

# What Does It Mean To Be a Shelf?

## *Semantic Bleaching and WordNet*

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### **Abstract**

In English, denominal verbs incorporate in varying degrees the meaning of the root noun as part of the verb's meaning. For example, one can box a present in a gift box but not in a paper bag, shelve a book on the mantelpiece but not on a spike. Other verbs such as land and warehouse exhibit bleaching to a much greater degree; for example, one can land a hydroplane on water, or warehouse parts in a barn, silo or any structure. In this paper, we describe the advantages and shortcomings in modeling semantic bleaching using WORDNET's hypernym/hyponym hierarchy, suggesting, along the way, directions for further refinement of the isa-relation.

## **1 Introduction**

WORDNET, Fellbaum (1998), provides a rich array of semantic relations that can be exploited for natural language tasks involving semantic inference. The hypernym/hyponym hierarchy represents one of these relations defined over nouns. Denominal verbs, being derived from nominal roots, inherit substantial semantic properties from associated nouns. In this paper, we show that the structure and organization of WORDNET's noun hierarchy has empirical consequences for the verbal system with respect to denominals.

### **1.1 Non-Bleaching Denominals**

In English, nouns can often function as location or locatum verbs, incorporating the nominal to a greater or lesser extent as part of the denominal verb's meaning. Kiparsky (1997) uses the term "bleaching" to express the degree of attenuation in nominal meaning.<sup>1</sup> For instance, consider the examples shown in (1), adapted from (?).

- (1) a. John boxed the present  
b. John PUT the present IN a <BOX>  
c. John boxed the present in a gift box  
d. # John boxed the present in a brown paper bag
  
- (2) a. Mary buttered the piece of toast  
b. Mary PUT <BUTTER> ON the piece of toast  
c. Mary buttered the toast with margarine/unsalted butter  
d. # Mary buttered the toast with marmalade/onions

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<sup>1</sup>The term semantic bleaching is more conventionally used in the linguistics literature in the context of language change.

The location verb *box* in (1a) has the informal meaning given in (1b). Here, PUT represents the underlying core verb, and angle brackets <...> are used to indicate the nominal constant that is lexicalized as a verb in the sense of (?). According to Kiparsky, *box* permits only a restricted range of possible location adjuncts, as shown in (1c) and (1d).<sup>2</sup> Similarly, the locatum verb *butter* in (2a), paraphrased in (2b), limits the choice of locatum adjuncts to either butter or its direct substitute, margarine, as shown in (2c) and (2d).<sup>3</sup>

## 1.2 Partial Bleaching

Interestingly, other denominals permit a wider, though still partially restricted, range of modification, e.g. location *shelve* and locatum *bread*, as shown in (3) and (4).<sup>4</sup>

- (3) a. Peter shelved a book  
 b. Peter shelved a book on the windowsill/mantelpiece/table/stand  
 c. # Peter shelved a book on the ball/spike/ceiling/floor/balcony
- (4) a. Sue breaded the fish  
 b. Sue breaded the fish with breadcrumbs/shredded coconut/crushed almonds  
 c. # Sue breaded the fish with marmalade/butter/treacle/ice

In (3), the location *shelf* may be replaced by “shelf-like” objects such as *windowsills* and *tables*, but not by other objects like *spikes* or *balconies*. This partial “bleaching” of *shelf* can be encoded as follows:

- (5) a. x PUT y ON <SHELF>  
 b. x PUT y ON z & shelf-like-object(z)

More formally, the concept of partial bleaching for *shelf* involves the replacement of the concrete constant <SHELF> with a variable *z* restricted by the predicate shelf-like-object. This paper explores whether and how clustering of semantic relations around shelf in a network like WORDNET can be used to define a concept such as shelf-like-object.

Another case of partial bleaching is given in (4) for the locatum verb *bread*. This example crucially involves the additional concept of *crumbs* or small particles, as the contrast between the examples in (4b) and (4c) indicates. That is, (4a) cannot be paraphrased using (6a); instead it is more accurately modelled by (6b).

