A Comparative Analysis of Beth Levin's English Verb Class Alternations and WordNet's Senses for the Verb Classes HIT, TOUCH, BREAK and CUT

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1.0 Abstract

Beth Levin's work on verb classes and alternations for the English language [Levin 1993] has created a means of 1) separating verbs into different classes based on their alternations and 2) generalizing syntactic patterns for these differing classes. WordNet [Miller, Beckwith, Fellbaum, Gross, Miller 1993] is an on-line dictionary/thesaurus developed by a group of psycholinguists at Princeton University which has the ability to distinguish the different senses of words and produce synonym sets and sentence glosses for these differing senses. By doing a comparative analysis of the two different works, we will be able to 1) see if WordNet's output is supportive of Levin's work, especially in her verb class distinctions and 2) test WordNet's accuracy in distinguishing a verb's different senses.

2.0 Introduction/Background

During the past three decades, there has been much interest and growth in the field of lexical semantics. However, there has been some skepticism about our ability to discover a general way of representing word meaning [Levin, Pinker 1992]. With the onset of computerized on-line lexicons there has been an increased emphasis on the properties and constraints of syntactic rules in order to improve the power and usefulness of these lexicons. This has led to a new methodology for investigating word meaning. While seeking syntax-based distinctions that can be applied to a class or group of words, recurring patterns of semantic elements have been observed by researchers [Levin 1993]. These observations correlate to findings from work done by Jackendoff, Pinker, Talmy and others, thus validating this new methodology and renewing an interest in ascertaining the core content of semantic representations.

This analysis will first give an overview of the basis behind Levin's verb class divisions and look at how she deals in particular with the verb classes HIT, TOUCH, BREAK and CUT. This will be followed by an overview of the principles behind WordNet's design with particular attention paid to how it distinguishes its different verb senses. The next section will contain a comparative analysis of the Levin and WordNet senses for the verb classes HIT, TOUCH, BREAK and CUT, followed by some concluding remarks.

3.0 Levin's English Verb Classes HIT, TOUCH, BREAK and CUT

The central force behind Beth Levin's verb class divisions is diathesis alternations. Alternations describe the behavior of a verb with respect to the expressions and interpretation of its arguments. Diathesis alternations refer to alternations regarding how these arguments are expressed. Sometimes the ways these arguments can be expressed result in a change of meaning. The main alternations involved with verb class distinctions are 1) causative/inchoative alternations; 2) middle construction alternations; 3) conative alternation; and 4) body-part possessor ascension alternations. Examples[1] of these alternations are included below:

Causative/inchoative alternations
(6) a. The little boy broke the window.
b. The window broke.
(7) a. Margaret cut the bread.
b. *The bread cut.

Middle construction alternations
(8) a. Margaret cut the bread.
b. The bread cuts easily.
(9) a. Terry touched the cat.(
b. *Cats touch easily.

Conative alternation
(10) a. Carla hit the door.
b. Carla hit at the door.
(11) a. Janet broke the vase.
b.*Janet broke at the vase.

Body-part possessor ascension alternations
(12) a. Margaret cut Bill's arm.
b. Margaret cut Bill on the arm.
(13) a. Janet broke Bill's arm
b.*Janet broke Bill on the arm.

1. All examples are taken from Levin, B., *English Verb Classes and Alternations: A Preliminary Investigation,* 1993. The * indicates an ill-formed sentence illustrating that this alternation does not hold for this verb.

Current researchers in the field of lexical semantics have concluded that certain syntactic behavior traits of verbs are central to their meaning. Thus the members of a particular verb class would be expected to have a shared aspect of meaning. Beth Levin proposes that differences in verb behavior can be explained if the diathesis alternations reflect specific components of verb meaning. With respect to the BREAK, CUT, HIT and TOUCH classes, the differences in verb behavior can be described by Table 1. Table 2 describes diathesis alternations in terms of the behaviors each is sensitive to. Note that while *break*, *cut*, *hit* and *touch* are all transitive verbs taking 2 arguments (a subject and an object) their verb behaviors differ. *Break* is a pure change of state verb, indicating that the state of something has altered or has been caused to be altered, but it does not entail the notion of contact or motion.[2] *Cut* on the other hand does require the notion of contact and motion in order to cause a state to be changed. Its verb behavior concerns the cause of a change of state. *Hit* differs from *touch* in that it also implies motion (i.e. contacting something through motion), while *touch* does not.

