Ghosts, Shadows and Resultatives : The Lexical Representation of Verbs

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ABSTRACT. *We construct a large-scale lexicon for a computationally viable NLP system. Our lexical representation of verbs and events yield a principled account for a range of syntactic phenomena manifested by a large number of English verbs. First, we distinguish three types of resultatives, each requiring a distinct lexical representation in the form of an event template. On the basis of the resultative data, we develop a framework for primary and secondary event templates and a check-off mechanism governing their cooccurrence. Our theory also allows us to define and account for the realization of two types of non-subcategorized arguments. "Ghosts" may appear with otherwise intransitive verbs in resultative constructions. "Shadows" can be selected by Figure/Ground verbs, for which we provide a unified classification by means of a* FIGURE *Feature. Our template theory and check-off mechanism account in a straightforward manner for the argument alternation patterns found among Figure/Ground verbs.*

RÉSUMÉ. *Nous construisons un grand lexique intégré à un système de traitement informatique de langue. La représentation lexicale des verbes et des événements associés nous permet d'expliquer d'une façon cohérente une gamme de phénomènes syntaxiques manifestés par un grand nombre de verbes anglais. Nous commençons par distinguer trois types de résultatifs associés à trois classes de verbes différentes dont chacune nécessite une représentation lexicale différente. A la suite des données associées aux constructions résultatives, nous développons une théorie dont les éléments principaux sont des schémas événementiels primaires et secondaires ainsi qu'un mécanisme de vérification régissant leur cooccurrence. Notre théorie nous permet de définir et de rendre compte de la réalisation de deux types d'arguments nonsélectionnés par le verbe. Les "fantômes" se manifestent avec les verbes intransitifs dans des constructions résultatives. Les "ombres" sont sélectionnées par les verbes Figure/Ground, pour lesquels nous proposons une classification uniforme basée sur le trait* FIGURE. *La théorie des schémas et du mécanisme de vérification associé rendent compte d'une façon directe des modèles d'alternances des arguments trouvées parmi les verbes Figure/Ground.*

KEYWORDS: *Semantic templates, argument projection, resultatives.*

MOTS-CLÉS : *schémas événementiels, projection des arguments, phrases résultatives.*

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1. Introduction

We construct a large-scale computational lexicon of English [FON 00], [FON 01]. The lexicon is specifically designed for integration with a parser in the Principles-and-Parameters framework, aiming at a wide range of NLP applications, [FON 91]. Following [RAP 98], [PUS 95], [JAC 90], *inter alia*, we adopt the format of semantic templates for the lexical representation of verbs and events. Event templates refer to the subcategorization properties of the appropriate verbs, as well as the aspectual properties of the events centered around the verbs. A limited number of templates characterize one or more verb classes each that exhibit specific semantic and syntactic behaviors. Thus, templates are a way of capturing the kinds of regular patterns and class-based structure of the verb lexicon that [LEV 93] demonstrates.

In this paper, we focus on a range of syntactic phenomena pertaining to subcategorization properties of a large number of verbs. Our analyses pattern verbs somewhat differently from [LEV 93] and yield more more-fine-grained classifications with respect to argument selection and alternations.

We begin by establishing a typology of resultatives, a kind of secondary predication. This leads us to a classification of verbs selecting for the different types of resultatives. The distribution of the resultatives motivates a proposal for a novel template theory based on primary and secondary templates and a strict check-off mechanism for the elements in the templates.

Background

Like [GRO 75], who classified 3,000 French verbs, or [SAI 99], who examined approximately 1,700 French verb senses, we aim at large-scale coverage of the verb lexicon for truly useful computational implementation. Both Gross and Saint-Dizier characterized verbs in terms of their syntactic behavior and arrived at a large number of small classes.[1] Our approach, while less broad, provides a theoretically motivated account for a well-circumscribed class of alternations involving non-subcategorized objects. We show that, for English verbs at least, the primary/secondary template representation results in coherent classes with a large number of members. The extent of our coverage and the applicability of the primary/secondary template approach is summarized in section 6.1. We review other theoretically motivated accounts in section 2.3.

1. Gross classified 3,000 French verbs into 2,000 distinct classes. Similarly, for Saint-Dizier, his verb classes contain an average of just 2 senses each.

2. Resultatives

Sentences (1) through (4) exemplify the resultative construction, a type of secondary predication.

(1) a. The burglar shattered the mirror into pieces
b. Chris wiped her hands clean

The phrases (*into pieces*/*clean*) specify the resultant states of the direct objects (*mirror*/*hands*) as a consequence of the actions. In (1a), a prepositional phrase (PP) is used to express the result; in (1b), the resultative is an adjectival phrase (AP). It turns out that verbs pattern into distinct classes with respect to their selection of resultatives.

We call verbs like *shred* and *tear* **verbs of transformation**. These are compatible with PP but not with AP resultatives.

(2) a. The spy shredded/tore the documents
b. The spy shredded/tore the documents into pieces
c. * The spy shredded/tore the documents illegible

Activity verbs such as *wipe*, *brush* and *scrub* select for AP, but not PP resultatives.

(3) a. John wiped/brushed/scrubbed the floor
b. John wiped/brushed/scrubbed the floor clean
c. * John wiped/brushed/scrubbed the floor (in)to a shiny surface

A third class of verbs, e.g. de-adjectivals which encode the resultant state, is incompatible with both AP and PP resultatives.[2]

(4) a. The alarm awakened the hotel guests
b. * The alarm awakened the hotel guests alert
c. * The alarm awakened the hotel guests into early risers

These data point to subtle semantic properties of the verbs that have important consequences for the structure and design of event templates with respect to subcategorization.

2. Some other verb classes are also incompatible with resultatives. For example, neither verbs of creation, e.g. *write* or *build*, nor verbs of destruction, e.g. *destroy*, allow for a resultative. Creation verbs refer to an event involving an effected entity, and at the same time bring about a change of state. In the case of destruction verbs, the entity no longer exists (or is removed from the frame of reference).