- (6) a. # x PUT <BREAD> ON y  
 b. x PUT crumbs of <BREAD> ON y  
 c. x PUT crumbs of z ON y

Partial bleaching in this case is encoded by the substitution of <BREAD> with the unrestricted variable *z*, as represented in (6c).<sup>5</sup>

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<sup>2</sup>Actually a Web search reveals other possible substitutions for gift box including: *case, album, container, trunk, cylinder, carton, crate, casing, coffin, tube, suitcase, slipcase, binder, clamshell, chest, tin and cabinet*.

<sup>3</sup>Some readers may find *margarine* unacceptable in (2c). However, the point here is that *butter* exhibits extremely limited bleaching.

<sup>4</sup>(3b) and (4b) are constructed from actual examples found on the Web.

<sup>5</sup>The notion *crumbs of z* needs to be further clarified to deal with cases where the relevant entity already comes in the form of small particles, e.g. *pork chops breaded with pumpkin seeds* or *Boneless center cuts of pork loin, breaded with cracked black pepper*.

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<noun.artifact> shelf
-- (a support that consists of a horizontal surface for holding objects)
=> <noun.artifact> support
-- (any device that bears the weight of another thing)

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Figure 1: WORDNET glosses for *shelf* and *support*

### 1.3 Full Bleaching

Still, other denominals allow complete bleaching to take place. For example, consider the location verbs in (7).

- (7) a. to land a hydroplane on water  
 b. to dump garbage by the roadside  
 c. to ditch a car in a vacant lot  
 d. to warehouse the empty crates in the silo

The examples in (7) indicate that one can *land*, *dump*, *ditch* or *warehouse* an object or objects anywhere. Here, we use the term “denominal” to encompass what Kiparsky terms as true and apparent denominals. In other words, we assume the verbs in (7) are semantically related to the corresponding nominals via the template in (8):

- (8) <DENOMINAL> = x PUT y IN/AT location(<NOMINAL>)

Another possibility is that apparent denominals like *dump* and *ditch* may be related to nominals via a common root, as suggested in (?).<sup>6</sup>

In a similar fashion, the meaning of locatum verbs *blanket* and *blindfold* can be completely diluted or basically paraphrased as “cover”, as shown in (9) and (10).<sup>7</sup>

- (9) a. highways blanketed with fog  
 b. burgers blanketed with onions  
 c. streets blanketed with cars  
 d. a steep embankment blanketed with dense foliage

- (10) blindfolded with his own shirt/duct tape/a filthy rag/a teacosy

To summarize, there appear to be at least three classes or levels of denominals with respect to the phenomenon of bleaching. First, denominals like *box* and *butter* more or less retain “the full force of the corresponding noun”, to use Kiparsky’s words. Second, verbs like *shelve* or *bread* permit the substitution of *shelf*-like objects or objects that can be broken down into *crumbs*, respectively. Finally, denominals such as *land*, *dump*, *ditch* or *blanket* and *blindfold*, allow the nominal meaning to be fully diluted or bleached.

## 2 WordNet and Bleaching

The main question explored in this paper is as follows:

Can WORDNET be used to predict the degree of bleaching for denominals?

<sup>6</sup>In this paper, we are primarily interested in synchronic data. Of course, historically speaking, *dump* and *ditch* as verbs (but not *land* or *warehouse*) pre-date the related nominal forms.

<sup>7</sup>These are actual examples are taken from the Web.

As a first stab at the problem, it seems appropriate to make use of the hierarchical semantic structure represented by WORDNET's hypernym/hyponym relation, which is designed to encode the *isa* (is a) or *aka* (a kind of) relation. In particular, consider the following hypothesis, shown in (11).

- (11) Denominal root Y may be bleached using X if X is a hyponym\* of Y<sup>8</sup>

## 2.1 Example of a Partially Bleaching Verb: *Shelve*

Consider again the location verb *shelve*, as shown in (12) (=3b).

- (12) Peter shelved a book on the windowsill/mantelpiece/table/stand

In WORDNET, *shelf* as a horizontal support has the following hyponyms:

- (13) bookshelf, hob, mantel, mantelpiece, mantle, chimneypiece, overmantel

A Web search was performed, revealing the following 9 distinct *shelf*-like objects and confirming the limited possibilities for bleaching with respect to *shelve*:<sup>9</sup>

- (14) windowsill, mantel, case, radiator, table, stand, carrel, bookstand, bookshelf

(13) and (14) intersect for examples *mantel* and *bookshelf* only.

