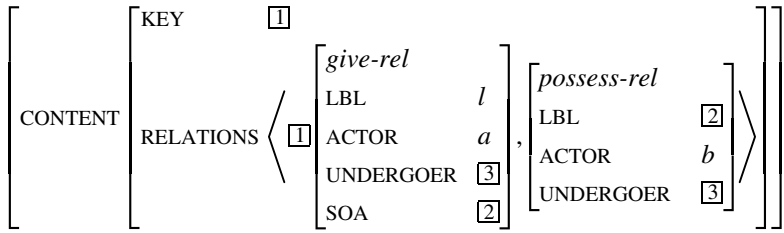
[15] Van Valin & Lapolla (1997) allow derived lexical entries to consist of a conjunction of predicate–argument structures, but many of the problematic cases we discuss in section 1 (e.g. instrumental *with*, commercial frame verbs, *spray/load* alternations), and some of the phenomena we discuss in the next section are not modeled through conjunctions of predicate-argument structures. The two-tier representations of Jackendoff (1990) can be seen to implicitly encode a conjunction of conceptual structures. But, again, Jackendoff does not make use of such structures to tackle the phenomena we discuss in this paper.

[16] Technically, the value of the RELATIONS attribute is taken to be a bag, i.e. a set that can have two identical members. For our purposes, nothing substantial hinges on the distinction between sets and bags.

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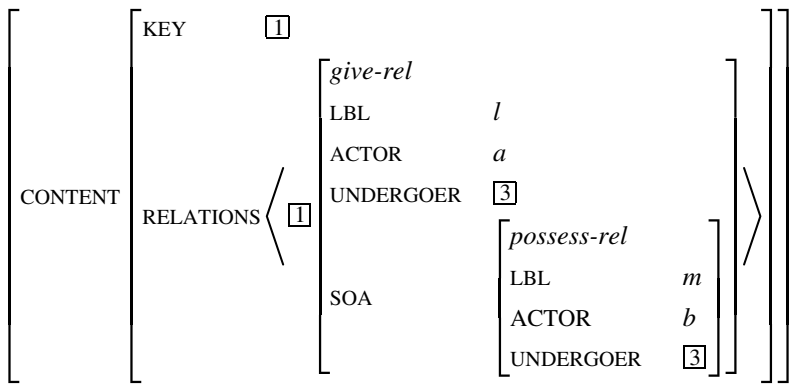
will not discuss them further in this paper. But labels also play a role in 'flattening' the lexical semantic structure of predicators. Consider verbs of transfer of possession discussed earlier (see figure (5)). In MRS, the semantic content of a verb such as *give* would be represented as follows:

(23) The semantic content of *give* in the MRS representation language



In essence, where a traditional lexical decomposition analysis might represent sub-situations by embedding one predicate within another, the value of the SOA argument is a semantic structure denoting not a situation of a particular type, but rather the label of another EP member of the RELATIONS attribute. Thus, in figure (23), the value of the SOA attribute is the *label* of the *possess-rel* EP. To facilitate comparison with other theories of linking (including our own previous work), we will depart from this aspect of MRS and will allow embedding of EPs as values of SOA attributes, in cases where one would traditionally use lexical decomposition (thus making our semantic representation language not quite *minimally* recursive!). Our representation of the semantic content of *give* will thus be as in figure (24).

(24) The semantic content of *give* in the adapted MRS representation language this paper uses



A final point regarding our semantic representation language. As argued in detail in Davis (2001), the particulars of the model-theoretic properties of each relation (for example, the properties of the denotation of *give-rel*, or more specific kinds of giving situations discussed below with respect to commercial

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exchange verbs) depend on the model-theoretic interpretation of the name of the type. As a consequence, lexical decomposition is kept to a minimum, basically being restricted to situation-types that involve a specific change of state. Nothing crucial hinges on the inclusion of this modest amount of lexical decomposition in our lexical semantic representations, although some of the linking rules we propose would have to be slightly modified were one to shun lexical decomposition altogether.

Our proposal is that lexical items can contribute more than a single EP and that one of these EPs (called the KEY, see figures (23) and (24)) plays a critical role in the mapping of arguments to direct argument functions, as indicated in the following two hypotheses (see Bouma et al. 2000 for an early proposal in this direction).[17]

HYPOTHESIS 2 (SEMANTIC SET HYPOTHESIS) Some lexical items include more than one EP in their semantic content and lexically select one of these EPs as their KEY.

HYPOTHESIS 3 (DIRECT ARGUMENT LINKING HYPOTHESIS) Direct arguments are linked off the value of the KEY attribute.[18]

HYPOTHESIS 4 (INDIRECT ARGUMENT LINKING HYPOTHESIS) Indirect arguments that are arguments of the KEY EP (or arguments of an argument of the KEY) are linked off the value of the KEY attribute; indirect arguments that are not arguments of the KEY EP (or not arguments of an argument of the KEY) are linked from other members of the RELATIONS attribute.

The KEY attribute is thus a means of indicating a portion of the semantics that is salient; that is, the KEY EP foregrounds one of the sub-situations in the semantics and its participants. The Direct Argument Linking Hypothesis requires that there exist an attribute-and-value path from the KEY attribute to each direct argument.[19]

As we now show, the structure of lexical semantic representations embodied in the Semantic Set and Direct/Indirect Argument Linking Hypotheses solves the difficulties we presented in the previous section. We begin with

[17] The fact that EPs in the RELATIONS list do not form a predicate–argument semantic tree of the kind depicted in figures (19) and (20) does not violate the constraint on fully scope-resolved MRS structures that they must form a semantic tree (see Copestake et al. 1999), since the latter notion concerns the *distinct* LBL of the RELATIONS value. Thus, the presence of two EPs within the semantic content of a stem that are not in a predicate-argument relation to each other does not preclude those two EPs bearing the same LBL value. The RELATIONS value of such an entry would not form a predicate-argument relation semantic tree, but the sentence containing it might still form a 'scopal' tree.