Finally, there is a fourth class of verbs such as *pound*, *crush* and *hammer* that may take both AP and PP resultatives:

(5) a. hammer the metal flat
b. hammer the metal into a bowl

Consider also:

(6) a. The substance froze/solidified solid/hard
b. The substance froze/solidified into a hard block

Verbs like *freeze* or *solidify* fall into a different class from activity verbs such as *hammer* in that they express a change of state. Both the AP and PP resultative further specify or elaborate on the state. (See also note 5 and the discussion of Wechsler in section 2.3.) It has been argued that the resultative in these cases is lexically entailed, [PUS 95]. Along similar lines, Washio [WAS 99] distinguishes *weak* and *strong* resultatives; in the former case the meaning of the verb is not completely independent of the meaning of the result. Washio classifies languages as either allowing both strong and weak resultatives, e.g. English, or weak only, e.g. Middle Mongolian, Japanese and Turkish, or neither, as in French. According to Talmy [TAL 85], French is an example of a *verb-framed* language, contrasting with *satellite-framed* languages like English with respect to verb lexicalization and the syntactic mapping of semantic components such as PATH/RESULT and MANNER. As (7) shows, in English MANNER is directly encoded by the verb, while PATH and RESULT are projected as adjuncts:

(7) a. They danced across the room
V+MANNER PATH
b. She rubbed the fork dry
V+MANNER RESULT

In French the verb lexicalizes PATH/RESULT, whereas MANNER is typically expressed by an adjunct, such as the gerundives in (8):

(8) a. Ils ont traversé la salle en dansant
V+PATH MANNER
They crossed the room dancing
b. Elle a sèché la fourchette en la frottant
V+RESULT MANNER
She dried the fork by rubbing it

In the next section, we develop in detail an inventory of templates to account for the resultative data and the appropriate verb classes in the case of satellite-framed languages only.[3]

2.1. *Semantic Templates*

Each verb in the lexicon is linked to a semantic template encoding both properties particular to that verb and properties common to all verbs in the relevant semantic class. A semantic template encodes the appropriate semantic relations between a constant (shown in <...>) and its arguments (shown as *x* and *y*). The constant may express a final state or manner of action. The following three basic templates correspond to the three distinct cases exemplified above.

(9) a. x CAUS y XFORM$_{<\text{manner}>}$(y') (Transformation)
b. The spy shredded the documents
c. x = spy, y = documents, y' = (new entity), <manner> = shredding

(10) a. x ACT$_{<\text{manner}>}$ ON y (Activities)
b. John scrubbed the floor
c. x = John, y = floor, <manner> = scrubbing

(11) a. x CAUS y BECOME <state> (Accomplishment)
b. The alarm awakened the hotel guests
c. x = alarm, y = hotel guests, <state>= awakened

We refer to these templates as **primary templates**.

(10) and (11) encode an important difference between manner and state. In (11), the de-adjectival verb itself (*awakened*) expresses the resulting state (*awake*) . However, manner verbs like *scrub*, *sweep* and *brush* do not encode the end state. They allow for the end state to be expressed by a resultative, as shown below.

(12) a. x ACT$_{<\text{manner}>}$ ON y & y BE <state>
b. John scrubbed the floor clean

3. The analysis in terms of primary and secondary templates to be developed in section 2.1 can be extended to verb-framed languages. For example, (8b) can be expressed as:

x CAUS y BECOME <dry> & x ACT$_{<\text{rubbing}>}$ ON y

The secondary template check off mechanism applies without change. Note secondary x must be covertly realized as an empty pronominal PRO. This follows from the tenseless gerundive structure.

c. John ACT$_{<scrubbing>}$ on floor & floor BE <state(*clean*)>

In (12), the end state (*clean*) is encoded by the resultative. The end state is represented by the **secondary template** in (13).

(13) y BE <state>

Secondary templates are constrained by the following principle.

(14) **Check Off Condition**: All secondary template elements must be checked off against corresponding elements in a primary template.

Therefore *y* in (12c) must be linked to, or checked off against, the primary template x ACT$_{<manner>}$ ON y. In other words, the two distinct *y*s must co-refer. Furthermore, check-off condition (14) prevents intransitives from co-occuring with resultatives, as in **John scrubbed clean*; the *y* in the secondary template cannot be checked off against a corresponding element in the intransitive template x ACT.[4]

Another condition is necessary to rule out sentences like (4b), repeated below as (15b).

(15) a. x CAUS y BECOME <state> & y BE <state>
b. * The alarm awakened the hotel guests alert
c. * The alarm CAUS the hotel guests BECOME <*awakened*> & the hotel guests BE <state(*alert*)>

This uniqueness condition is given in (16).

(16) **Unique State Condition**: <state> may occur at most once in a template.

(16) implies that the secondary template must not contain <state> if the primary template does.

Finally, a sentence like (2b) with a PP resultative, repeated below as (17b), expresses the transformation of *y* into a new entity (*y'*).

(17) a. x CAUS y XFORM (y') & y BECOME y'
b. The spy shredded the documents into pieces
c. *The spy* CAUS *documents* XFORM (*pieces*) & *documents* BECOME *pieces*

4. For discussion on how intransitives and resultatives can be combined via a dummy object, see section 3.

The preposition *into* refers to a transformation. The associated secondary template contains two arguments, *y* and *y'*, which must both be checked off. Hence, the PP resultative is only compatible with primary templates like x CAUS y XFORM (y'), which mention both *y* and *y'*. We have now explained the ungrammaticality of (3c).

Our analysis yields a three-way classification of verbs with respect to resultative-taking properties.[5] The lexicon in which the verbs are thus classified feeds into a principles-and-parameters parser, PAPPI [FON 91], so that secondary predicates can be identified and analyzed.

2.2. *Syntactic Representation*

A number of proposals exist specifying the syntax of the resultative in the literature. The three main possibilities are the following:

1) [CAR 92]: a ternary branching syntactic analysis in which the resultative and its subject do not form a syntactic unit. Under this analysis, the form of a resultative is as in (18), where the verb phrase is ternary branching:

(18) $[_{V}$ water] $[_{NP}$ the tulips] $[_{AP}$ flat]

2) [NEE 91]: The verb and resultative form a unit at the level of logical representation, as in (19).

(19) $[_{V}$ wipe-clean] $[_{NP}$ the table]

3) [HOE 88] proposes a small clause analysis, which we adopt here. The resultative and the direct object form a syntactic unit. This goes along with the proposal that the direct object and resultative form a semantic unit, as indicated by the secondary template analysis from the previous section.

The syntactic structure that we assume is a binary branching analysis, in which the direct object and resultative form a small clause.

The structure is shown in (20) and (21), for AP and PP resultatives, respectively.

(20) $[_{VP}$ $[_{V}$ wipe] $[_{AP}$ $[_{NP}$ the table] $[_{A'}$ clean]]]

5. Sentences like *The potter rounded the clay into a ball* and *They widened the road into a highway* are only apparent counterexamples. The NP in the PP does not refer to a totally transformed entity: the *ball* is still *clay* and the *highway* is still a *road.* The difference between an *into*-phrase that signals a new entity versus one that does not can be teased out by means of an entailment test. For example, *The spy shredded the document into pieces *and now it is a useless document.* Compare with *They widened the road into a highway and now it is a suitable road for trucks.* By the same token, *into a hard block* in (6b) constitutes a modification of the change of state denoted by the verb *freeze* or *solidify*, rather than a new entity: *the substance froze/solidified into a hard block and the substance is still usable*.