To broaden the notion of *shelf*, note that it is defined in WORDNET to be an instance of the concept *support*, as shown in Figure 1.<sup>10</sup> WORDNET does not make a distinction between functional and non-functional *isa*-relations in the hypernym/hyponym hierarchy, as noted by (?). Here, *shelf* bears a functional *isa*-relation with respect to *support*, i.e. a *shelf* functions as a kind of *support*, to be distinguished from the type of *isa*-relation that obtains between, say, *bookshelf* and *shelf*. The relevance of the distinction will be made clear below.

Let us tentatively revise the definition in (11) as follows:

- (15) Denominal root Y may be bleached using X if
- a. X is a hyponym\* of Y, or
  - b. Z is a functional hypernym<sup>+</sup> of Y, and X is a hyponym<sup>+</sup> of Z<sup>11,12</sup>

Using (15b), we can account for *windowsill* and (*book*)*stand* in (14). A simple search reveals that these two items are related to *shelf* via the notion of *support*, as illustrated

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<sup>8</sup>\* is used to denote the reflexive transitive closure operation. For the base case when X=Y, other criteria also come into play, e.g. the introduction of new or crucial information, as in *land a hydroplane on dry land*.

<sup>9</sup>These were manually extracted from all 850 results returned by GOOGLE using the keywords: **shelved +on**. A similar protocol was used in all searches described here. Note that the potential for polysemy requires manual intervention to exclude examples such as *maps are shelved on the back wall*, *periodicals are shelved on many floors and tiers*, and *the UN has shelved a US resolution on China*.

<sup>10</sup>Although *support* is the functional superordinate of *shelf*, WORDNET encodes other kinds of superordinate relations. For example, the holonym relation indicates that a *shelf* can also be part of a *bookcase*, *counter*, *cabinet*, *closet* or *bureau*.

<sup>11</sup>+ represents the transitive closure operation.

<sup>12</sup>For the purposes of this paper, we put aside the important problem of how to define functional hypernymy. This information must be introduced from sources external to WORDNET. See also note 14.

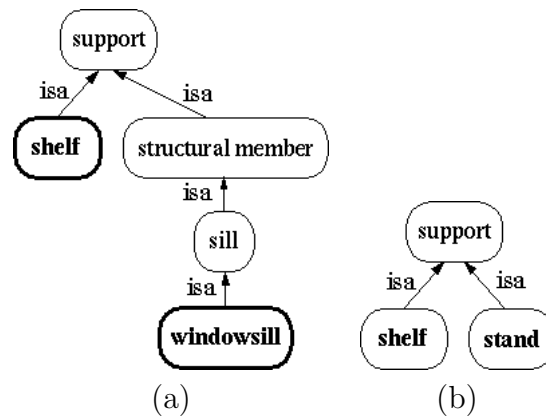


Figure 2: Path from *shelf* to *windowsill* and *stand*

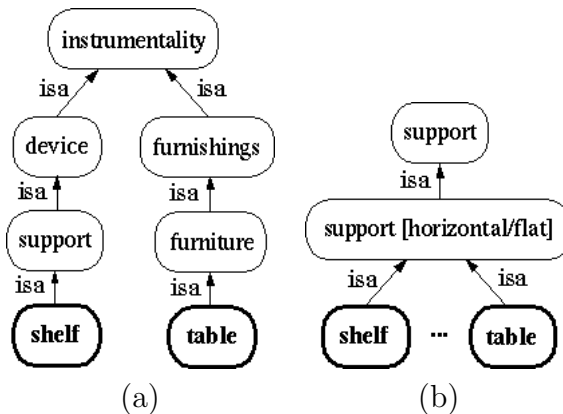


Figure 3: Paths for *shelf* and *table*

in Figure 2. In fact, Figures 2(a–b) represent the shortest possible link between the concepts.<sup>13</sup>

However, (15b) does not allow us to account for *table*. The shortest path between *table* and *shelf* is illustrated in Figure 3(a). This path contains higher concepts such as *device*, *instrumentality* and *furnishings* that are in no way *shelf*-like. From another viewpoint, complete bleaching in the WORDNET hierarchy occurs when non-functional relations, such as that between *furnishings* and *instrumentality*, are required to complete the derivation. Hence, the restriction to functional *isa*-relations in (15b).