Class	Verb Behavior
BREAK	pure verb of change of state
CUT	verb of causing a change of state by moving something into contact with an entity that changes state
HIT	verb of contact by motion
TOUCH	pure verb of contact

Table 1: Verb Behavior of BREAK, CUT, HIT, and TOUCH Classes

Diathesis Alternation	Sensitivity to Behavior
Body-part possessor ascension	sensitive to the notion of contact
Causative/inchoative	pure change of state
Conative	sensitive to both motion and contact
Middle construction	verbs involving causing a change of state

Table 2: Behavior Sensitivity of Four Diathesis Alternations

By merging these tables together, we can observe unique patterns of behavior for these verb classes with respect to the diathesis alternations involved (see Table 3). Note that *break,* while being a pure change of state verb, also falls into the category of causing a change of state, illustrating how the middle construction alternation is in effect a sub-categorization of the change of state.

From these observations of verb behavior and meaning in relation to diathesis alternations, it can be argued that verbs can be broken into classes based on their shared properties [Levin 1993]. The point should be emphasized that a single alternation is not sufficient to distinguish a verb class, but by studying several distinct alternations simultaneously, we get a more accurate and revealing pattern of shared behavior for use in creating distinct verb classes.

Diathesis Alternations	BREAK	CUT	HIT	TOUCH
Body-part possessor ascension	NO	YES	YES	YES
Causative/inchoative	YES	NO	NO	NO
Conative	NO	YES	YES	NO
Middle Construction	YES	YES	NO	NO

Table 3: Selected Verb Classes and Four Diathesis Alternations

2. Although contact may be a part of a breaking action, it is not required.

4.0 WordNet's Design and Verb Senses

WordNet is an on-line lexicon based on pyscholinguistic theories and research that attempts to mimic how people organize lexical memory [Miller, Beckwith, Fellbaum, Gross, Miller 1993]. The central organizing feature for the lexical entries is a lexical matrix. The lexical matrix is a mapping between words and the *synsets* (synonym sets) where they belong. However, due to the nature of verbs, the complexity of their predicate argument structures (noun phrases), and other verb features (e.g. entailment, polysemy), it is not reasonable to represent verb entries in the lexicon merely with synsets [Miller, Fellbaum, 1992]. WordNet organizes verbs into senses based on *synsets* and other verb features. It provides short glosses to indicate the "meaning" of the sense [Fellbaum, 1993].

WordNet was not designed to recognize the syntactic regularities that are a part of the semantic meaning of verbs. However, to compensate for this, WordNet includes one or more generic sentence frames for each *synset*. These frames distinguish features of the verbs by demonstrating the "kinds" of sentences they encompass. These frames indicate specific features of verbs that have been highlighted by researchers such as Levin (e.g. argument structure, prepositional phrases and adjuncts, sentential complements and animacy of the noun arguments [Miller, Fellbaum 1991]). The sentence frames are limited to a standard, generic format that includes the following:

Somebody ----s something
Something ----s
Something is ----ing PP
Something ----s something
Something ----s somebody
Somebody ----s somebody
Somebody ----s
Somebody ----s something to somebody
Somebody ----s that CLAUSE

An example of how WordNet captures generalizations by means of syntactic alternations can be seen by looking at two classes in WordNet[3]:

Mental creation verb class (such as *fabricate* and *compose*)
Raw material creation verb class (such as *bake* and *cast*)
Levin distinguishes these verbs by two classes, the BUILD class and the CREATE class. Which share some alternations in common, but also differ in some alternations. According to its designers, WordNet can generalize the meanings of *create from raw material* and *create mentally* in terms of different relations that link verbs like *cast* and verbs like *compose* to their common superordinate *create*. The different verb frames associated with the common superordinate and the individuals capture syntactic differences between similar verbs.