[18] The Matrix grammar development framework has adopted a similar idea from Davis & Koenig 2000a, see Flickinger et al. 2003.

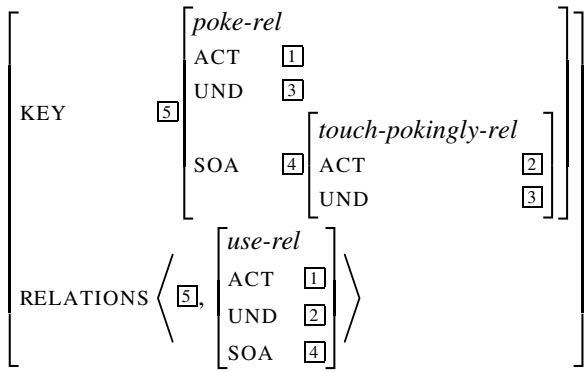
[19] Depending on what the allowable kinds of EPs are, this also limits the number of direct arguments that a verb can have. However, we will not attempt to formulate constraints on the complexity of EPs in this paper.

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MRS representations of *poke* and *eat*, as used in sentences (6a) and (6b), respectively, repeated below as (25a) and (25b). For readability, we omit in these and subsequent figures irrelevant LBL attributes.

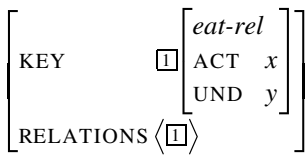
(25) (a) They poked the body with a stick.
(b) They eat ice-cream with a knife.

(26) The lexical semantic representation of both *poke* and *poke with*

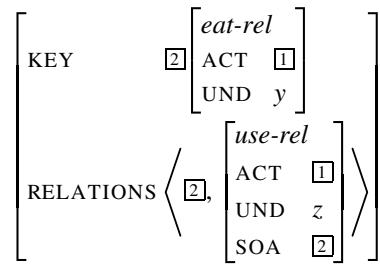


(27) The lexical semantic representations of *eat* and *eat with*

(a) *eat*



(b) *eat with*

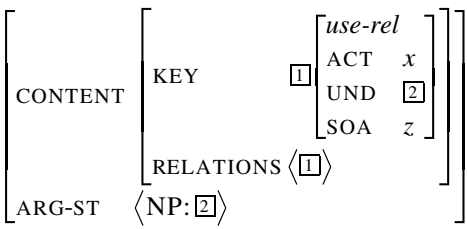


The first figure can be paraphrased as 1 *affected* 3 *in causing* 2 *to* 4 *touch* 3 *and used* 2 *to effect the* 4 *touching*, the second as 1 *ate* 2 *and used* 4 *to do so*. We thus analyze the agentive use of *poke* as including a *use-rel* which describes situations in which one agent acts on an entity to cause an effect (the canonical description of situations which include an instrument). This assumption accounts for the fact that instruments are always entailed to be participants in situations described by agentive uses of *poke*. But, in contrast to the lexical semantic representation diagrammed in figure (8), the meaning of *poke* is not reducible to a subtype of *use-rel*. It also includes another component, a causal event whose effect is a touching event. A comparison of

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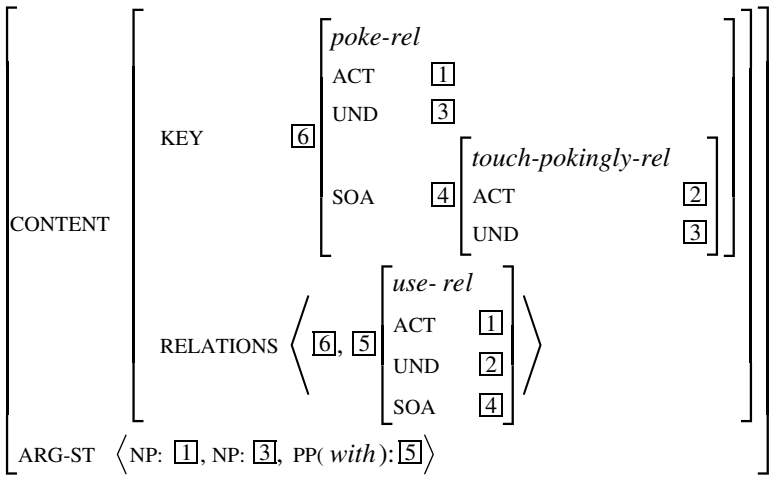
the meaning of *poke* and *eat with* clarifies the usefulness of postulating two components in the semantics of *poke*. The base entry of the verb *eat* describes a class of situations, some of which do not include an instrument participant, and therefore its lexical semantic representation, diagrammed in figure (27a), does not include a *use-rel*. Rather, the presence of an instrument (and the concomitant presence of a *use-rel* describing the use situation in which the entity is an instrument) is dependent on the occurrence of a *with*-PP, as indicated in figure (27b). Consequently, the lexical semantic representations of *eat* and *eat with* differ, but not those of *poke* and *poke with*. But this semantic difference has no effect on the oblique expression of an instrument because the constraint that links a *use-rel* (or a subtype of it) to a PP headed by *with* targets members of the RELATIONS list, not the KEY value, and both *poke* and *eat with* include such a relation on the RELATIONS list. Figure (28) is a simplified representation for instrumental uses of *with*, while figure (29) provides simplified representations of the entries for *poke with* and *eat with*.