The commonality we seek between *table* and *shelf* is that they're both horizontal or flat surfaces capable of support. Given this, there exists a functional relationship between the two concepts not currently represented in WORDNET. One possible implementation is to refine the concept of *support* to reflect a feature [HORIZONTAL] (or FLAT), as shown in Figure 3(b). In fact, something of this form is independently necessary to prevent (15b) from overgenerating, as (16), a list of the unqualified hyponyms of *support*, indicates.

- (16) andiron, firelog, dog, dogiron, arch support, back, backrest, backboard, baluster, base, pedestal, stand, bearing, bearing wall, bedpost, bookend, brace, bracket, bridge, foot, foothold, footing, handrest, hanger, harness, harp, headstock, leg, perch, pier, pillow block, rack, stand, rest, rib, rocker, seat, shelf, skeg, sling, spoke, radius, step, stair, stirrup, stirrup iron, stock, gunstock, structural member,

<sup>13</sup>We adopt the breadth-first WORDNET search engine described in (?) to find the shortest connection or path between concepts.

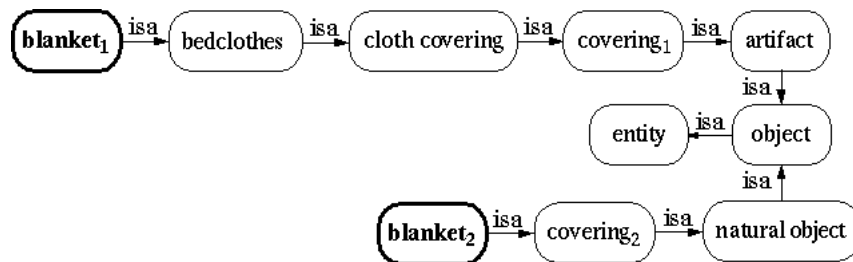


Figure 4: WORDNET hierarchy for *blanket*

tailstock, tee, football tee, undercarriage, yoke

## 2.2 Examples of Non-Bleaching Verbs: *Asphalt* and *Tarmac*

*Asphalt* and *tarmac*, along with *butter* in (2), are examples of non-bleaching denominals.

- (17) a. the crew asphalted/tarmacd the road with fresh asphalt/new tarmac  
 b. # the crew asphalted/tarmacd the road with concrete  
 c. # the crew asphalted/tarmacd the road with cobblestones

*Asphalt* and *tarmac* both lie at the very bottom of WORDNET's hypernym/hyponym hierarchy. Hence the first part of the bleaching rule (15), repeated here as (18), admits no candidates.

- (18) Denominal root Y may be bleached using X if  
 a. X is a hyponym\* of Y, or  
 b. Z is a functional hypernym<sup>+</sup> of Y, and X is a hyponym<sup>+</sup> of Z

Both nominals are instances of *paving material*, a functional superordinate with the following set of hyponyms:

- (19) asphalt, concrete, cement, reinforced concrete, ferroconcrete, blacktop, blacktopping, macadam, tarmac, paving, pavement

Hence (18b) incorrectly rules in (17b). A potential fix for this is to hypothesize that (18b) applies only when the set of X satisfying (18a) is non-empty. This amounts to hypothesizing that leaf nodes are always non-bleachable:

- (20) Denominals derived from leaf nodes are non-bleachable

Unfortunately, (20) is unmaintainable. *Asphalt* and *tarmac* belong to the class of *Butter Verbs*, see (?), with the template in (21), generalizing (2b).

- (21) x PUT <y> ON/IN z

where *y* represents the noun from which the verb is derived.

Two other members of this class, *blanket* and *blindfold*, are also represented by leaf nodes in WORDNET. However, as was seen previously in (9) and (10), these are highly bleachable verbs. How can we explain the bleachability of verbs like *blanket*?

The hierarchical structure relevant for *blanket* is given in Figure 4. As can be seen, WORDNET distinguishes between artificial and natural coverings, *covering<sub>1</sub>* and *covering<sub>2</sub>*

(respectively), a distinction not relevant in semantic bleaching. With respect to the bleaching rule shown previously in (18b), the superordinate nodes up to and including *covering* have functional value and those above do not.<sup>14</sup>

Hence, (18b) predicts that *blanket* is highly bleachable with any kind of covering, natural or otherwise, defined in the WORDNET hierarchy. Many of these are listed in (22a) and (22b).

