Extending VerbNet with Novel Verb Classes

Karin Kipper [△], **Anna Korhonen** [†], **Neville Ryant** [△], **Martha Palmer** [*]

[△]Computer and Information Science Department
University of Pennsylvania
{kipper}@linc.cis.upenn.edu, {nryant}@unagi.upenn.edu
[†] University of Cambridge
Computer Laboratory
{alk23}@cam.ac.uk
[*]Department of Linguistics
University of Colorado at Boulder
{martha.palmer}@verbs.colorado.edu

Abstract

Lexical classifications have proved useful in supporting various natural language processing (NLP) tasks. The largest verb classification for English is Levin's (1993) work which defined groupings of verbs based on syntactic properties. VerbNet (Kipper et al., 2000; Kipper-Schuler, 2005) – the largest computational verb lexicon currently available for English – provides detailed syntactic-semantic descriptions of Levin classes. While the classes included are extensive enough for some NLP use, they are not comprehensive. Korhonen and Briscoe (2004) have proposed a significant extension of Levin's classification which incorporates 57 novel classes for verbs not covered (comprehensively) by Levin. This paper describes the integration of these classes into VerbNet. The result is the most extensive Levin-style classification for English verbs which can be highly useful for practical applications.

1. Introduction

Lexical classes, defined in terms of shared meaning components and similar (morpho-)syntactic behavior of words, have attracted considerable interest in NLP (Jackendoff, 1990; Levin, 1993). These classes are useful for their ability to capture generalizations about a range of (cross-)linguistic properties. NLP systems can benefit from lexical classes in a number of ways. Such classes define the mapping from surface realization of arguments to predicate-argument structure, and are therefore an important component of any system which needs the latter. As the classes can capture higher level abstractions (e.g. syntactic or semantic features) they can be used as a principled means to abstract away from individual words when required. They are also helpful in many operational contexts where lexical information must be acquired from small application-specific corpora. Their predictive power can help compensate for lack of sufficient data fully exemplifying the behavior of relevant words. Lexical classes have proved helpful in supporting a number of (multilingual) tasks, such as computational lexicography, language generation, machine translation, word sense disambiguation, semantic role labeling, and subcategorization acquisition (Dorr, 1997; Prescher et al., 2000; Korhonen, 2002). While this work has met with success, it has been small in scale. Large-scale exploitation of the classes has not been possible because no comprehensive classification is available.

The largest and the most widely deployed classification in English is Levin's (1993) classification of verbs. VerbNet (VN) (Kipper et al., 2000; Kipper-Schuler, 2005)[1] – the most extensive on-line verb lexicon currently available for English – provides detailed syntactic-semantic descriptions of Levin classes organized into a refined taxonomy. While

VN has proven useful for a variety of natural language tasks (see Section 5.), it mainly deals with Levin-style verbs (i.e. verbs taking noun (NP) and prepositional phrase complements (PP)) and thus also suffers from limited coverage. Experiments have been reported which indicate that it should be possible, in the future, to automatically supplement VN with novel classes and member verbs from corpus data (Brew and Schulte im Walde, 2002; Korhonen et al., 2003; Kingsbury, 2004). While an automatic approach would avoid the expensive overhead of manual classification and enable application-specific tuning, the very development of the technology capable of large-scale classification requires access to a target gold standard classification more extensive than that available currently.

Korhonen and Briscoe (2004) have proposed a substantial extension to Levin's original classification which incorporates 57 novel classes for verb types not covered (comprehensively) by Levin. They have demonstrated the utility of these classes by using them to support automatic subcategorization acquisition and shown that the resulting extended Levin classification has a fairly extensive coverage over the English verb lexicon. While these novel classes are potentially very useful for the research community, their practical use is limited by the fact that no detailed syntactic-semantic descriptions are provided with the classes, and no attempt has been made to organize the classes into a taxonomy or to integrate them into Levin's taxonomy.

Our paper addresses these problems: it describes the integration of the novel classes of Korhonen and Briscoe into VerbNet. The result is a single coherent resource which now provides the most comprehensive and versatile Levin-style verb classification for English. This extended resource is freely available for the research community.