(28) A simplified entry for *with*



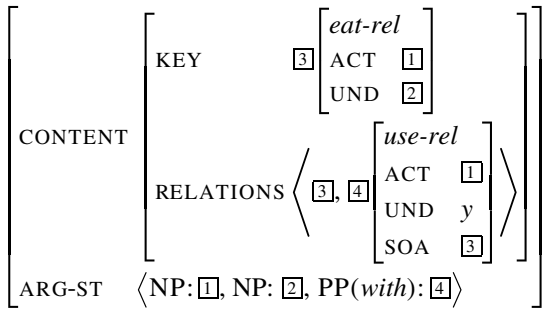
(29) Simplified entries for *poke with* and *eat with*

(a) *poke with*



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(b) *eat with*

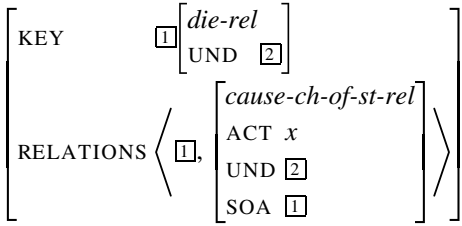


To summarize, the first and second NP members of the ARG-ST of each verb correspond to the respective least embedded ACTOR and UNDERGOER of their KEY, as predicted from the *act-vb* and *und-vb* classes represented in figure 4, revised in accordance with Hypothesis 3. The occurrence of a subcategorized PP headed by *with* is licensed by general mechanisms for licensing subcategorized PPs within the approach to linking we advocate (see Gawron 1986, Davis 1996, Wechsler 1995a, b). Crucially, whether the meaning contributed by this PP is part of the base entry of the verb or whether the PP subcategorization requirement is added to the ARG-ST does not affect the linking of the UNDERGOER in the *use-rel* EP to the oblique that realizes it. We leave open how the additional PP subcategorization requirement is added to the ARG-ST list. It could be added through lexical rules, as in Pollard & Sag 1994, through the combination of a type-underspecified *eat* with lexical classes, as in Koenig 1999b, or through the use of an underspecified DEPS attribute, as in Bouma et al. (2001). But however it is added, the semantic content it contributes or targets ensures that the head of this PP is *with*. To conclude, the presence of an additional *use-rel* in figure (27b), but not in figure (26), represents the difference in the semantic status of the instrument dependents in sentence (6a) and (6b). It is therefore semantically motivated. But the similarity in the lexical semantic representations of the base entry for *poke* and the derived entry for *eat with* accounts for their similar encoding of the instrument role as a *with*-PP.

The inclusion of more than one EP in the lexical semantic representations of predicators also allows for a straightforward account of the French data we discussed in the previous section. A representation of the lexical semantic representation of *en mourir* is given in figure (30) (we omit, for simplicity, the additional constraint that the causal ACTOR be inanimate).

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(30) The lexical semantic representation of *en mourir*

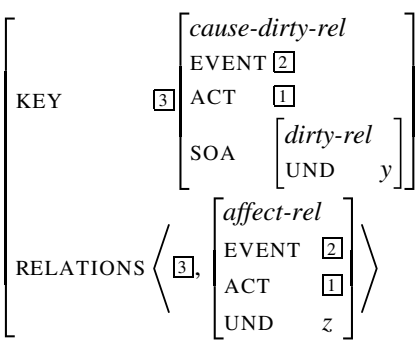


The KEY of *en mourir* is still a *die-rel*, exactly like *mourir*, since argument or adjunct 'cliticization' in Romance is not a semantic-altering morphological operation (i.e. is not a morpholexical operation in the sense of Ackerman 1992). Hence the UNDERGOER is mapped to subject position in both cases and for the same reasons. But the RELATIONS of *en mourir* also contains a *cause-ch-of-st-rel* to reflect the semantic contribution of the affix *en*. Finally, because the value of the SOA attribute of this latter relation is constrained to be *die-rel*, the fact that *en mourir* and *tuer* 'kill' describe the same class of events is accounted for. But, in contrast to *en mourir*, *tuer* selects the *cause-ch-of-st-rel* as its KEY and thus realizes its semantic arguments differently. In other words, the semantic content contributed by adjuncts realized as lexical affixes is simply encoded as an added EP on the predicator's RELATIONS; the EP of the base entry remains the KEY of the derived word and the mapping of argument positions to direct grammatical functions is therefore not altered, given Hypothesis 3. Each EP is a lexical semantic structure semantically justified by the entailments of *en mourir* and linking can proceed for this derived word as predicted, since the new EP is not required to be part of (or to include) the base entry's EP.

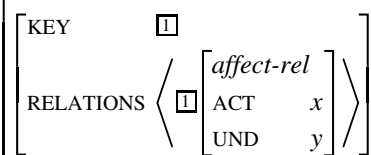
The very same strategy applies to the extended datives discussed in Leclère (1975). The lexical semantic representation of *leur salir* is thus as diagrammed in figure (31a) and should be contrasted with that of *affecter* in figure (31b).

(31) The lexical semantic representations of *leur salir* and *affecter*

(a) *leur salir*



(b) *affecter*



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The dative affix contributes the *affect-rel* EP, in accordance with the derived verb's meaning, the same EP which *affecter* 'to affect' inherently encodes. But the KEY of *leur salir* remains that of the caused change of state for the same reason that the KEY of *en mourir* remains that of *mourir*. As a consequence, subject and object linking is not affected, in accordance with the Direct Argument Linking Hypothesis.