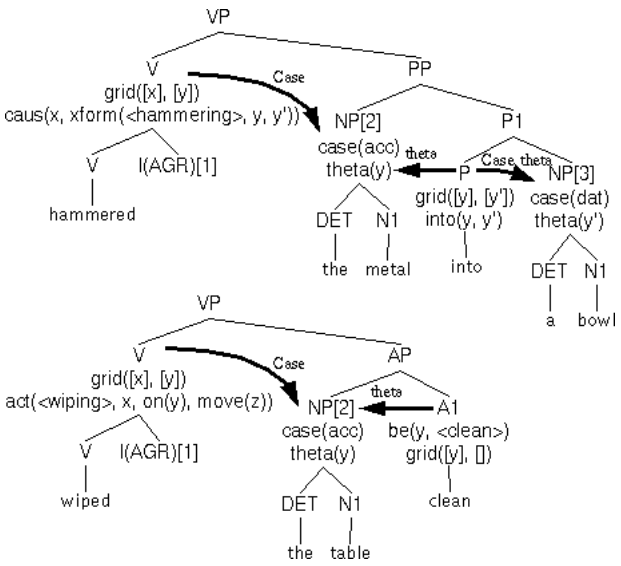

Figure 1. *Syntax of resultatives*

(21) [$_{VP}$ [$_{V}$ hammer] [$_{PP}$ [$_{NP}$ the metal] [$_{P'}$ [$_{P}$ into] [$_{NP}$ a bowl]]]]

We assume that the resultative itself is an A' or P', and the phrase headed by the resultative is a small clause AP or PP [STO 83]; this phrase has as its structural subject the entity whose resulting state (*flat, clean, into a bowl*) is being asserted. The semantic intuition captured by this structural representation is that the direct object and the resultative form a semantic unit, in which the resultative predicate refers to the end state of the verb's object, which is in turn the "subject" of the resultative. Note that the verb's object is a structural subject, according to the X'-schema.[6]

In the Principles-and-Parameters framework [CHO 81], Case and theta-role assignment proceed as follows:

1) Transitive verbs accusative Case-mark nominal objects. When the syntactic object is a small clause, this Case is assigned to the nominal subject of the small

6. This is does not mean that the event structures could not translate or map into a Carrier-Randall-style ternary branching analysis. However, the separation between primary and secondary templates most naturally carries over to the small clause/verb-shell analysis that we adopt. Furthermore, our analysis captures the fact that the direct object of the construction is the subject of the resultative [SIM 83]. Note, we restrict our attention to core cases of resultatives involving change of state and transformation into a new entity; in particular, we distinguish these cases from those involving subject-oriented goal phrases such as *the tourist followed the guide into the museum* or *John ran to the store*.

clause via the mechanism of exceptional Case-marking.[7]

2) A problem that all accounts must deal with is the assignment of thematic roles to the object without violating the Theta Criterion, i.e. the the restriction that there must be a one-to-one correspondence between roles and arguments. The object that undergoes a change of state is both an argument of the verb and the resultative. Under our approach, obligatory check off at the template level ensures that the y element is co-identified. At the level of syntax, y is simply assigned to the modified phrase by the resultative head.

The processes described above are summarized in figure 1.

2.3. *Related Work*

Goldberg [GOL 95, GOL 01] addresses the topic of resultatives within Construction Grammar. Goldberg proposes that only patients are eligible for resultative modification. However, for examples such as *She sang the audience dizzy*, where *the audience* is arguably an experiencer, Goldberg has to extend the notion of patient to "potential patient", a modification that is difficult to define precisely. Our theory instead refers only to syntactically mapped entities like x and y; their semantic interpretation is a function of both their position within the template and the semantics of the verb that selects them; e.g. y represents an object that undergoes a change of state in template x CAUS y BECOME <state>, but this is not necessarily so in x ACT ON y. A y that undergoes a change of state is a prototypical example of a patient, but only in the latter case is y a candidate for AP resultative modification.

Bresnan and Zaenen [BRE 90] account for the distribution of resultatives by means of the binary syntactic classification feature [$\pm r$]. Patient-like roles, as well as "non-semantic arguments" such as fake reflexives (to be discussed in section 3), are marked with [-r]. The generalization then is that resultatives select for [-r] elements. The LFG account parallels our approach in certain respects. For example, we employ y check-off for the resultative secondary template y BE <state>. LFG uses the equivalent [-r] selection. Similarly, there is a logical separation between verb representation and syntax in both approaches. In LFG, the mapping is controlled by the assignment of syntactic classification features, including [$\pm r$]; in our approach, secondary templates are equated with small clauses. However, the secondary template device extends to much more than just resultatives; it has far-reaching consequences for mapping lexical entities into syntax, to be expanded upon in section 5.

Wechsler [WEC 97] distinguishes between "control" and "raising" resultatives. Control resultatives modify subcategorized direct objects and refer to a "canonical end state" constrained by the semantics of the verb. This predicts a restricted range

7. Exceptional Case marking (ECM) is independently needed to handle verbs like *believe* in *Bill believed him to be insane*.

of possible resultatives.[8] Our approach is primarily syntactic, putting aside pragmatic constraints on the result phrase; hence we will limit ourselves to the following remarks:

1) While "canonicity" is a fuzzy concept, it is clear that the state resulting from any action must be constrained by the nature of the action itself, the entity being acted upon, and possible instruments. For example, a verb of removal such as *sweep* can never be compatible with a change in color, e.g. *#sweep the driveway red*. However, within the semantic constraints imposed by the verb and its arguments, there is a range of possible resulting states: e.g. *sweep the room clean*/*clear*/*spotless*/*sparkling*/*broom-clean*.

2) With respect to raising resultatives, Wechsler is incorrect in asserting that non-subcategorized objects are unconstrained with respect to the resultant state. For example:

(22) She drank the teapot empty/half-empty/*half-full

Drink denotes an event of consumption or disappearance, which explains the compatibility with *empty*. But *half-empty* and *half-full* are denotationally equivalent. Yet only the former is felicitous, indicating that there exists a constraint from the verb's consumption/disappearance nature.

3. Ghosts

The previous sections dealt with resultatives that are optionally selected for by transitive verbs. In this section, we discuss resultatives occuring with intransitive (unergative) verbs. Unergative verbs like *run* can occur with any number of adjuncts, e.g. *She ran* (*in her new shoes*)(*in the morning*)(*on the pavement*). The nouns in these adjuncts may occur as direct arguments provided that they are accompanied by a resultative. We call such direct objects, **ghosts**.