We introduce VN in section 2. and the novel classes of Ko-

---

[1]http://verbs.colorado.edu/ kipper/verbnet.html

rhonen and Briscoe in section 3. Section 4. describes the integration of the new classes into VN. Section 5. provides discussion on the present and future work.

2. Description of VerbNet

VerbNet is a hierarchical domain-independent, broad-coverage verb lexicon with mappings to several widely-used verb resources, including WordNet (Miller, 1990; Fellbaum, 1998), Xtag (XTAG Research Group, 2001), and FrameNet (Baker et al., 1998). It includes syntactic and semantic information for classes of English verbs derived from Levin's classification which is considerably more detailed than that included in the original classification.

Each verb class in VN is completely described by a set of members, thematic roles for the predicate-argument structure of these members, selectional restrictions on the arguments, and frames consisting of a syntactic description and semantic predicates with a temporal function, in a manner similar to the event decomposition of Moens and Steedman (1988). The original Levin classes have been refined and new subclasses added to achieve syntactic and semantic coherence among members. The resulting class taxonomy incorporates different degrees of granularity. This is an important quality given that the desired level of granularity varies from one NLP application to another.

2.1. Syntactic Frames

Each VN class contains a set of syntactic descriptions, or syntactic frames, depicting the possible surface realizations of the argument structure for constructions such as transitive, intransitive, prepositional phrases, resultatives, and a large set of diathesis alternations listed by Levin as part of each verb class. Each syntactic frame consists of thematic roles (such as *Agent, Theme, Location*), the verb, and other lexical items which may be required for a particular construction or alternation.

Semantic restrictions (such as *animate, human, organization*) are used to constrain the types of thematic roles allowed in the classes. Each syntactic frame may also be constrained in terms of which prepositions are allowed.

Additionally, further restrictions may be imposed on thematic roles to indicate the syntactic nature of the constituent likely to be associated with the thematic role. Levin classes are characterized primarily by NP and PP complements. Some classes also refer to sentential complementation, although this extends only to the distinction between finite and nonfinite clauses, as in the various subclasses of *Verbs of Communication*. In VN the frames for class *Tell-37.2* shown in Examples (1) and (2) are illustrative of how the distinction between finite and nonfinite complement clauses is implemented.

(1) Sentential Complement (finite)
"Susan told Helen that the room was too hot."
Agent V Recipient Topic[$+sentential - infinitival$]

(2) Sentential Complement (nonfinite)
"Susan told Helen to avoid the crowd."
Agent V Recipient Topic[$+infinitival$ -wh_inf]

2.2. Semantic Predicates

Each VN frame also contains explicit semantic information, expressed as a conjunction of boolean semantic predicates such as 'motion,' 'contact,' or 'cause.' Each of these predicates is associated with an event variable E that allows predicates to specify when in the event the predicate is true ($start(E)$ for preparatory stage, $during(E)$ for the culmination stage, and $end(E)$ for the consequent stage). Relations between verbs (or classes) such as antonymy and entailment present in WordNet and relations between verbs (and verb classes) such as the ones found in FrameNet can be predicted by semantic predicates. Aspect in VN is captured by the event variable argument present in the predicates.

2.3. Status of VerbNet

Before integrating the novel classes, VN 1.0 had descriptions for 4,100 verbs (over 3,000 lemmas) distributed in 191 first-level classes, and 74 new subclasses. These descriptions used 21 thematic roles, 36 selectional restrictions, 314 syntactic frames and 64 semantic predicates. The lexicon also relies on a shallow hierarchy of prepositions with 57 entries. The coverage of VN 1.0 has been evaluated through a mapping to almost 50,000 instances from Proposition Bank's corpus instances (Kingsbury and Palmer, 2002). VN syntactic frames account for over 78% of the exact matches found to the frames in PropBank. The information in the lexicon has proved useful for various NLP tasks such as word sense disambiguation and semantic role labeling (see Section 5.). In VN 1.0 Levin's taxonomy has gained considerably in depth, but not in breadth. Verbs taking adjectival (ADJP), adverbial (ADVP), particle, predicative, control and sentential complements were still largely excluded, except where they showed interesting behavior with respect to NP and PP complementation. Many of these verb types are highly frequent in language and thus important for applications. As the new classes being proposed cover these verb types, it made sense to invest effort on incorporating them into VN.