We now turn to the linking of commercial transaction verbs. As we discussed in the previous section, these verbs describe identical classes of situations, but link their arguments differently, contra the assumption of the SBH. Our solution to this problem is based on the following assumptions:

- Commercial events include several sub-situations, each represented by a separate Elementary Predication.
- These situations are shared by all words which evoke the commercial event frame, including *buy* and *sell*, probably *pay*, and possibly *charge*.[20]
- Individual words that evoke the commercial event frame select a different EP as the KEY. Since linking constraints for direct arguments target the KEY, the subcategorization of words that evoke the same frame can be accounted for.

Our first assumption is justified by the properties of the commercial event frame, discussed in Fillmore (1977). Each commercial event involves two transfers, a transfer of goods (or services) and a transfer of money or any goods serving as barter. Furthermore, two sentient entities are jointly responsible for each transfer. The buyer is responsible both for money or barter being transferred to the seller and for goods being transferred to him. Similarly, the seller is responsible both for goods being transferred to the buyer and for money or barter being transferred to him. In other words, the buyer is a participant in a situation of giving money and in a situation of obtaining goods, while the seller is a participant in a situation of giving goods and in a situation of obtaining money. In all, then, a commercial event is composed of four sub-situations. The presence of four sub-situations results from two constraints. The first constraint pertains to acts of giving in exchange situations and ensures that any situation categorized as an act of x giving y to z within an exchange situation is also categorized as an act of z obtaining y from x. The second constraint pertains to exchanges of goods and ensures that in any exchange situation, x's transfer of y to z is accompanied by z's countertransfer of t to x (money, barter, …). We thus posit the model-theoretic constraints among situations stated in (32).

[20] The grammaticality of sentences such as *Blockbuster charges a $1.25 restocking fee for movies that are late by more than one week*, which do not seem to describe an event in which the customer receives anything in return for the fee, suggests that the existence of a countertransfer to the money transfer might be a mere (strong) implicature in the case of *charge*. Some uses of *pay* seem to display the same weakening of the required presence of a countertransfer. We leave the resolution of this issue to another venue.

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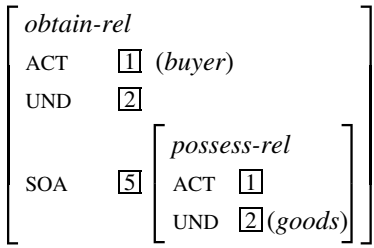
(32) (a) If a situation *s* is described by/supports an *exchange-give-rel* semantic relation, it must also be described by/support an *obtain-rel* semantic relation and the obtainer of the *obtain-rel* is the recipient of the *exchange-give-rel* and the obtained item is identical to the given item.

(b) Any situation *s* that is described by/support an *exchange-rel* semantic relation must also be described by/support two instances of *exchange-give-rel*, one in which goods are transferred from an entity *a* to *b* and another in which money or barter is transferred from *b* to *a*.

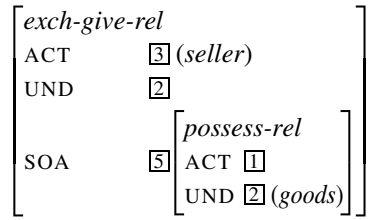
The lexical semantic representation of commercial transaction verbs reflects our model-theoretic assumptions in that each commercial event verb includes in its lexical semantic representation the four exchange relations in figure (33). One of these relations is selected as the KEY of the verb's lexical semantic content. At present, we view KEY selection as a matter of lexical stipulation (all the possibilities are attested); we discuss the possible semantic consequences of KEY selection below. The resulting lexical semantic representation of various commercial exchange verbs thus follows from the nature of commercial exchange situations together with the lexical stipulations in (34).[21]

(33) The four semantic relations constituting a commercial event

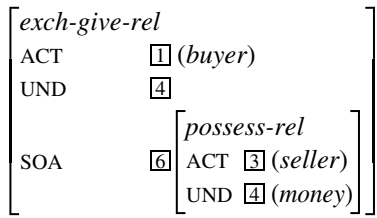
(a) obtaining goods



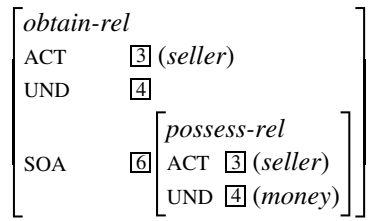
(b) giving goods



(c) giving money



(d) obtaining money



[21] One reviewer wonders whether other sets of verbs might not show the same kinds of problems as commercial event verbs and cites *fear*/*frighten* and *win*/*lose*/*beat* as such possible examples. Space prevents us from considering all possible sets of verbs that parallel the issue raised by commercial event verbs. We note though, that *fear* and *frighten* are not mutually entailing doublets like the commercial verbs (basically, *frighten* is the causative version of *fear*, as argued in Wechsler (1995b), among others). Verbs of winning, on the other hand, *do* parallel our commercial event verbs and should include more than one elementary predication in their list of relations.

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(34) (a) *buy*: its KEY is (a)
(b) *sell*: its KEY is (b)
(c) *pay*: its KEY is (c)
(d) *charge*: its KEY is (d)

Figures (36) and (37) illustrate how KEY selection differences account for the distinct linking behavior of the verbs *buy* and *sell*. The semantic equivalence of *buy* and *sell* is represented by the content of their RELATIONS attributes and the constraints in (32). The semantically predictable part of their linking properties is in the mapping of ACTOR and UNDERGOER to ARG-ST positions; the irreducible and idiosyncratic part of their linking properties is in each verb's selection of KEY. Since the EP representing obtaining goods is selected as KEY for *buy*, it is the ACTOR and UNDERGOER of this EP which are mapped onto the first and last NP members of the ARG-ST list, respectively, in accordance with the linking classes represented in figure (4) above. Since the EP representing giving goods is selected as KEY for *sell*, it is the ACTOR and UNDERGOER of that EP which are mapped onto the first and last NP members of the ARG-ST list.