(23) a. She ran her new shoes threadbare
b. * She ran her new shoes
c. She ran the morning away
d. * She ran the morning
e. She ran the pavement/her soles thin[9]
f. * She ran the pavement

8. Note there are other restrictions on resultative selection. For example, as [GOL 95] has noted, deverbal past participles are always excluded, e.g. **cram the suitcase broken.* The reason for this constraint is at present not well-understood.

9. A reviewer questioned the acceptability of phrases like *ran the pavement thin*. However a web search turned up many naturally occurring instances of these and similar phrases, such as the ones in (22), (23) and (24).

Ghosts are not part of the verbs' basic event structure, i.e. they are not subcategorized for by the verb. Instead, they are thematically unconstrained entities that appear in direct object position.

Optionally unergative verbs, i.e. verbs that can undergo Indefinite Object Deletion, also show the same behavior:

(24) a. She drank/boiled the tea
b. * She drank/boiled the teapot
c. She drank/boiled the teapot dry/empty
d. She drank the pub dry/empty

As described earlier, AP resultatives have the following secondary template:

(25) y be <state>

That is, resultatives require a direct object [LEV 95]. Following the checking theory that was introduced earlier, (23a) has template (26):

(26) x act$_{<manner>}$ & y be <state>

Now there is a mismatch between unchecked *y* and the primary template missing a *y*, which would cause the derivation to fail. However, we propose the following licensing mechanism:

(27) **Licensing Ghosts**: Check off *unchecked* y, resulting y* unrestricted

A ghost element *y** licensed in this fashion must appear in direct object position. Note that (27) does not apply in the case of (obligatorily) transitive verbs, i.e. those containing a *y* in the primary template, because the "unchecked y" pre-condition will not be met.

Fake reflexives [SIM 83] fall out as a special case of ghost argument realization. Fake reflexives occur with unergatives accompanied by a resultative:

(28) a. John jogged
b. John jogged himself dizzy
c. * John jogged himself
d. * John jogged dizzy

Jog in (28b) has the same template, and is accounted for in the same way, as *run* in (23a). The corresponding parse is shown in figure 2. The check-off procedure causes *himself* to be marked with the theta role *y** indicating thematic unrestrictedness.

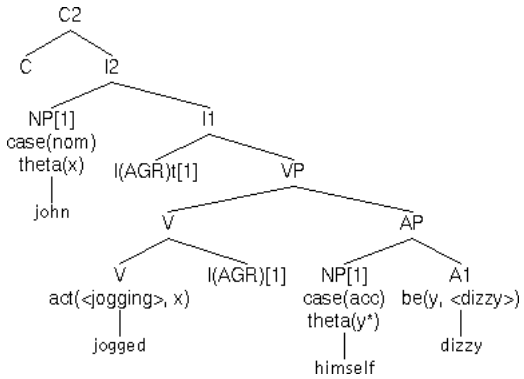

Figure 2. *John jogged himself dizzy*

4. Figure/Ground Verbs

In the previous section, we characterized ghosts. In what follows, we focus on verbs selecting for arguments denoting Figure and Ground in the sense of [TAL 88], specifically those verbs where the Ground denotes a fixed Location and the Figure a moved Material. We define *Figure*/*Ground* verbs as those that can take both a Figure and Ground simultaneously as objects, as in (29b) and (30d). We further distinguish between those verbs that take either a Figure or Ground argument as their only (unmodified) object. Examples (29a) and (29c) show that *rub* is a Ground verb.

(29) a. rub the skin (Ground)
b. rub the skin with lotion
c. * rub the lotion (Figure)
d. rub the lotion into the skin

On the other hand, *set* in (30) is a Figure verb.

(30) a. * set the ring (Ground)
b. set the ring with the diamond
c. set the diamond (Figure)
d. set the diamond into the ring

For *set* in (30), the Figure and Ground arguments are represented by the *diamond* and *ring*, respectively.

4.1. *The* FIGURE *Feature*

We propose that within the framework of the template theory introduced in section 2, the difference between verbs like *rub* and *set* is indicated by the presence or absence of the the feature FIGURE in the template as shown in (31).

(31) a. x ACT$_{<\text{manner}(\textit{rubbing})>}$ ON y[10]
b. x CAUS y BECOME <state(*set*)> [FIGURE]

In (31b), *set* is defined to be a Figure verb by the presence of the feature FIGURE. Implicit in the corresponding template (31a) for *rub* is the assumption that verbs are Ground verbs, unless otherwise marked.

The FIGURE feature operates as follows:

(32) [**FIGURE**]: The argument encoding the Figure feature in a Figure/Ground verb template must be realized in syntax.

In other words, a Figure verb must always have an overt Figure argument by definition. Constraint (32) rules out (30a), which contains only a single Ground argument. (Conversely, all subcategorization frames for a Ground verb must contain a Ground argument.)

Although a Figure verb must allow the Figure argument to appear without modification, further constraints with respect to other arguments may apply. For example, contrast the Figure verb *spread* in (33) with *set* in (30).

(33) a. * spread the bread (Ground)
b. * spread the bread with cheese
c. spread the cheese (Figure)
d. spread the cheese on(to) the bread

In particular, compare (33b) with (30b). Although the Figure *cheese* is present in (33b), it cannot appear in a *with*-LOCATION phrase. By contrast, *set* permits its arguments to appear in *with*-LOCATION and *into*-MATERIAL, as in (30b) and (30d). The difference between these two Figure verbs hinges on whether the Ground argument counts as a shadow, which we define as a syntactically promotable argument in a sense which we make precise in section 5. That is, the Ground argument for *set* is a shadow, whereas the corresponding argument for *spread* is not. The converse situation arises with Ground verbs such as *inundate* in (34).

10. *Rub* is encoded using the ACT template because it admits an AP resultative: e.g. *rub the skin raw*.

(34) a. inundate the office (Ground)
b. inundate the office with email
c. * inundate the email (Figure)
d. * inundate the email into the office

The mechanism for the realization of the Figure and Ground arguments will also be discussed in detail in section 5.

4.2. ±FIGURE

Verbs such as *inject* in (35) and *settle* in (36) behave both like Figure and Ground verbs.

(35) a. inject the patient
b. inject the patient with drugs
c. inject the drug
d. inject the drug into the patient

(36) a. settle Australia
b. settle Australia with convicts
c. settle the convicts
d. settle the convicts in Australia

The corresponding semantic template is given in (37).

(37) x CAUS y BECOME <state(*injected*/*settled*)> [±FIGURE]

That is, verbs like *inject* and *settle* may or may not exhibit the feature FIGURE.