3. Description of the new classes

The resource of Korhonen and Briscoe (2004) includes a substantial extension to Levin's classification with 57 novel classes for verbs as well as 106 new diathesis alternations. The classes were created using the following semi-automatic approach[2]:

Step 1: A set of diathesis alternations were constructed for verbs not covered extensively by Levin. This was done by considering possible alternations between pairs of subcategorization frames (SCFs) in the comprehensive classification of Briscoe (2000) which incorporates 163 SCFs (a superset of those listed in the ANLT (Boguraev et al., 1987) and COMLEX Syntax dictionaries (Grishman et al., 1994)), focusing in particular on those SCFs not covered by Levin. The SCFs define mappings from surface arguments to predicate-argument structure for bounded dependency constructions, but abstract over specific particles and

---

[2]See Korhonen and Briscoe (2004) for the details of this approach and http://www.cl.cam.ac.uk/users/alk23/classes/ for the latest version of the classification.

prepositions. 106 new alternations were identified manually, using criteria similar to Levin's.

Step 2: 102 candidate lexical-semantic classes were selected for the verbs from linguistic resources of a suitable style and granularity: (Rudanko, 1996; Rudanko, 2000), (Sager, 1981), (Levin, 1993) and the LCS database (Dorr, 2001).

Step 3: Each candidate class was evaluated by examining sets of SCFs taken by its member verbs in syntax dictionaries (e.g. COMLEX) and whether these SCFs could be related in terms of diathesis alternations (106 novel ones or Levin's original ones). Where one or several alternations were found which captured the sense in question, a new verb class was created.

Identifying relevant alternations helped to identify additional SCFs, which often led to the discovery of additional alternations. For those candidate classes which had an insufficient number of member verbs, new members were searched for in WordNet. These were frequently found among the synonyms, troponyms, hypernyms, coordinate terms and/or antonyms of the extant member verbs. The SCFs and alternations discovered during the identification process were used to create the syntactic-semantic description of each novel class. For example, a new class was created for verbs such as *order* and *require*, which share the approximate meaning of "direct somebody to do something". This class was assigned the following description (where the SCFs are indicated by number codes from Briscoe's (2000) classification):

3. ORDER VERBS

SCF 57:   *John ordered him to be nice*
SCF 104:   *John ordered that he should be nice*
SCF 106:   *John ordered that he be nice*

Alternating SCFs: 57 ↔ 104, 104 ↔ 106

The work resulted in accepting, rejecting, combining and refining the 102 candidate classes and - as a by-product - identifying 5 new classes not included in any of the resources used. In the end, 57 new verb classes were formed, each associated with 2-45 member verbs. Table 1 shows a small sample of these classes along with example verbs.

The evaluation of the novel classes showed that they can be used to support an NLP task and that the extended classification has good coverage of the English verb lexicon.

Class	Example Verbs
URGE	*ask, persuade*
FORCE	*manipulate, pressure*
WISH	*hope, expect*
ALLOW	*allow, permit*
FORBID	*prohibit, ban*
HELP	*aid, assist*
DEDICATE	*devote, commit*
LECTURE	*comment, remark*

Table 1: Examples of K&B's Verb Classes

4. Incorporating the New Classes into VerbNet

Although the new classes of Korhonen and Briscoe (K&B) are similar in style to the Levin classes included in VN, their integration to VN proved a major task. The first step was to assign the classes VN-style detailed syntactic-semantic descriptions. This was not straightforward because the K&B classes lacked explicit semantic descriptions and had syntactic descriptions not directly compatible with VN's descriptions. Some of the descriptions available in VN had to be enriched for the new classes for this task. The second step was to incorporate the classes into VN. This was complicated by the fact that K&B is inconsistent in terms of granularity: some classes are broad while others are fine-grained. Also the comparison of the new classes to Levin's original classes had to be done on a class-by-class basis: some classes are entirely new, some are subclasses of existing classes, while others require reorganization of original Levin classes. These steps, which were conducted largely manually in order to obtain any reliable result, are described in sections 4.1. and 4.2., respectively.