Linking of the remaining arguments of *buy* and *sell* follows from the account of linking of PPs with semantically potent prepositional heads proposed in Wechsler (1995a) and Davis (2001), following work by Gawron (1986), and the Indirect Argument Linking Hypothesis. Summarizing Wechsler's and Davis' work, the CONTENT of *to* and *from* with transfer of possession verbs (and semantically potent prepositions heading verbal complements in general) is structure-shared with that of (a part of) the verb's CONTENT. Since the CONTENT of the *to*-PP of *sell* is identical to (a part of) the KEY relation, its linking must proceed from the KEY, as per Hypothesis 4, and since the KEY of *sell*, on the other hand, is a subtype of *give-rel*, the linking of the goal of transfer will be that of *give*, namely a *to*-PP. The case of *from*-PPs with verbs such as *buy*, *borrow*, or *rent* is more complex, as the object of the preposition does not denote any of the participants denoted within the KEY EP. We can imagine two possibilities, each with several variants. First, we could, along with Jackendoff (1990), assume that these PPs target the original possessor of the goods. Adopting Jackendoff's proposal literally would require revising our analysis of acts of giving to include an abstract notion of motion (possessional GO in Jackendoff's conceptual structure representation) of the goods *from* the seller *to* the buyer. Alternatively, if we wish to avoid this Schank-style (see Schank 1973) semantic decomposition, we could implement this hypothesis by positing that the semantic content of *buy* includes one additional EP, or that the *from*-PP adds this EP to the semantic content of the VP it is part of. This new EP could be paraphased as 'the buyer caused the seller not to have the goods'; such an analysis assumes with Van Valin & Lapolla (1997) that *from* targets these embedded negative eventualities (on a par with verbs such as *dissuade from*). Second, one could draw on the parallel between *buy* and *obtain* and analyze the

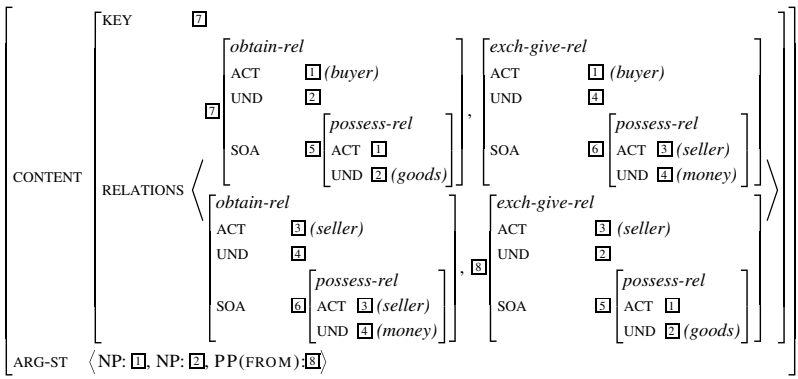
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from-PP as denoting the *exch-give-rel* whose causal agent is the seller. This last possibility is bolstered by clauses containing the verb *obtain*, in which the referent of the object of *from* does not need to have possessed the obtained goods, as sentence (35) suggests.

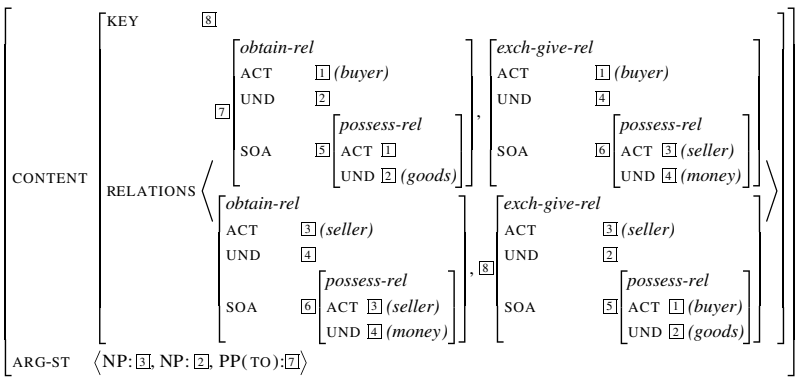
(35) Maureen obtained a degree in Social Engineering from the University of Delaware.

Since choosing between these possibilities is difficult and somewhat tangential to our point in this paper, we will not discuss the matter further here. For expository purposes, though, we will assume that the *from*-PP targets the *exch-give-rel* whose causal agent is the seller in the figures below. Finally, the money, not being an argument within the KEY of *buy* or *sell*, must be linked from other EPs in the RELATIONS attribute; i.e. the rule for linking the *for*-PP to the money exchanged will target the relations that involve transfer of money. (Note that whether we are talking about giving money – for *buy* – or obtaining money – for *sell* – the linking does not vary. We have no explanation for this fact at present.)

(36) A representation of the relevant parts of the lexical entry for *buy*



(37) A representation of the relevant parts of the lexical entry for *sell*



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Let us sum up our solution to the difficulty which commercial exchange verbs present for the SBH. First, by using a flat set of EPs as our representation of the semantic content of predicators, we can represent the uniform semantic content corresponding to the commercial exchange frame which all verbs evoking this frame share. Second, by letting lexical entries idiosyncratically designate one of the EPs as the one responsible for the linking of direct arguments, we can account for the different linking behavior of the various commercial exchange verbs.