5.0 Comparative Analysis

A straight forward comparative analysis of Beth Levin's verb classes based on alternations and WordNet's verb senses is not possible. The Levin verb classes deal with the primary sense of the verb and WordNet deal with multiple senses of a verb. The data for both deal with verbs, but it is not in a compatible format. However, a reasonable comparison can be made using WordNet's Semantic Concordance [Miller, Leacock, Tengi, Bunker, 1993] to extract sentences from the Brown Corpus for every WordNet sense for each word in the Levin verb classes BREAK, CUT, HIT, and TOUCH (see Appendix B for examples). These sentences are then compared to the Levin data in Appendix A, looking for senses that do not have the same alternations as the primary sense. The comparative analysis will focus on inspecting the Levin data with the sentences found through WordNet looking for 1) specific verb sense exceptions to the alternation findings and 2) faulty verb sense categories in WordNet. This study is interested in looking at the results of a comparative analysis and the additional benefits of interleaving two research efforts.

5.1 Using Verb Senses and Alternations to Distinguish Verb Classes

Levin has classified verbs according to their "primary sense" and grouped them according to the alternations they take part in. For example, see Appendix A for the alternations of *break* (and other members of that class such as *smash*). A search of the Brown Corpus for uses of these verbs using WordNet uncovers senses of these verbs that apparently do not participate in some of the alternations identified for the class by Levin.[4]

3. Examples shown come from Miller, Fellbaum, "Semantic Networks of English", 1991.
4. For further insight into the differing senses of the verb *break*, see Palmer, Polguere, 1994.

WordNet verb sense 2 for the verb *break* (act in disregard of laws and rules)[5] (see Appendix B)

(832)[6] Causative/Inchoative

a. John broke the law. (causative variant)

b. *The law broke. (see 832 and 834 in Appendix A)

(834) Instrument Subject Alternation:

a. Bob broke the law with a gun.

b. *The gun broke the law. (see 832 and 834 in Appendix A)

WordNet verb sense 3 for the verb *break* (reduce to bankruptcy) (no example sentence found with xescort)

(832) Causative/Inchoative Alternation:

a. The recession broke John.

b. *John broke. (see 832 in Appendix A)

WordNet verb sense 2 for the verb *smash* (as in hitting a home-run) (see Appendix B)

(832) Causative/Inchoative Alternation:

a. Hector smashed a 3-run homer.

b. *A 3-run homer smashed. (see 832 in Appendix A)

(837) Body-Part Possessor Ascension Alternation:

a. *Tony smashed herself on the arm*. (see 837 in Appendix A)

b. Tony smashed her arm.

WordNet verb sense 13 for the verb *cut* (reduce or diminish) (see Appendix B)

(295) Conative Alternation:

a. Carol cut the price.

b. *Carol cut at the price. (see 295 in Appendix A)

(298) Middle Alternation:

a. Carol cut the price.

b. *The price cuts easily. (see 298 in Appendix A)

WordNet verb sense 3 for the verb *beat* (move rhythmically) (see Appendix B)

(247) Causative Alternation:

a. *John beat the heart. (see 247 and 248 in Appendix A)

b. The heart beat.

a. John's heart beat a rhythm.

b. A rhythm beat. (see 247 and 248 in Appendix A)

(248) Middle Alternation:

a. *John beat the heart. (see 247 and 248 in Appendix A)

b. The heart beats easily. (see 247 and 248 in Appendix A)

WordNet verb sense 2 for the verb *nudge* (prod, push) (see Appendix B)

(284) With/Against Alternation:

a. John nudged the feather against the cat. (see 284 and 292 in Appendix A)

b. John nudged the cat with the feather.

(292) Resultative Phrase:

Carrie nudged the door open. (see 284 and 292 in Appendix A)

5.2 Exceptions to the WordNet Sense data

WordNet has an extensive collection of verbs (in excess of 20,000) broken down into various senses. In order to test

5. The sentences that are italicized should be improper according to the Levin Data (see Appendix A).The sentences preceded by a '*' are those that are now improper.
6. Index numbering is based on the indices used in Section 7.0 Levin Data.

the accuracy of these senses, an inspection was made of the sentence glosses and WordNet output for each of the words in the Levin class member lists for the classes BREAK, CUT, HIT and TOUCH looking for discrepancies and missing senses.

Chip
WordNet sentence frame for *chip*, sense 4 (cut a nick into):
Something ----s somebody. [You can chip some part of a person's body (e.g. tooth, bone), but you cannot chip somebody]

Missing sense:
chip => as in golf, "John chipped the ball up onto the green."