4.1. Syntactic-Semantic Descriptions of Classes

Assigning syntactic-semantic descriptions to the new classes involved work on both VN and K&B. The different sets of SCFs used required creating new roles, syntactic descriptions and restrictions on VN. The set of SCFs in K&B is broad in coverage and relies, in many cases, on finer-grained treatment of sentential complementation than present in VN. Therefore, VN's syntactic descriptions had to be enriched with a more detailed treatment of sentential complementation. On the other hand, prepositional SCFs in K&B do not provide VN with explicit lists of allowed prepositions as required, so these had to be added to the classes. Also, no syntactic description of the surface realization of the frames was included in K&B and had to be created. Finally, information about semantic (thematic) roles and restrictions on the arguments was added to K&B.

4.1.1. Thematic Roles

In integrating the new classes, it was found that none of the 21 VN thematic roles seemed to appropriately convey the semantics of the arguments for some classes. As an example, the members of the proposed URGE class describe events in which one entity exerts psychological pressure on another to perform some action (*John urged Maria to go home*). While the urger (*John*) is assigned the role *Agent* as the volitional agent of the action and the urged entity (*Maria*) is assigned *Patient* as the affected participant, it is unclear what thematic role best suits the urged action (of going home). A new *Proposition* role was included which seemed to more appropriately describe the semantics of the urging event. Similar situations arose in the integration of 8 other classes. In the end, two new thematic roles were added to VN, *Content* and *Proposition*.

4.1.2. Syntactic Descriptions

Only 44 of VN's syntactic frames had a counterpart in Briscoe's classification. This discrepancy is the by-product of differences in the design of the two resources. Briscoe

abstracts over prepositions and particles whereas VN differentiates between otherwise identical frames based on the precise types of prepositions that a given class of verbs subcategorizes for. Additionally, VN may distinguish two syntactic frames depending on thematic roles (e.g. there are two variants of the Material/Product Alternation Transitive frame differing on whether the object is the *Material* or *Product*).

Regarding sentential complements the opposite occurs, with VN conflating SCFs that Briscoe's classification considers distinct. In integrating the proposed classes into VN it was necessary to greatly enrich the set of possible syntactic restrictions VN allows on clauses. The original hierarchy contained only the valences ± *sentential*, ± *infinitival*, and ± *wh_inf*. The new set of possible syntactic restrictions consists of 55 such features accounting for object control, subject control, and different types of complementation. Examples (3), (4), (5), and (6) show the VN realizations and the set of constraints for the proposed FORCE class which includes two frames with object control complements.

(3) Basic Transitive
   "I forced him."
   Agent V Patient

(4) P-P-ING-OC (into-PP)
   "I forced him Prep(into) coming."
   Agent V Patient into Proposition[+oc_ing]

(5) NP-PP (into-PP)
   I forced John into the chairmanship."
   Agent V Patient into Proposition[-sentential]

(6) NP-TO-INF-OC
   "I forced him to come."
   Agent V Patient Proposition[+oc_to_inf]

4.1.3. Semantic descriptions

Integrating the new classes also required enriching VN's set of semantic predicates. Whenever possible, existing VN predicates were reused. However, as many of the incoming classes represent concepts entirely novel to VN, it was necessary to introduce 30 new predicates to adequately provide descriptions of the semantics of these incoming classes.

4.2. Integrating the Classes into VerbNet

After assigning the class descriptions, each of K&B's classes was thoroughly investigated to determine the feasibility of it being added to VN. Of the classes proposed, two were rejected as being either insufficiently semantically homogeneous or too small to be added to the lexicon, with the remaining 55 selected for incorporation. The classes fell into three different categories regarding Levin's classification: 1) classes that could be subclasses of existing Levin classes; 2) classes that require a reorganization of Levin classes[3]; 3) entirely new classes.