4.3. *Further Restrictions*

Verbs like *cram* and *jam* in (38) appear to be exceptions to the Figure/Ground model in that they allow neither the Figure nor the Ground to appear alone.

(38) a. * cram/jam the clothes (Figure)
b. * cram/jam the suitcase (Ground)
c. * cram/jam the clothes crumpled
d. cram/jam the suitcase full
e. cram/jam the clothes into the suitcase
f. cram/jam the suitcase with clothes

However, note that the addition of a AP resultative to the Ground argument (only) is permitted, as shown in (38d). Hence, given the linked primary and secondary template model from section 2, the corresponding template must be as in (39).

(39) x ACT* $_{<\text{manner}(\textit{cram/jam})>}$ ON y (MATERIAL z) & y BE <state(*full*)>

We define ACT* to be like the element ACT in the activity template, except that the event must be made telic through the addition of other syntactic elements, e.g. through secondary predication as in (38d). (38e) and (38f) represent (bounded) accomplishments in the sense that the *suitcase* is filled with *clothes* in each case. In other words, prepositions like *into* and Location *with* supply these verbs with the boundedness they require to be complete.

Finally, note (38c) is out because *cram* and *jam* are Ground verbs.

4.4. *Related Constructions*

4.4.1. *Perception and Hunt/Search Verbs*

There are also cases of apparent Figure/Ground verbs such as *hunt* and *search* verbs, as in (40), and perception verbs such as *smell*, *feel*, *taste*, as in (41).

(40) a. I hunted game (in the woods)
b. I hunted the woods (for game)

However, unlike true Figure/Ground verbs, these do not involve Figure dislocation or movement. Consider (41) for example.

(41) a. tasted the soup
b. tasted the soup for poison
c. tasted the poison
d. tasted the poison in the soup

At first glance, *taste* appears to exhibit many of the properties of a Figure/Ground verb.[11] However, contrast (41) with (35), repeated below as (42).

(42) a. inject the drug
b. inject the patient
c. inject the drug into the patient

11. The inability of arguments like *poison* to appear in a *with*-LOCATION indicates it is not a displaced Material argument.

d. inject the patient with drugs

In (42c), the Material *drug* undergoes dislocation. Hence, both *drug* and Location *patient* are arguments of the verb *inject*. There is no corresponding dislocation involved in (41d), i.e. the poison is not displaced into the soup as a result of tasting. Hence, only *poison* is a direct argument of *taste*. This difference manifests itself in syntactic structure as follows:

(43) a. taste $[_{NP}\ [_{NP}$ the poison $][_{PP}\ [_{P}$ in $][_{NP}$ the soup $]]]$
b. inject $[_{PP}\ [_{NP}$ the drug $][_{P'}\ [_{P}$ into $][_{NP}$ the patient $]]]$

In (43a), the Location *soup* attaches as an adjunct to the direct object *poison*. In (43b), *the drug* and *the patient* combine to form a double-object small-clause construction along the lines of [PES 95].

4.4.2. *Location and Instrument Verbs*

Verbs like *poke* in (44) and *dig* in (45) seem at first glance to be Location (Ground) verbs.

(44) a. poke the cloth
b. poke the cloth with a needle
c. * poke the needle
d. poke the needle into/through the cloth

(45) a. dig the ground
b. dig the ground with a spade
c. * dig the spade
d. dig the spade into the ground

However, these are Location/Instrument verbs, to be distinguished from Ground verbs like *rub* in (29). In particular, Location/Instrument verbs may permit Instrument promotion to subject, whereas the corresponding Material promotion to subject is impossible for Ground verbs, as shown in (46).[12]

12. We do not address in this paper the general case of promotion to subject. Subject promotion seems to depend on a variety of semantic features. For example, the notion of sentience seems to be relevant for unaccusative and middle formation.
Unaccusative formation is available to verbs whose external argument in the corresponding transitive can be a cause or agent, e.g. *melt* is marked as ±SENTIENT allowing for *John/the sun melted the ice*; *the ice melted*. However, middle formation must be based on +SENTIENT verbs whose subject is an agent: **John/the sugar rotted the teeth*/**Molars rot without difficulty*. See [FEL 89] and [FON 00] for more detail.
Similarly, [WOJ 76] and [SCH 89] discuss the possible semantic features determining the promotability of subjects of instruments.

(46) a. The needle poked (through) the cloth
b. The spade dug into the ground
c. * The lotion rubbed (into) the skin

Finally, cross-linguistic variation exists with respect to the feature ±FIGURE. For example, in Korean, the counterparts to English Ground verbs may be Figure verbs, and vice versa, [KIM 99].

5. Shadows

Section 3 discussed one kind of non-subcategorized object, which we called ghosts. In this section, we consider the status of a different type of non-subcategorized object, call it a *shadow*, such as *the crumbs* in (47c) and (47d) for Figure/Ground verbs.[13] (47a) shows that *wipe* is a Ground verb as defined in section 4. The Material (Figure) argument *the crumbs* is non-subcategorized in the sense that it cannot occur alone in direct object position, as shown in (47e):[14]

(47) a. John wiped the table
b. John wiped the table of crumbs
c. John wiped the crumbs off the table
d. John wiped the crumbs up/away
e. * John wiped the crumbs[15]

The notion of a secondary template and the requirement to check off arguments against corresponding primary elements have been established in section 2. In keeping with this framework, the secondary template mechanism also accounts for non-subcategorized objects. In the examples to follow, non-subcategorized objects will be represented by *z* to distinguish them from subcategorized direct objects (represented by *y*). Examples of secondary templates are given in (48).

(48) a. z UP/AWAY/OUT
b. z OFF/FROM y
c. y OF z

13. Note that our usage of the term differs from that found in [PUS 00]. Also compare the default arguments of [PUS 95], which may appear as non-obligatory adjuncts but do not necessarily promote into direct object or subject position.
14. Two other tests for non-subcategorization are adjectival passivization, [JON 94], and middle formation, [HAL 93].
15. This reading is available only with a Location rather than Material interpretation for *the crumbs*. For example, imagine a scenario in which John is holding a magnifying glass and wiping each crumb individually.

The corresponding primary template for *wipe* is given in (49).

(49) x ACT$_{<\text{manner}(\textit{wiping})>}$ ON y (MATERIAL z)

In terms of template structure, we define a shadow argument as follows:

(50) A *shadow* is a non-subcategorized element in the verb's primary template that is promotable to direct object or subject.