Scrape
WordNet sense 3 for the verb *scrape* (cut the surface of; wear away the surface of):

Sentence found using the Semantic Concordance:
"At 7:25 two hotel doormen came thumping down the steps, carrying a saw-horse to be set_up as a barricade in_front_of the haberdashery_store window next to the entranceway, and as I watched them in their gaudy red coats that nearly ->SCRAPED<- the ground, their golden, fringed epaulets and spic, red visored caps, I suddenly saw just over their shoulders Jessica gracefully making her way through the crowd.

This sense is not either cutting the surface of or to wear away the surface, but a better sense would be *to almost touch;graze a surface*.

Missing sense:
scrape => almost touching; graze a surface, "The full-length gowns scraped above the dance floor surface."

Lash
Missing sense:
lash => verbal anger, "Julie lashed out angrily at John."

This is close to sense 2 (give a beating to; subject to a beating), but it is a big enough difference to warrant a separate sense (based on the sense distinctions used for other verbs, such as *break*).

Bump
WordNet sense 2 for the verb *bump* (bump and grind; dance with a pelvis thrust):

Sentence found using xescort:
"'We ->BUMP<-', one said; and the other went_on to development of the idea."

Unless this sentence is from an article on the origin of the bump and grind dance style, this seems to be a faulty sense reading.

6.0 Conclusions

The comparative analysis data provided in Section 5.0 is by no means exhaustive, but is meant to be illustrative to the utility of such a comparison. The work done by Beth Levin and the WordNet designers at Princeton are examples of current, well-established research going on in the field of Computational Semantics. Doing comparative studies of this type can validate the Levin work and improve upon it during the process. What is interesting about this comparison is how the two distinct approaches can be interleaved. Invariably, the WordNet senses that do not follow the diathesis alternations of the primary sense are conceptually quite distinct. *Break the law* is very different syntactically from *break a stick*. This actually confirms Levin's claims, since the law does not change state and therefore would not be expected to appear in the same alternations as the stick. Neither is there a concrete contact possible in *Carol cut the price*, disallowing the conative alternation, **Carol cut at the price*. The consistency of the association of semantic components with particular types of alternations suggests that this is an appropriate methodology for testing semantic distinctions between senses.

One conclusion of this analysis is that by looking at the different senses of the verbs and their verb classes, one can get a more definitive class member list for the different classes (e.g. Break verbs - Class Members: break (except acts that lead to disregard or violation of the law or that lead to bankruptcy), chip...). The more accurate the verb classes can be made, the more likely they can some day be used as tools for on-line lexicographers and/or natural language generators/processors.

The WordNet on-line dictionary is a work in progress. The researchers have developed a Semantic Concordance that provides a means 1) of error detection and 2) testing the completeness and soundness of WordNet. Analyzing the output as I have done, by looking for sentences for all senses of a verb and comparing them with verb class data can be a secondary means of validating and verifying WordNet's capabilities and design.

Future work that would be of interest would include finding verbs that are in multiple verb classes (according to Levin) and examine their word senses using WordNet to see if the process of refining the verb class member lists could be expedited. Additionally, looking into the causal relations involved with the verb senses that do not follow the diathesis alternations of their verb class could shed light on the nature of the exceptions. Also of interest would be to analyze WordNet's senses for words using other resources like *The BBI Combinatory Dictionary of English*, a book of grammatical and lexical collocations.

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Appendix A - Levin Data: Verb Classes and their Participation in Alternations

Break verbs - Class Members: break, chip, crack, crash, crush, fracture, rip, shatter, smash, snap, splinter, split, tear

(831) Tony broke the window with a hammer.

(832) Causative/Inchoative Alternation:
- a. Tony broke the window.
- b. The window broke.

(837) *Body-Part Possessor Ascension Alternation:
- a. *Tony broke herself on the arm.
- b. Tony broke her arm.

(838) Unintentional interpretation available:
- a. Reflexive Object:

(833) Middle Alternation:
a. Tony broke the crystal vase.
b. Crystal vases break easily.

(834) Instrument Subject Alternation:
a. Tony broke the window with a hammer.
b. The hammer broke the window.

(835) *With/Against Alternation:
a. Tony broke the cup against the wall.
b. *Tony broke the wall with the cup.