4.2.1. Entirely Novel Classes

A total of 42 classes could be added to the lexicon as novel classes or subclasses without any restructuring. Some of

---

[3]Levin focused mainly on NP and PP complements, but many verbs classify more naturally in terms of sentential complementation

these overlapped to an extent with existing VN classes semantically but syntactic behavior of the members was sufficiently distinctive to allow them to be added as new classes without restructuring of VN. 35 novel classes were actually added as new classes while 7 others were added as new subclasses (e.g. an additional novel subclass, *Continue-55.3*, was discovered in the process of subdividing *Begin-55.1*). The 35 new classes all share the quality of not overlapping to any appreciable extent with a pre-existing VN class from the standpoint of semantics. For instance, K&B's classes of FORCE, TRY, FORBID, and SUCCEED express entirely new concepts as compared to VN 1.0.

4.2.2. Novel Sub-Classes

Some of the proposed classes, such as CONVERT, SHIFT, INQUIRE, and CONFESS were considered sufficiently similar in meaning to current classes and were added as new subclasses to existing VN classes. For example, both the proposed classes CONVERT and SHIFT are similar syntactically to the VN class *Turn-26.6*. However, whereas the members of *Turn-26.6* exclusively involve total physical transformations, the members of the proposed class CONVERT invariably exclude physical transformation, instead having a meaning that involves non-physical changes such as changes in the viewpoint of the Theme (*I converted the man to Judaism.*). Similarly, the verbs of SHIFT might be characterized as the class of verbs only taking the intransitive frames from CONVERT. Consequently, as both SHIFT and CONVERT are semantically similar, yet still distinct, from the existing VN class *Turn-26.6*, they were added as subclasses to 26.6, yielding the new classification *Turn-26.6.1*, *Convert-26.6.2*, and *Shift-26.6.3*.

4.2.3. Classes Where Restructuring Was Necessary

13 of the proposed classes overlapped significantly in some way with existing VN classes (either too close semantically or syntactically) and required restructuring of VN.

Classes such as WANT, PAY, and SEE obviously overlapped with existing VN classes *Want-32.1*, *Give-13.1*, and *See-30.1* in terms of meaning. Nor could the proposed classes be distinguished from the existing classes by recourse to syntactic behavior. Adding such classes required restructuring of VN to produce classes whose verb membership was the union of the overlapping proposed and existing classes and whose SCFs, similarly, were the union of those for each of the overlapping classes.

Broadly, the process of integrating the classes can be divided into two categories: 1) merging proposed classes with the related VN class; 2) adding the proposed class as a novel class but making modifications to existing VN classes.

Cases involving merger of a proposed class and an existing class: In considering these classes for addition to VN, it was observed that semantically their members patterned after a pre-existing class almost exactly. In the cases where the frames from the new classes were a superset of the frames recorded in VN, then the existing VN class was restructured by adding the new members and by enriching its syntactic description with the novel frames.

	VN 1.0	Extended VN
First-level classes	191	237
Thematic roles	21	23
Semantic Predicates	64	94
Select. Restr. (semantic)	36	36
Syntactic Restr. (on sent. compl.)	3	55
Lemmas	3007	3175
Verb senses	4173	4526

Table 2: Summary of the Lexicon's Extension

For example, both K&B's proposed WANT class and the VN class *Want-32.1* relate to the act of an experiencer desiring something. VN class *Want-32.1* differs from the proposed WANT class in its membership and in that it considers only alternations in NP and PP complements whereas the proposed class WANT also considered alternations in sentential complements, particularly control cases.

Added as new class but requiring restructuring of classes: K&B's work is of particular importance when considered in the context of classes of *Verbs With Predicative Complements*, whose members are frequent in language. These verbs classify more naturally in terms of sentential rather than NP or PP complementation. The proposed class CONSIDER overlaps with four of VN's classes (*Appoint-29.1*, *Characterize-29.5*, *Declare-29.4*, and *Conjecture-29.6*), none of which were originally semantically homogeneous. The process of adding CONSIDER as another class of verbs with predicative complement gave us the opportunity to revise these four problematic classes making them more semantically homogeneous by using the more detailed coverage of complementation presented in K&B.