In (49), Material *z* is an example of a shadow. It may be realized as an oblique object, as in (47b), where the direct object encodes the Ground argument. It may also be promoted to direct object, as in (47c) and (47d). In this section, we will also consider cases of subject promotion for Location/Instrument verbs such as *poke* and *dig* shown earlier in (46).

Next, consider Figure verbs such as *spread* in (33), and *scatter* in (51) below, that contain a non-subcategorized argument that does not promote.

(51) a. scatter the seeds
b. scatter the seeds on the fields
c. * scatter the fields
d. * scatter the fields with seed

In the case of Figure verbs such as *daub* in (52), and *set* in (30), the Ground argument may be promoted, i.e. it is a shadow.

(52) a. daub the paint
b. daub the paint on the wall
c. * daub the wall
d. daub the wall with paint

5.1. *Promotion to Direct Object*

We now consider Material argument promotion to direct object for various classes of removal and put verbs.

5.1.1. *Removal Verbs*

Consider the (Ground) change-of-state verb *clear*:

(53) a. Mary cleared the table
b. Mary cleared the table of dishes

c. * Mary cleared the table up/away
d. * Mary cleared the dishes
e. Mary cleared the dishes from the table
f. Mary cleared the dishes up/away

Removal verbs are comprised of several subclasses that are semantically and syntactically distinct, but they all contain two internal arguments: a removed entity (Material/Figure), and a Location (Ground) from which this entity is removed. *Clear* has template (54).

(54) x CAUS y BECOME <state(*clear*)> (REMOVE z)

The shadow argument *z* is optionally realized in syntax, as (53a) and (53b) indicate. Shadow *z* also cannot stand alone, as shown in (53d). However, it can occupy the direct object position when accompanied by the demoted Ground argument (53e), or by a completive particle such as *up* in (53f).

Shadows are realized in syntax according to the following rule:

(55) **Shadow Realization Rule**: Shadow arguments are not realized in syntax except when checked off by matching secondary template elements.

Next, we state the rule of secondary template argument realization:

(56) **Secondary Template Subject Rule**: Subjects of secondary templates must be realized as direct objects

As shown in (57a), for dyadic prepositions *z* OFF/FROM *y*, *z* and *y* occupy subject and object positions in syntax, following [PES 95]. A concrete example from the implementation is shown in figure 3. When combined with template (54), the secondary subject *z* will be checked off against the primary shadow *z* and promoted to direct object by (56). The subcategorized direct object y will either be realized obliquely, as in the object of the preposition, such as *z* OFF/FROM *y*, or entirely suppressed when omitted in the secondary template, as with *z* UP/AWAY/OUT.

(57) a. [$_{PP}$ z [$_{P'}$ [$_{P}$ off/from] y]]
b. [$_{PP}$ z [$_{P'}$ [$_{P}$ up/away]]]

For monadic prepositions, the sole argument, i.e. z, will be realized in syntax as the internal subject of the secondary predicate, as shown in (57b).

The data in (53) can be explained as follows. (53f) corresponds to template (58).

(58) x CAUS y BECOME <state> (REMOVE z) & z UP

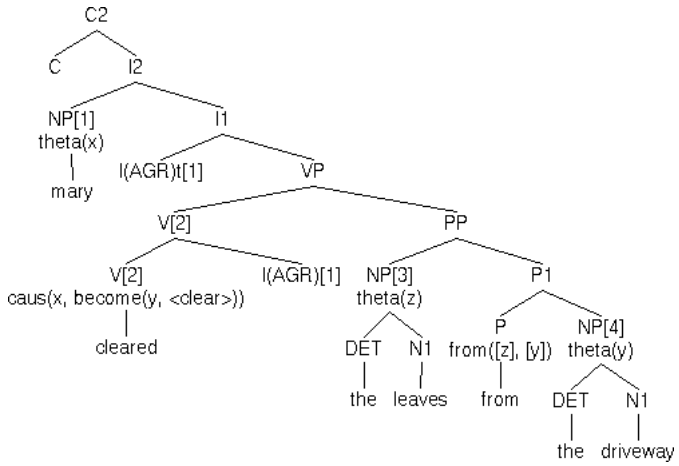

Figure 3. *Mary cleared the leaves from the driveway*

However, the secondary template argument realization rule requires *z* (not *y*) to appear as the direct object. Hence (53c) is ungrammatical.

(53d) is ungrammatical since in the absence of a secondary template, the direct object must be *y*.

(53e) is represented by template (59):

(59) x CAUS y BECOME <state> (REMOVE z) & z FROM y

The secondary *z* checks off against the primary *z* and is promoted to direct object. Note *y* is also checked off and realized obliquely as the object of the preposition *from*.

The grammaticality of (53f), introduced by template (58), is accounted for, because *z* checks off against shadow *z*, and *z* here obeys the secondary template argument realization rule. Note that *y* is suppressed since it is not mentioned in the secondary template.

Finally, consider (53b) again, shown here as (60a):

(60) a. Mary cleared the driveway of leaves
b. x CAUS y BECOME <state> (REMOVE z) & y OF z

Here, *y* is the subject of the secondary template. Hence, there is no promotion of the shadow argument as direct object.

The verbs *wipe*, *squeeze* and *sweep* belong to the subclass of removal verbs that specify the manner of removal, [LEV 93]. These verbs also employ a shadow argument, the Material entity. Consider (61) below.

(61) a. Mary swept the driveway
b. * Mary swept the driveway up
c. * Mary swept the driveway of leaves[16]
d. Mary swept the leaves off the driveway
e. Mary swept the leaves up
f. * Mary swept the leaves

This class and the change-of-state by removal verbs discussed earlier differ with respect to the resultative construction (described in section 2) but pattern almost alike with respect to non-subcategorized arguments. Hence, we can account for the distribution using the primary template (62):

(62) x ACT$_{<\text{manner}>}$ ON y (REMOVE z)

The secondary template check off and direct object promotion mechanism we applied to change-of-state removal verbs can be deployed here. However, for manner verbs, shadow argument promotion is obligatory. This difference accounts for the ungrammaticality of (61c) given (63).

(63) x ACT$_{<\text{manner}>}$ ON y (REMOVE z) & y OF z

In other words, once *z* appears in a secondary template, it must be realized as the direct object. For verbs with template (63), such as (61c), promotion of *z* clashes with (56), the secondary subject realization rule, and the derivation fails.

Consider next another subclass of removal verbs, zero-affix denominals derived from instruments, such as *rake*, *iron*, *brush*, *sandpaper*, *shovel* and *vacuum*, [LEV 93]:

(64) a. Mary ironed the pants
b. * Mary ironed the pants of wrinkles
c. * Mary ironed the wrinkles
d. Mary ironed the wrinkles out
e. Mary ironed the wrinkles from the pants

16. Some speakers may find example (61c) marginally acceptable. However, other verbs in the same class do not accept this construction: **Mary brushed/raked/shoveled the driveway of leaves*.