(836) *Conative Alternation:
a. Tony broke the window.
b. *Tony broke at the window.

*Tony broke himself.
b. Body-Part Object:
Tony broke his finger.

(839) Resultative Phrase:
Tony broke the piggy bank open.
Tony broke the glass to pieces.

(840) Zero-related Nominal:
a break
a break in the window
*the break of a window

Cut verbs - Class members: chip, clip, cut, hack, hew, saw, scrape, scratch, slash, snip

(294) Carol cut the bread with a knife.

(295) Conative Alternation:
a. Carol cut the bread.
b. Carol cut at the bread.

(296) Body-Part Possessor Ascension Alternation:
a. Carol cut herself on the thumb.
b. Carol cut her thumb.

(297) *Causative Alternations:
a. Carol cut the bread.
b. *The bread cut.

(298) Middle Alternation:
a. Carol cut the whole wheat bread.
b. Whole wheat bread cuts easily.

(299) Instrument Subject Alternation:
a. Carol cut the bread with a knife.
b. The knife cut the bread.

(300) Characteristic Property of Instr. Alternation
a. This knife cut the bread.
b. This knife cuts well.

(301) Unintentional interpretation available:
a. Reflexive Object:
Carol cut herself.
b. Body-Part Object
Carol cut her finger.

(302) Path Phrase:
Carol cut the paper from one end to the other.

(303) Resultative Phrase:
Carol cut the envelope open.
Carol cut the bread to pieces.

(304) Zero-related Nominal:
a cut, *the cut of the paper
get a cut on the finger

Hit verbs - Class members: bang, bash, batter, beat, bump, butt, dash, drum, hammer, hit, kick, knock, lash, pound, rap, slap, smack, smash (where no effect implicated), strike, tamp, tap, thump, thwack, whack

(241) With/Against Alternation:
a. Paula hit the stick against/on the fence.
(Doesn't imply: Paula hit the stick.)
b. Paula hit the fence with the stick.
(Implies: Paula hit the fence.)

(242) *Through/With Alternation:
a. *Paula hit the stick through/into the fence.
b. Paula hit the fence with the stick.

(243) Conative Alternation:
a. Paula hit the fence (with the stick).
b. Paula hit at the fence (with the stick).

(244) Body-Part Possessor Ascension Alternation:
a. Paula hit Deirdre on the back.

(247) *Causative Alternations:
a. Paula hit the fence (with a stick).
b.*The fence hit (with a stick).

(248) *Middle Alternation:
a. Paula hit the fence.
b.*The fence hits easily.

(249) Instrument Subject Alternation:
a. Paula hit the fence with the stick.
b. The stick hit the fence.

(250) Unintentional interpretation available:
a. Reflexive Object:
Paula hit herself on the doorknob.
b. Body-Part Object:

b. Paula hit Deirdre's back.

(245) Together Reciprocal Alternation (transitive):
a. Paula hit one stick against another.
b. Paula hit the sticks together.

(246) *Simple Reciprocal Alternation (transitive):
a. Paula hit one stick against another.
b.*Paula hit the sticks.
(on the relevant reciprocal interpretation)

Paula hit her elbow on the doorknob.

(251) Resultative Phrase:
Paula hit/kicked the door open.
Paula banged the window shut.

(252) Zero-related Nominal:
a hit/*give a hit/*get a hit in the shoulders
a kick/give a kick/get a kick in the shins

Touch verbs - Class members: caress, graze, kiss, lick, nudge, pat, peck (=kiss), pinch, prod, sting, stroke, tickle, touch

(283) Carrie touched the cat.

(284) *With/Against Alternation:
a. *Carrie touched the stick against the cat.
b. Carrie touched the cat with the stick.

(285) *Through/With Alternation:
a. *Carrie touched the stick through/into the cat.
b. Carrie touched the cat with the stick.

(286) *Conative Alternation:
a. Carrie touched the cat.
b.*The cat touched.

(287) Body-Part Possessor Ascension Alternation:
a. Carrie touched him on the shoulder.
b. Carrie touched his shoulder.

(288) *Causative Alternations:
a. Carrie touched the cat.
b.*The cat touched.

(289) *Middle Alternation:
a. Carrie touched that cat.
b.*That cat touches easily.