Some readers might question whether this last step is progress. After all, we have traded Jackendoff's 1990 analysis of the distinct linking of commercial exchange verbs, which is based on postulated differences in conceptual structure, for an analysis which is partly based on lexical stipulation. But we believe this interpretation of our analysis would be erroneous. First, linking is still semantically based, in the sense that once the KEY is selected, linking follows as before from general, semantically-based linking classes such as those represented in figure (4). Second, the purported semantic differences among commercial exchange verbs is not, we believe, motivated by any empirical observation. It is rather a consequence of the need to provide the right conceptual 'geometry' so that linking constraints can appropriately apply. In that respect, representations of these putative differences effectively involve disguised syntactic diacritics. Our analysis simply avoids clothing syntactic distinctions in semantic garb. Third, we do not claim that KEY selection has no conceptual import. Choosing a particular commercial event verb (and therefore the KEY it selects) might direct more of the focus of a listener's attention to that particular component compared to other components of the commercial exchange frame. Moreover, the choice of one verb or another will depend on features of context and discourse, so that the difference might be said to be semantic in a broad sense. But, importantly, and contra the assumption made by Jackendoff and others, this possible conceptual import of KEY selection is not denotational (model-theoretic); it does not pertain to differences in the properties of the situations felicitously described by the various verbs.

Finally, the rejection of the semantic tree hypothesis, and the adoption in its place of the hypothesis that direct arguments are linked off the KEY of a predicator, also help us maintain Pinker's intuition that there is a semantic difference between the two variants of verbs such as *spray* or *load*, without being forced to add unmotivated semantic predicates such as BY solely to ensure the appropriate 'geometry'. We assume that $spray_{\text{loc}}$ denotes a simple change of location, while $spray_{\text{with}}$ denotes a subset of those situations, namely situations that are changes of state, as well as changes of location of the kind described by $spray_{\text{loc}}$ (see Gropen et al. 1991). Thus the semantics of $spray_{\text{with}}$ is as indicated in figure (38a), while that of $spray_{\text{loc}}$ only includes the second member of the RELATIONS, which, perforce, given a general constraint that a sign's KEY is token-identical with a member of the RELATIONS value, will

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be also the KEY, as indicated in figure (38b). The different KEY EPs, in turn, entail differences in the selection of direct arguments. Crucially, the semantic difference between the two *spray* variants is represented without resorting to semantically unmotivated predicates/keywords. The locus of the lexical stipulation is in KEY selection and is not erroneously presumed to be a property of described situations.

Finally, we note that KEY selection across lexical items is not wholly random. Patterns of KEY selection correspond with the 'narrow conflation classes' of Pinker (1989) or the classes enumerated in Levin (1993). Thus, while verbs such as *splatter* and *splash* display the same alternation of CONTENT value and KEY selection as *spray*, most English verbs of caused motion do not. One way to state generalizations about KEY selection at this level is in terms of relationships between classes in the hierarchical lexicon; see Riehemann 1998, Koenig 1999a, Davis 2001, among others. But whatever mechanism one prefers for analyzing other phenomena of lexical derivation (such as morpholexical rules) can be employed to express this type of relationship.

(38) CONTENT values of $spray_{\text{with}}$ and $spray_{\text{loc}}$

(a) $spray_{\text{with}}$

$$\begin{bmatrix} \text{KEY} & \boxed{3}\begin{bmatrix} \textit{spray-ch-of-st-rel} \\ \text{ACT } \boxed{1} \\ \text{UND } \boxed{2} \\ \text{SOA } \begin{bmatrix} \textit{ch-of-st-rel} \\ \text{UND } \boxed{2} \end{bmatrix} \end{bmatrix} \\ \text{RELATIONS} & \left\langle \boxed{3}, \begin{bmatrix} \textit{use-rel} \\ \text{ACT } \boxed{1} \\ \text{UND } \boxed{4} \\ \text{SOA } \boxed{3} \end{bmatrix}, \begin{bmatrix} \textit{spray-ch-of-loc-rel} \\ \text{ACT } \boxed{1} \\ \text{UND } \boxed{4} \\ \text{SOA } \begin{bmatrix} \textit{ch-of-loc-rel} \\ \text{FIG } \boxed{4} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

(b) $spray_{\text{loc}}$

$$\begin{bmatrix} \text{KEY} & \boxed{5} \\ \text{RELATIONS} & \left\langle \boxed{5}\begin{bmatrix} \textit{spray-ch-of-loc-rel} \\ \text{ACT } \boxed{1} \\ \text{UND } \boxed{4} \\ \text{SOA } \begin{bmatrix} \textit{ch-of-loc-rel} \\ \text{FIG } \boxed{4} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

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3. More examples of KEY selection

In this section we analyze additional cases of verb linking and subcategorization under the Semantic Set and Direct Argument Linking Hypotheses. We first describe other sets of verbs that present problems very similar to the model-theoretic dilemma posed by commercial event verbs. We show that our analysis of commercial exchange verbs also extends to these other cases.

The pair *replace* and *substitute* are one such case (noted briefly in Croft 1991). Consider the following sentences.

(39) (a) Bill replaced the sugar with salt.
(b) Bill substituted salt for the sugar.
(40) (a) Joan carved a canoe out of the log.
(b) Joan carved a log into a canoe.