This class patterns exactly like the *wipe* and *sweep* class, see [LEV 93] and [PIN 89].[17]

5.1.2. *Put Verbs*

The large class of verbs of putting, [LEV 93] and [PIN 89], parallel removal verbs in that their event structure also contain both a Material and a Location argument. The change-of-state subclass of put verbs, e.g. *load*, *spray* and *paint*, pattern syntactically in a similar fashion with respect to their removal verb counterparts. Consider:

(65) a. I painted the wall
b. I painted the wall with latex paint
c. * I painted latex paint
d. I painted latex paint on the wall

These verbs have template (66).

(66) x CAUS y BECOME <state> (ADD z)

The only difference between (66) and the equivalent template for remove verbs, viz. (62), is that the the shadow argument z is introduced either by *add* instead of *remove*. This semantic distinction controls the choice of available prepositions. Hence, instead of y of z and z from y, we have:

(67) a. z ON/ONTO/INTO y
b. y WITH z

The same checking and argument promotion mechanism accounts for the data in (65).

5.2. *Shadows and Resultatives*

Denominal Figure verbs like *heap*, *pile* and *stack* admit both an AP resultative and a shadow Location, as (68e) shows.[18]

(68) a. pile the books

17. *Strip* is a remove verb having apparently a dual character. It takes a resultative, as in: stripped the furniture *bare*/*clean*, thus qualifying it as a manner verb, and at the same time it is compatible with the secondary template *y* OF z, as in: *stripped the furniture of varnish*, thereby also qualifying it as a change-of-state verb.
One possible approach to this problem is to directly note the exception in the lexical entry for *strip*. Another is to adopt the argument from [PUS 95] that in certain cases, the resultative is lexically entailed, as in the case of *solid* in: *the substance froze solid*.
18. A reviewer pointed out that, in some dialects, *stack* may take a single Location argument: as in *stack the shelves* or *She's got a part-time job stacking shelves*, where *stack* means *fill*.

b. pile the books high
c. pile the books on the shelves
d. * pile the shelves
e. pile the shelves high (with books)
f. pile the shelves with books

In (68), the *books* are being reconfigured into a pile. The pile (of books) can be further modified by a degree resultative, as in (68b) and (68e).[19]

The template for *pile* is given in (69).

(69) x CAUS y RECONFIG <*pile*> (LOC z)

The Location *z* is a shadow argument, which can be promoted under the usual conditions, as in (68f).

Consequently, (68b) has template (70).

(70) x CAUS y RECONFIG <*pile*> (LOC z) & y BE <state(*high*)>

Finally, to account for (68e), we chain two secondary templates: one for shadow promotion and the other to express the end state encoded by the resultative, as in shown in (71).

(71) x CAUS y RECONFIG <*pile*> (LOC z) & z WITH y & y BE <state(*high*)>

(71) captures a important divergence between syntax and semantics. Syntactically, the resultative modifies the direct object, i.e. the promoted (shadow) Location (*shelves*). However, on the semantic level, the resultative modifies the original Figure (*books*).

5.3. *Related Work*

Our primary/secondary division has advantages over the single-template theory with monotonic augmentation advocated in [RAP 98]. In particular, it is hard to see how template augmentation can be strictly monotonic when oblique arguments are promoted into direct object position, as is the case with shadows. Violation of monotonicity can be avoided by using two distinct templates: the disadvantage being that semantic-relatedness between the two kinds of structures will be lost. In contrast, the

19. Deadjectival verbs like *clean*, which do not admit an AP resultative, are compatible with a PP resultative that refers to a degree of change: **clean the glass shiny*/*clean the glass to a shine*. Note that the PP does not express a new entity here.

Class	Semantic Template	Count
AP resultative only	x ACT ON y	1067
PP resultative only	x CAUS y XFORM (y′)	344
AP and PP resultatives	x ACT ON y, x CAUS y XFORM (y′)	120
No AP or PP resultatives	x CAUS y BECOME AT(z)	95
	x CAUS y BECOME <state>	357
	x CAUS y BECOME EXIST(±)	25
	Total:	2008

Figure 4. *Primary Template Coverage*

notion of a secondary template for *the dishes from the table* in a sentence like *Mary cleared the dishes from the table* (=53e) allows us to preserve the form of the primary template for *Mary cleared the table* (=53a).

Moreover, monotonicity is compromised in the case of intrinsic unaccusatives such as *blossom* and *bloom* as in *the roses blossomed/bloomed*, that permit both a stative and a change of state, or inchoative, interpretation. In [RAP 98], the templates [x <state>] and BECOME [x <state>] represent the stative and inchoative readings, respectively. Monotonicity here is undermined since there is an implicit BE in [x <state>] that is effectively replaced by the addition of BECOME.

6. Application to NLP

The theory described in the preceding sections has been applied to a substantial number of verb frames and the resulting lexicon has been implemented for use in a linguistically sophisticated English parser. In the following sub-sections, we review the coverage of the theory and describe how templates are mapped into syntax.

6.1. *Coverage*

The basic or primary templates described in this paper apply across a large number of Levin classes [LEV 93]. Of the 4,150 verb senses listed by Levin, our templates cover approx. 2,000, as shown in Figure 4.[20]

20. Levin covers 3,100 distinct verb forms (strings). These occur in a total of 57 verb classes, some with subclasses. A given string may occur in more than one class, i.e. be polysemous.
21. G_{dat} is an empty dyadic preposition in the sense of [PES 95] as used in double object constructions, e.g. *sent Mary* G_{dat} *a book*.
22. G_{ben} is another empty dyadic preposition, distinct from G_{dat} (see previous note), that is the covert counterpart of benefactive *for*, as in *Carmen bought Mary* G_{ben} *a dress*. Note some verbs like *sing* and *recite* may take both G_{dat} and G_{ben}: e.g. *The diva sang the audience an aria* can mean either *an aria for the audience* or *to the audience*.

Semantic Template	Arguments		Count
z FROM y	z:figure	y:ground	55
z G_{dat} y[21]	z:ground	y:figure	113
y TO z	y:figure	z:ground	25
y FOR z	y:figure	z:ground	104
z G_{ben} y[22]	z:ground	y:figure	89
z ON(TO) y	z:figure	y:ground	46
y WITH z	y:ground	z:figure	46
z INTO y	z:figure	y:ground	15
y OUT OF z	y:ground	z:figure	15
		Total:	508

Figure 5. *Secondary Template Coverage*

Secondary templates for dyadic prepositions such as *from* and *with*, as used in section 5 to account for alternations involving shadows, also apply across numerous Levin classes. Figure 5 show the coverage.