5. Conclusion and Future Work

A limitation in Levin's widely-employed verb classification is that it deals mostly with NP and PP complements with the result that verbs taking ADJP, ADVP, predicative, control and sentential complements are not included or addressed in depth. With respect to NLP applications this is a serious limitation because many of the missing verb types are highly frequent in language. Thus integrating K&B's novel classes is a crucial extension of VerbNet.

A summary of how this integration affected VN and the result of the extended lexicon is shown in Table 2. The figures show that our work enriched and expanded VN considerably. The number of first-level classes grew significantly (from 191 to 237), along with the set of semantic predicates and the syntactic restrictions on sentential complements.

An obvious question from the NLP point of view is the practical usefulness of the extended VN. Korhonen and Briscoe (2004) showed that new classes now incorporated in VN can be used to significantly aid an NLP task (subcategorization acquisition) and that the extended classification has good coverage over the English verb lexicon (as evaluated against WordNet). The evaluation of the extended VN was beyond the scope of our work; however, we can expect to see improved results on many NLP applications in the near future, given the promising results reported by Korhonen and Briscoe and the wide use of VN in the research community. Currently, the use of verb classes in VN 1.0 is being attested in a variety of applications such as automatic verb acquisition (Swift, 2005), semantic role labeling (Swier and Stevenson, 2004), robust semantic parsing (Shi and Mihalcea, 2005), word sense disambiguation (Dang, 2004), building conceptual graphs (Hensman and Dunnion, 2004), and creating a unified lexical resource for knowledge extraction (Crouch and King, 2005), among others.

In the future, we hope to extend VN's coverage further. It is planned to search for additional novel classes and members using automatic methods, e.g. clustering. This is now realistic given the more comprehensive target and gold standard classification provided by VN. In addition, we plan to include in VN statistical information concerning the relative likelihood of different classes, SCFs and alternations for verbs in corpus data, using, e.g. the automatic methods proposed by McCarthy (2001) and Korhonen (2002). Such information can be highly useful for statistical NLP systems utilizing lexical classes.

Acknowledgments

6. References

Collin F. Baker, Charles J. Fillmore, and John B. Lowe. 1998. The Berkeley FrameNet project. In *Proceedings of the 17th International Conference on Computational Linguistics (COLING/ACL-98)*, pages 86–90, Montreal.

Branimir Boguraev, Ted Briscoe, John Carroll, David Carter, and Claire Grover. 1987. The derivation of a grammatically-indexed lexicon from the Longman Dictionary of Contemporary English. In *Proceedings of the 25th annual meeting of ACL*, pages 193–200, Stanford, CA.

Chris Brew and Sabine Schulte im Walde. 2002. Spectral clustering for German verbs. In *Conference on Empirical Methods in Natural Language Processing*, Philadelphia, USA.

Ted Briscoe. 2000. *Dictionary and System Subcategorisation Code Mappings*. Unpublished manuscript, http://www.cl.cam.ac.uk/users/alk23/subcat/ subcat.html, University of Cambridge Computer Laboratory.

Dick Crouch and Tracy Holloway King. 2005. Unifying lexical resources. In *In Proceedings of Interdisciplinary Workshop on the Identification and Representation of Verb Features and Verb Classes*, Saarbruecken, Germany.

Hoa Trang Dang. 2004. *Investigations into the Role of Lexical Semantics in Word Sense Disambiguation*. Ph.D. thesis, CIS, University of Pennsylvania.

Bonnie J. Dorr. 1997. Large-scale dictionary construction for foreign language tutoring and interlingual machine translation. *Machine Translation*, 12(4):271–325.

Bonnie J. Dorr. 2001. LCS Verb Database. In *Online Software Database of Lexical Conceptual Structures and Documentation*, University of Maryland.

Christiane Fellbaum, editor. 1998. *WordNet: An Eletronic Lexical Database*. Language, Speech and Communications. MIT Press, Cambridge, Massachusetts.