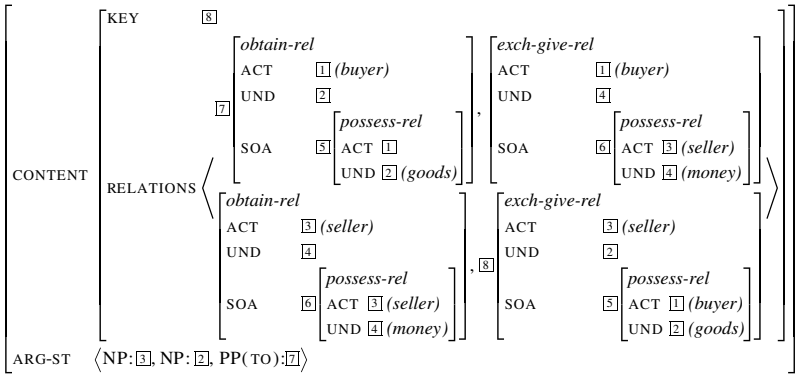
Intuitively, the situations described by each verb contain more than one eventuality, as is the case for commercial event verbs. Any replacement or substitution involves two events of caused change of location. Any carving (at least the kind of carving described by the sentences in (40)) involves an event of incision and removal of material, a resulting change of shape of an object, and the eventual creation of a new object (more on this below). Since all these events comprise more than one component, their lexical semantic representations include more than one EP, thereby raising the question of which one is the one relevant to the linking of direct arguments. Again, KEY selection seems free (for *carve* and similar verbs of creation) or more or less lexically arbitrary, as the contrast between *replace* and *substitute* shows (see Croft 1991 for somewhat similar remarks). The situation is even more complex with *carve*. This is because the effect of the incision/removal events can be categorized in two ways. First, it can be viewed as a transformation of one object *into* another. The linking of *carve* then follows that of the causative version of *transform*, as in (41). Alternatively, it can be viewed as the emergence of one object *from* or *out of* another. The linking of *carve* then follows that of the parallel use of *make*, as in (42).

(41) The experience transformed him into a workoholic.
(42) You can make pie out of crumbles.

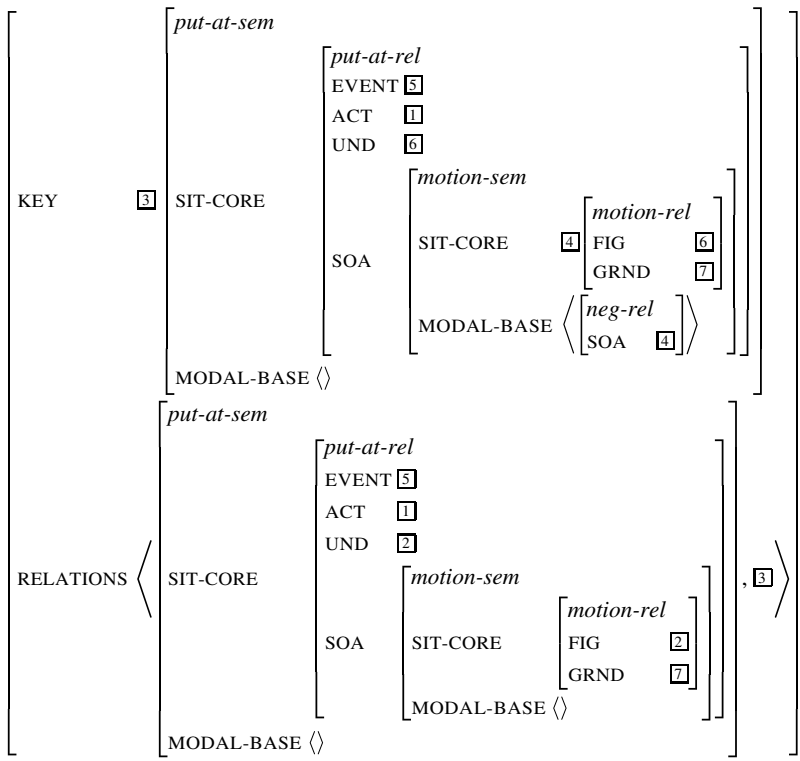
Since our theory currently has nothing to say about these alternative, partly metaphorical categorizations, we restrict ourselves to predicting the linking of direct arguments of *replace* and *substitute*. As was the case for situations of exchange, two different events are included in a replacement/substitution situation, as shown in figures (43) and (44), which represent the semantic content of these two verbs.

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(43) CONTENT values of *substitute for*



(44) CONTENT values of *replace with*



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Each verb describes situations that fit two descriptions: an agent causes an entity to move into a space (the entity designated by the attribute value identified by 2 in figures (43) and (44)), and the same agent causes another entity to move out of that space, or prevents it from occupying that space (the entity designated by the attribute value identified by 6 in figures (43) and (44)). Accordingly, the RELATIONS attribute of both verbs contains two EPs, one for each description. The fact that these two descriptions concern the same situation is represented in the figure by the identity of the values of the attribute EVENT (which corresponds to the event variable in Davidsonian semantics), namely 5. Note that the lexical semantic representations of the EPs included in figures (43) and (44) are more complex than the representation of EPs we have used until now. The content of situational EPs is now divided into two parts, a situational core which represents the basic relation between participants that characterizes the described situations (a possession relation, a motion relation, a putting relation, …) and a modal component which evaluates these relations at an appropriately selected set of possible worlds (see Koenig & Davis 2001 for justification and details on the distinction between situational core and modal base). For our purposes, it suffices to say that in this analysis both *replace* and *substitute* describe situations in which one object is caused to be at a certain (possibly abstract) position (this content is represented by the first member of the RELATIONS list in the two figures) and another is caused *not* to be at that position (this content is represented by the second member of the RELATIONS list in the two figures; see the *neg-rel* in the second EP in figure (43)). To represent the event-synonymy of *replace* and *substitute*, both verbs include the same RELATIONS value in their CONTENT. But each selects a different element of the RELATIONS as its KEY. *Replace* selects the taking-out event as KEY and therefore links the replaced entity to the second member of the ARG-ST list. *Substitute* selects the putting-in event as KEY and therefore links the substituted entity to the second member of the ARG-ST list. As was the case for commercial exchange verbs, the *act-vb* and *und-vb* classes correctly determine the linking of the KEY semantic relation's arguments to the subject and object functions for both verbs without being required to provide lexical semantic representations that run afoul of their model-theoretic event-synonymy.