(22) a. **Natural coverings**

scale, shell, test, body, covering sheath, case, integument, blanket, mantle, crust, incrustation, encrustation, envelope, shell, eggshell, slough, peridium, pericarp, seed vessel, perianth, floral envelope, theca, sac, indusium, bark

b. **Artificial coverings**

artificial skin, bootleg, canopy, casing, cloak, cloth, covering, clothing, clothes, apparel, vesture, wearing apparel, wear, coating, coat, cover plate, fig leaf, flap, floorcover, floor covering, folder, footwear, footgear, imbrication, overlapping, lapping, instep, mask, mercy seat, paddlebox, protective covering, protection screen, cover, covert, concealment, swathing top, upholstery, wrapping, wrap, wrapper

Given these examples, the functional concept of *covering* is clearly well-motivated and pertinent to the bleaching of *blanket*. More precisely, the bleaching rule given by (18b) predicts the derivation of (23b) from (23a).

(23) a. x PUT <BLANKET> ON/OVER z

b. x PUT <COVERING> ON/OVER z

Nevertheless, the WORDNET definition is a limited one. Almost anything can function as a *blanket*. As (24) illustrates, a Web search reveals a large variety of entities.

(24) snow, fog, parachutes, sauce, smog, debris, ash, flowers, glaze, wildflowers, bacon, forest, garland, mixed grill, turkey, ham, smoke, compost, clippings, mulch, cheese, onions, plants, fallout, panels, bodies, pines, mixture, foliage, tephra, blast material, craters, salsa, yogurt, shards, paper, scrub, cars, till, wilderness, loess, crabmeat, fondue, logos, landmines, deposits, Teflon, bags, turf, notices, bracken, heather, moss, mud, fronds, trees, groves, posters, handbills, doorknobs, powder, haze, sand, absorbent, leaves, stars, crickets, peanuts, plaques, foul air, particles, ice, rainforest, spruce, cedar, coating<sup>15</sup>

(23b) is essentially correct. However, for the purpose of semantic bleaching, and any other operation requiring the extension of the concept of *covering*, the node should be augmented with a distinguished pointer to *object*, indicating the possibility of free substitution.<sup>16</sup>

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<sup>14</sup>Lending support to this is the fact that there is a switch in lexicographer's file numbering. *Blanket* through *covering* are classified either as <noun.artifact>, in the upper half of Figure 4, or <noun.object>, in the lower half. Above *covering*, there is a change in classification, concepts *artifact* through *entity* are labeled generically as <noun.Tops>.

<sup>15</sup>We exclude from (24) metaphorical examples that were also reported including: love, details, color, white, lights, warm hearts, concern, enthusiasm, gray, memories, glory, protection, starry night, anonymity and responses.

<sup>16</sup>This is an oversimplification. Not all objects can function as a covering, e.g. *#blanketed with air*.

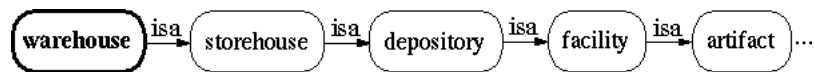


Figure 5: WORDNET hierarchy for *warehouse*

### 2.3 Pocket Verbs: *warehouse* and *spindle*

Locative denominals *warehouse*, as in (7d), and *spindle*, as in (25), are members of the class of *Pocket Verbs*, see (?), with the template in (26), generalizing (5a).

(25) the dragon has been spindled on a spear<sup>17</sup>

(26) x PUT y ON/IN <z>

where *z* represents the noun from which the verb is derived.

Consider first the relevant fragment of WORDNET hierarchical structure for *warehouse* shown in Figure 5. Here, arguably the functionality of *warehouse* is lost for nodes higher than *depository*. Again, the WORDNET concept of a *depository*, given in (27), is a limited one, as almost any structure can be turned into a *warehouse*.