(290) *Instrument Subject Alternation:
a. Carrie touched the fence with a stick.
b.*The stick touched the fence.
(on a nonstative interpretation)

(291) Unintentional interpretation not available:
a. Reflexive Object:
Carrie touched herself. (intentional only)
b. Body-Part Object:
Carol touched her hair. (intentional only)

(292) *Resultative Phrase:
*Carrie touched the door open.

(293) Zero-related Nominal:
a touch/*give a touch
a pat/give a pat

Appendix B - WordNet (xescort) Data: Example Sentences From the Brown Corpus with Sense Information

Break (verb sense 2)

Match found in file br-k10, sentence 34 - Matching senses:
Primary Key = break (verb sense 2) Word Number = 20
Before them stalked the beadle, proclaiming as he went,'' Thus the Council deals_with those who ->BREAK<- its laws- adulter ers, thieves, murderers, and lewd persons.

Chip (verb sense 2)

Match found in file br-r08, sentence 61 - Matching senses:
Primary Key = chip (verb sense 2) Word Number = 12
Miss_Pulova has a voice that Maria_Callas once described as'' like ->CHIPPING<- teeth with a screw_driver'', and her round, opalescent face becomes fascinatingly reflective of the emotions demanded by the role of Rosalie.

Smash (verb sense 2)

Match found in file br-a13, sentence 106 - Matching senses:
Primary Key = smash (verb sense 2) Word Number = 7
Hector_Lopez, subbing for Berra, ->SMASHED<- a 3- run homer off Bill_Henry during another 5- run explosion in the fourth.

Cut (verb sense 13)

Match found in file br-j60, sentence 15 - Matching senses:
Primary Key = cut (verb sense 13) Word Number = 27
To light industry, the economies of being on one floor are much slighter, but efficiency_engineers usually believe_in them, and

manufacturers looking_for ways to ->CUT<- costs cannot be prevented from turning_to efficiency_engineers.

Scrape (verb sense 3)

Match found in file br-k29, sentence 89 - Matching senses:
Primary Key = scrape (verb sense 3) Word Number = 42
At 7:25 two hotel doormen came thumping down the steps, carrying a saw-horse to be set_up as a barricade in_front_of the haberdashery_store window next to the entranceway, and as I watched them in their gaudy red coats that nearly ->SCRAPED<- the ground, their golden, fringed epaulets and spic, red visored caps, I suddenly saw just over their shoulders Jessica gracefully making her way through the crowd.

Beat (verb sense 2)

Match found in file br-k07, sentence 57 - Matching senses:
Primary Key = beat (verb sense 2) Word Number = 24
The music drove_them_off, or away, and he was free to walk_on_air in a very_few moments, humming and jiving within, ->BEATING<- the rhythm within.

Beat (verb sense 3)

Match found in file br-k29, sentence 90 - Matching senses:
Primary Key = beat (verb sense 3) Word Number = 5
My heart almost stopped ->BEATING<-.

Bump (verb sense 2)

Match found in file br-r07, sentence 161 - Matching senses:
Primary Key = bump (verb sense 2) Word Number = 3
‘‘ We ->BUMP<-’’, one said; and the other went_on to development of the idea.

Bump (verb sense 4)

Match found in file br-r07, sentence 64 - Matching senses:
Primary Key = bump (verb sense 4) Word Number = 14
Their father, when he came_back from those many business trips, just ->BUMPED<- their mother on the forehead with his lips and asked if anybody had thought to mix the martinis and put them in the electric icebox.

Dash (verb sense 1)

Match found in file br-k05, sentence 152 - Matching senses:
Primary Key = dash (verb sense 1) Word Number = 7
That absence of an urgent self-indulgence ->DASHED<- them awake like a pail of water.

Nudge (verb sense 2)

Match found in file br-k06, sentence 31 - Matching senses:
Primary Key = nudge (verb sense 2) Word Number = 4
His mother was ->NUDGING<- him, but he was still falling.

Lash (verb sense 2)

Match found in file br-r08, sentence 27 - Matching senses:
Primary Key = lash (verb sense 2) Word Number = 11
For the remainder of the movie, Chancellor_Neitzbohr proceeds to ->LASH<- the piano stool with a slat from a Venetian_blind that used to hang in the pre war Reichstag.