6.2. *Implementation*

Semantic templates form the core of a large English lexicon under development for a PROLOG-based parser in the principles-and-parameters framework, [FON 91]. The interface between the semantic template lexicon and the rest of the parser is shown in Figure 6. Syntactic lexical entries for verbs used for parsing are derived off-line from verb templates via mapping rules to be described below. Example mappings for the activity verb *wipe* and for *clean*, both as an adjectival resultative and main verb, are given in Figure 7. We describe the mapping process below:

1) For example, the verbs *wipe* and *clean* have the lexical entries defined by semTemplate/1 as shown in Figure 8. That is, *wipe* and *clean* belong to classes activity(manner) and accomplishment(state), respectively. The predicate semTemplateNetwork/3 defines these classes as having semantic templates act(manner(*wiping*),x,on(y)) and cause(x,become(y,state(*clean*))), mirroring (10a) and (11a), respectively.

2) The mapping from semantic templates into syntax is determined by linking rules (defined by linkRule/1) as shown in Figure 8. For the verb *wipe*, these rules translate act(manner(*wiping*),x,on(y)) into the syntactic theta-grid entry grid([x],[y]), which spells out the verb's basic subcategorization requirements, i.e. it has an external theta role (x) to be realized as a subject, and an internal theta role (y) to be realized as a direct object.

Note that a syntactic lexical entry for a verb does not contain information about whether that verb can take an AP or PP resultative. Semantically-derived information

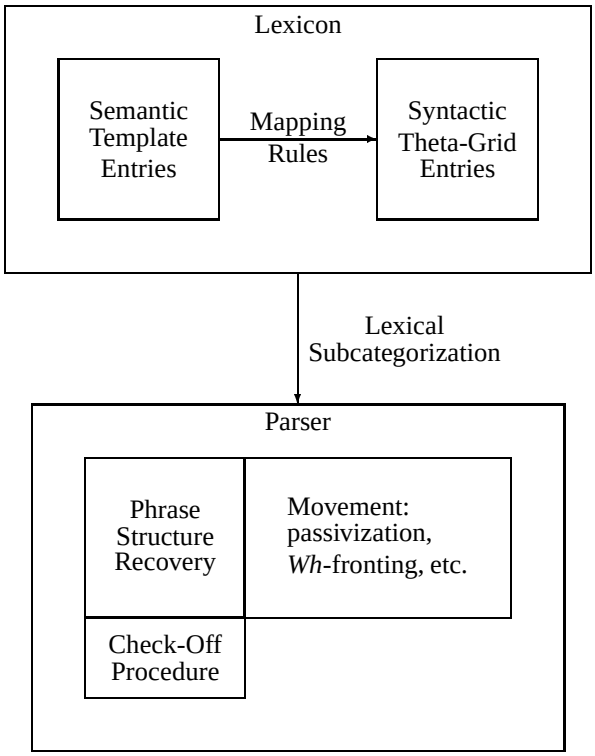

Figure 6. *System Architecture*

Template:	**Theta-Grid Entry:**	**Syntax:**
wipe:	*wipe*:	*wipe*:
act(manner(*wiping*),x,on(y))	grid([x],[y])	$[_{NP}$ x $][_{VP}$ $[_{V}$ *wipe*$][_{NP}$ y$]]$
clean(A):	*clean*(A):	*clean*(A):
be(y,state(*clean*))	grid([y],[])	$[_{AP}$ $[_{NP}$ y $][_{A'}$ $[_{A}$ *clean*$]]]$
clean(V):	*clean*(V):	*clean*(V):
caus(x,become(y,state(*clean*)))	grid([x],[y])	$[_{NP}$ x $][_{VP}$ $[_{V}$ *clean*$][_{NP}$ y$]]$

Figure 7. *Mapping Templates into Syntax*

```
% Lexical entries
semTemplate(wipe,v,activity(wiping),[morph(wipe,[])]).
semTemplate(clean,v,accomplishment(clean),[morph(clean,[])]).

% Verb classes
semTemplateNetwork(activity(M),[],[act(manner(M),x,on(y))]).
semTemplateNetwork(accomplishment(S),[],[caus(x,become(y,state(S)))]).

% External theta role
linkRule(act(_,X,_),        [grid([X],_)]).
linkRule(caus(X,_),         [grid([X],_)]).

% Internal theta role(s)
linkRule(act(_,_,on(Y)),    [grid(_,[Y])]).
linkRule(become(Y,_)),      [grid(_,[Y])]).

% Resultative
linkRule(be(Y,_),           [grid([Y],[])]).
```

Figure 8. *Examples of Lexical Entries and Linking Rules*

is factored out and checked separately from subcategorization requirements.[23]

3) In the case of resultatives, the secondary template determines the underlying syntax. Further syntactic processes such as passivization and *wh*-fronting may be independently applied to this initial structure. Figure 3 illustrates the complete parse tree obtained for the passive sentence *The table was wiped clean*. Both the passive sentence and its active counterpart *Somebody wiped the table clean* have the same semantic template. By 12a, the relevant template is act(manner(*wiping*),x,on(y)) & be(y,state(*clean*)). Following linkRule/1, grid([y],[]) represents the syntactic frame for the secondary template. This produces a (AP) small clause structure headed by *clean*. This AP is attached as a sister to *wipe*, forming the verb phrase (VP) shown in the parse tree. The check-off mechanism operates at the point of attachment between the realization of the secondary template (the small clause) and the main template (the verb). In this case, secondary y will be checked off against the corresponding y in the primary template when the VP is formed.

23. One advantage of this approach, apart from simplifying lexical representation, is that the separation of semantics from syntactic constraints allows exceptional licensing of examples that normally cannot be parsed because subcategorization requirements are violated. For example, pure intransitives such as *run*, lacking an object y, do not normally take resultatives: **John ran dizzy*. However, a fake reflexive *himself* as in *John ran himself dizzy* can be inserted to rescue the sentence.

7. Conclusions

We have shown how the representation of verbs in terms of a system of primary and secondary templates together with a check-off or argument identification mechanism can account for a range of subcategorization phenomena exhibited by a large number of English verbs. In terms of implementation, primary and secondary templates map into verb-shell and small clause structure, respectively. The check-off mechanism can also be integrated in a straightforward manner into the structure-building routines for parsing.

Our class-based account of the syntax and semantics behavior of verbs, although initially inspired by [LEV 93], is a much finer-grained classification. For example, we showed that Levin's *spray*/*load* class can be further subdivided into Figure and Ground verbs, with important syntactic consequences.

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