Ralph Grishman, Catherine Macleod, and Adam Meyers. 1994. COMLEX syntax: building a computational lexicon. In *Proceedings of the International Conference on Computational Linguistics*, Kyoto, Japan.

Svetlana Hensman and John Dunnion. 2004. Automatically building conceptual graphs using VerbNet and WordNet. In *In Proceedings of the 3rd International Symposium on Information and Communication Technologies (ISICT)*, pages 115–120, Las Vegas, NV.

Ray Jackendoff. 1990. *Semantic Structures*. MIT Press, Cambridge, Massachusetts.

Paul Kingsbury and Martha Palmer. 2002. From Treebank to PropBank. In *Proceedings of the 3rd International Conference on Language Resources and Evaluation*, Las Palmas, Canary Islands, Spain.

Paul Kingsbury. 2004. Verb clusters from PropBank annotation. Technical report, University of Pennsylvania, Philadelphia, PA.

Karin Kipper, Hoa Trang Dang, and Martha Palmer. 2000. Class-based construction of a verb lexicon. In *AAAI/IAAI*, pages 691–696.

Karin Kipper-Schuler. 2005. *VerbNet: A broad-coverage, comprehensive verb lexicon*. Ph.D. thesis, Computer and Information Science Dept., University of Pennsylvania, Philadelphia, PA, June.

Anna Korhonen and Ted Briscoe. 2004. Extended Lexical-Semantic Classification of English Verbs . In *Proceedings of the HLT/NAACL Workshop on Computational Lexical Semantics*, Boston, MA.

Anna Korhonen, Yuval Krymolowski, and Zvika Marx. 2003. Clustering polysemic subcategorization frame distributions semantically. In *Proceedings of the 41st Annual Meeting of ACL*, pages 64–71, Sapporo, Japan.

Anna Korhonen. 2002. Semantically motivated subcategorization acquisition. In *ACL Workshop on Unsupervised Lexical Acquisition*, Philadelphia.

Beth Levin. 1993. *English Verb Classes and Alternation, A Preliminary Investigation*. The University of Chicago Press.

Diana McCarthy. 2001. *Lexical Acquisition at the Syntax-Semantics Interface: Diathesis Alternations, Subcategorization Frames and Selectional Preferences*. Ph.D. thesis, University of Sussex.

George A. Miller. 1990. WordNet: An on-line lexical database. *International Journal of Lexicography*, 3(4):235–312.

Marc Moens and Mark Steedman. 1988. Temporal Ontology and Temporal Reference. *Computational Linguistics*, 14:15–38.

Detlef Prescher, Stefan Riezler, and Mats Rooth. 2000. Using a probabilistic class-based lexicon for lexical ambiguity resolution. In *18th International Conference on Computational Linguistics*, pages 649–655, Saarbrücken, Germany.

Juhani Rudanko. 1996. *Prepositions and Complement Clauses*. State University of New York Press, Albany.

Juhani Rudanko. 2000. *Corpora and Complementation*. University Press of America.

Naomi Sager. 1981. *Natural Language Information Processing: A Computer Grammar of English and Its Applications*. Addison-Wesley Publising Company, MA.

Lei Shi and Rada Mihalcea. 2005. Putting pieces together: Combining FrameNet, VerbNet and WordNet for robust semantic parsing. In *Proceedings of the Sixth International Conference on Intelligent Text Processing and Computational Linguistics*, Mexico City, Mexico.

Robert Swier and Suzanne Stevenson. 2004. Unsupervised semantic role labelling. In *Proceedings of the 2004 Conference on Empirical Methods in Natural Language Processing*, pages 95–102, Barcelona, Spain, August.

Mary Swift. 2005. Towards automatic verb acquisition from VerbNet for spoken dialog processing. In *In Proceedings of Interdisciplinary Workshop on the Identification and Representation of Verb Features and Verb Classes*, Saarbruecken, Germany.

XTAG Research Group. 2001. A lexicalized tree adjoining grammar for English. Technical Report IRCS-01-03, IRCS, University of Pennsylvania.