(27) archive, archives, chancery, bank, bank building, drop, maildrop, postbox, mailbox, letter box, pillar box, library, depository library, athenaeum, atheneum, lending library, circulating library, museum, Louvre, Louvre Museum, science museum, repertory, sperm bank, storehouse, depot, entrepot, storage, store, granary, garner, magazine, powder store, powder magazine, railhead, treasure house, warehouse, storage warehouse, godown, treasury

For completeness, (28) shows the result of a Web search on the bleaching of *warehouse*.<sup>18</sup>

(28) housing, bonding warehouse, storage, building, hanger, apartment, silo, shed, bin, room, cubicles, basement, institution, jail, prison, facility, nursing home, repository, shelter, brothel, pediatric ward, universities, research laboratories, barracks, hostel, retail outlets, state hospitals, orphanages, stall, archives, libraries, museums, stores, factory, distribution centre, asylums, government schools, insecure wing, winter quarters, housing projects, hospital hallways, sanatoria, tenement hotel, study halls, boarding house, sanctuary, classroom

In Figure 6(a) however, the noun *spindle* represent a specialized concept and thus is not subject to extensive bleaching. Applying bleaching rule (18) results in the following (simplified) lists, assuming that *rod* and *stick* are the uppermost functional nodes. Our rule predicts limited bleaching, producing robust and reasonable candidates (though incomplete), confirmed by the data in (29b).

(29) a. **Bleaching rule:** baton, wand, rod, pole, boom, caber, mast, spar, stilt, ramrod, shaft, spindle, mandrel, arbor, axle, journal, thill, bow, club, staff  
 b. **Web data:** rod, shaft, spear, incisor

<sup>17</sup>This example is taken from: *Enter the Rambo Warrior, who shouts, "Yo, Dragon!" and before you know it, the dragon has been spindled on a spear and is lying dead at the Warrior's feet.*

<sup>18</sup>No attempt has been made in (28) to separate nouns for structures such as *shed* and *silo* from general locational labels such as *sanctuary* and *jail*. There are also many cases of metaphorical use, some of these are: police files, databases, indexed flat file structures, relational tables, liquid nitrogen, portfolio, data repositories, mainframe, state foster care system, unconscious mind and bilingual education classes.



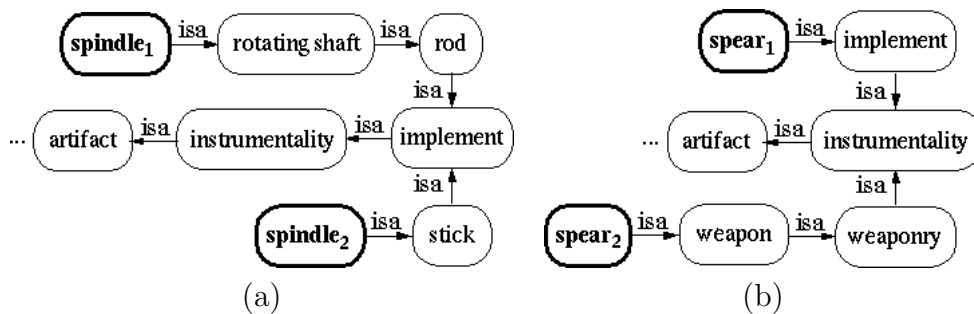


Figure 6: WORDNET hierarchy for *spindle* and *spear*

Finally, note that Figure 6(b) indicates that *spear* can only be reached in WORDNET via the generic concepts of *implement* and *instrumentality*. WORDNET distinguishes two senses of *spear* in terms of its functionality. The corresponding glosses for *spear<sub>1</sub>* and *spear<sub>2</sub>* are given in (30a) and (30b).

- (30) a. an implement with a shaft and a barbed point used for catching fish  
 b. a long pointed rod used as weapon

Although the definitions include the terms *shaft* and *rod* as components of a *spear*, both terms being candidates returned by the bleaching rule, there is no direct functional semantic relation here. Obviously, a *sharpened shaft* or *rod* can function as a *spear*. The notion of an indirect functional relation remains to be defined in future work.

### 3 Conclusions

In this paper, we have investigated how WORDNET can be used to help formalize the notion of semantic bleaching as it applies to denominal verbs. We have defined, and refined over a series of examples incorporating varying degrees of bleaching, a bleaching rule formally defined over the WORDNET hypernym/hyponym hierarchy. We have argued for a notion of functionality relevant to bleaching and, in particular, the need to tease out or distinguish functional isa-relations within the noun hierarchy.

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