We now turn to uses of verbs in which the 'inherent meanings', and consequently the linking pattern, are overridden by another predicate 'superimposed' on them, a phenomenon dubbed lexical subordination in Levin & Rapoport (1988) and illustrated with the resultative sentences in examples (45)–(47). (The literature on the English resultative construction is by now too large for us to cite here. See Rappaport Hovav & Levin (2001) for a recent account and bibliographical pointers.)

(45) (a) Kim squeezed the juice out of the lemon.
(linking is like *extract*)
(b) The company processed the vitamins out of the food.
(linking is like *extract*)

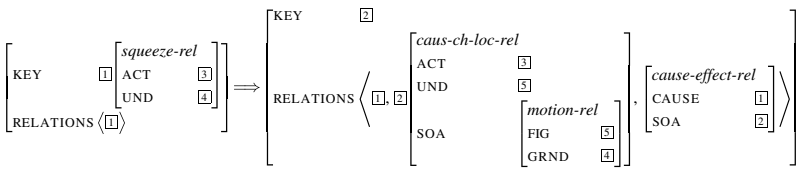
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(46) They talked Sandy into leaving early.
(linking is like *lure*, *coax*)

(47) The trucks rumbled out of the warehouse.
(linking is like verbs of motion)

As indicated below each example, the linking properties of these derived verb meanings are not arbitrary; they parallel those of verbs that have this (derived) meaning as their *primary* meaning. The notion that the meaning of a verb can include more than one EP and the notion of KEY selection are useful in modeling these facts as well. In particular, if the semantics of *squeeze*, *process*, *talk*, and *rumble* in each example corresponds, in matters relevant to linking, to that of the verb(s) below it, then we can postulate that the verbs' KEY attributes are identical in each case. More precisely, each 'subordinated' verb undergoes a lexical rule or combines with a lexeme class that adds the relevant EP and selects the newly introduced EP as the KEY. For expository purposes, the lexical rule as it applies to verbs such as *squeeze* as used in sentence (45a) is represented in figure (48). (We only indicate the rule as it applies to *squeeze* for reasons of space.).

(48) The application of the caused-motion lexical rule to *squeeze*



The figure reads as follows. In addition to the base entry for *squeeze* described on the left of the arrow, there is a related, derived entry which adds to the squeezing relation included in the verb's CONTENT a caused-motion relation. Moreover, it is this additional EP which is the KEY of the derived entry. Similar lexical rules would be introduced to relate the sound emission resultative entry (as Goldberg & Jackendoff 2003 calls it) exemplified in sentence (47) to its more basic entry.[22]

[22] This analysis of lexical subordination and resultatives is lexical in nature. It assumes that the change in meaning is due to the application of a lexical rule (or the combination of a type-underspecified entry with a lexeme class, as in Koenig (1999b)). But, as M. Butt has pointed out to us, several researchers have recently advocated a more constructional approach to this issue. According to such a view, the change in meaning is not in the verb's lexical semantic representation, but is rather induced by the syntactic environment in which it is embedded. If such a view is adopted, lexical subordination does not illustrate the usefulness of the notions of KEY and RELATIONS of EPs in lexical semantic representations, since the alternation in meaning stems from the phrase-structural environment in which the verb is embedded. We cannot, for reasons of space, compare fully these two approaches to lexical subordination. For our purposes, it is sufficient to conclude that the need to abandon the Semantic Tree Hypothesis in favor of the Semantic Set Hypothesis holds

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4. Conclusion

We have argued in this paper that the simplest way of preserving a contentful Semantic Basis Hypothesis is to abandon the 'singly-rooted tree' conception of lexical semantics, replacing it instead with a conjunction of elementary predications. In arguing against traditional models, we have aimed throughout to draw as clear a distinction as possible between information which is truly semantic, in a model-theoretic sense, and that which is syntactic (including lexically stipulated). Much recent research has tended to ascribe variations in linking patterns among predicators to underlying semantic differences even in cases where, as we have argued here, those differences cannot be clearly demonstrated. By representing the CONTENT of predicators in terms of a set of RELATIONS and a single specified KEY, we achieve two goals. First, we permit a degree of lexical idiosyncrasy in linking, by allowing KEY selection to be independent of (situation) semantic criteria. This style of representation makes evident which information in a lexical entry constrains the class of situations a predicator denotes and which does not. Second, by requiring that direct arguments of a verb be linked via a path of attributes that passes through KEY, we impose a sort of bottleneck on information passing between the semantic representation and syntactic subcategorization. The richness of a verb's semantics is not in itself constrained, but only a limited portion is syntactically accessible in a given lexical entry. By separating the channel of accessibility from the remainder of the semantic representation, we are also able to finesse questions regarding the extent of semantic decomposition and the overall level of semantic detail required in lexical entries, as there are no syntactic consequences arising from, for example, a decision about whether or not to represent the fact that food enters the mouth in the lexical entry for *eat*, or whether to represent the fact that a leg is in motion in a *kick*.

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irrespective of whether lexical subordination and resultative uses of verbs are ultimately a lexical or a phrase-structural phenomenon. Irrespective of the best analysis of resultatives, several of the phenomena we discussed above justify a *lexical* Semantic Set Hypothesis (French adjunct clitics and commercial exchange verbs, at least).

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