# Renovating the Verb Hierarchy of English Wordnet

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## Abstract

English Wordnet's hierarchy of senses is a key feature that enables the resource to be used for a wide range of analysis, however, it is only complete for nouns and not for other parts of speech. In this work, we propose an improvement of the hierarchy of verbs, such that all verbs are connected to one of eight top synsets. We evaluate this resource in terms of improved connectivity and in comparison to SimVerb-3500, and show that this hierarchy makes the resource more useful. We extensively discuss further improvements that would make English Wordnet more practical for a wide range of applications and bring it closer in line with other lexical resources for verbs.

## 1 Introduction

English Wordnet is still the primary resource for lexical semantic analysis in computational linguistics and its model of links between words has proved invaluable to a wide range of experiments (Jin et al., 2024; Stanisz et al., 2024). The nouns in English Wordnet form a complete hierarchy with a single root element, however, there is no such complete hierarchy for other part-of-speech values. In this paper, we look at the verbs of English WordNet editions, including the Princeton WordNet (Miller, 1995; Fellbaum, 2010, PWN) and the more recent Open English Wordnet versions (McCrae et al., 2019)[1]. We firstly examine the nature of hypernymy and troponymy in wordnets and develop guidelines for the establishment of links between verbal synsets. We then use these principles to 'renovate' the verb hierarchy of English WordNet leading to a far more complete hierarchy of verbs. We examine how this improves the hierarchy in terms of connectedness and compare this with a semantic similarity resource. This new hierarchy is also released as part of the 2024 edition of Open English WordNet.

We then discuss some of the challenges with the verb hierarchy in English Wordnet, in particular, related to the representation of frame information in the wordnet, as well as how this can relate to other frame resources, such as FrameNet (Baker et al., 1998). Finally, this paper will look at some perspectives for the improvement of verb modelling in WordNet in particular through the establishment of new relations that would further connect verbs together.

## 2 Related Work

Classifications of verbs have been investigated from a number of directions based on their syntactic and semantic properties (Levin, 1993) and this has led to the development of a number of resources such as VerbNet (Schuler, 2005), FrameNet (Baker et al., 1998) and PropBank (Kingsbury and Palmer, 2002). These resources are focused on the use of frame semantics (Fillmore, 1976), which is complementary to the graph structure used by wordnets and as such, there has been much interest in linking these resources with English Wordnet in order to provide a complete description of verb semantics. One of the first of these efforts was by Shi and Mihalcea (2005), who linked FrameNet, VerbNet and WordNet and this was further extended by Laparra and Rigau (2010). Similar mappings were developed by Tonelli and Pighin (2009) and (Ferrández et al., 2010) and this lead to the creation of SemLink (Palmer, 2009), later extended with the inclusion of OntoNotes (Hovy et al., 2006) to SemLink+ (Palmer et al., 2014). Similarly, other resources such as Predicate Matrix (Lopez de Lacalle et al., 2014) and the conceptual descriptions of Stoyanova and Leseva (2023) have produced large-scale resources that combine these resources. In particular, Leseva et al. (2018)'s classification used the hypernymy structure of English Word-

[1]We use the term 'English Wordnet' to cover releases by both projects

net to provide a joint classification of verbs. They found that the majority of verbs could be accommodated in the classification, but noted that there was a large amount of semantic mismatch between the hypernyms in WordNet and the hierarchy of FrameNet.

Other approaches to the classification of verbs have focused on other features such as the morphosyntax of verbs, for example by examining the morphosyntactic derivations (Šojat and Srebačić, 2014) or by noun derivations (Mititelu et al., 2021), which would allow the verb relations to be connected to the noun hierarchy. Finally, other attempts have classified verbs through ontological categories, such as events (Puşcaşu and Mititelu, 2008) using TimeML or through upper ontologies such as SUMO (Chow and Webster, 2007).

More recently, VerbAtlas (Di Fabio et al., 2019) has introduced a large-scale resource that organises all the WordNet synsets into semantic frames, however, it still has substantial quality issues.

## 3 Verb Hierarchy

Verbs in English Wordnet form a hierarchy based on a 'is a manner of' relationship known as *troponymy* as introduced by Fellbaum and Miller (1990). In contrast to the noun hierarchy, verbs are much more polysemous and their senses are not as sharply distinct as the nouns' senses. Still verbs, like nouns, follow a substitution test using a template such as "if someone/thing Xs (someone/thing), then something must also Y (someone/thing)", for example "if someone nibbles something, then someone must also eat something". Substitution is a necessary condition for a verb hypernym but it may cause issues as outlined by Fellbaum and Miller (1990) if not phrased well. Secondly, there may be differences in the morphosyntax of verbs that make it hard to properly apply the substitution as such some other changes should be allowed.

- Changing the preposition used to mark a particular argument in a frame or changing a direct object to a prepositional argument, e.g., 'punish (somebody with something)'[02505278-v] to 'impose (something on somebody)'[00750288-v];
- Replacing a direct object or prepositional argument with 'something' or 'someone', e.g., 'do (something)'[02566500-v] to 'act'[02372362-v];
- Dropping a direct object, e.g., 'observe (a holiday)'[02584595-v] to 'behave'[00010428-v].

Importantly, the subject must have the same semantic role, as this always makes a sense distinction, as discussed below.

For noun definitions, most definitions in WordNet follow a *genera-differentia* style of definition where a noun (the *genera*), which is generally the hypernym, is further differentiated by other criteria (the *differentia*) to give the specific sense. For verbs, the form of the definition does not generally follow this principle, instead, verb meaning is given by a verbal phrase with some arguments or adjuncts. As such, it is less often the case that a hypernym occurs within the definition. For some cases, when the definition contains a verb with a simple adverb or adjunct this can hold, for example, 'behave unnaturally or affectedly' (dissemble, pretend, act)[01725433-v] was marked with 'behave'[00010428-v] as the hypernym in OEWN 2024. However, for many other cases this does not hold, for example, 'render unable to see' (blind)[02172999-v] does not imply any 'rendering' takes place, and instead this verb was mapped to the hypernym of 'alter'. Another issue is that frequently the main verb of the definition is a light verb, such as in 'come to a halt' (stop, halt)[01864781-v] which cannot be mapped to the corresponding sense of the verb 'reach or enter a state, relation, condition, use, or position' (come)[00543200-v], as the substitution test would fail ('if something stops, it must also come'). A more extreme example of this is the copula 'be'[02610777-v], which is given as the hypernym of 138 verbs in Princeton WordNet 3.1. This seems to be a misunderstanding of the concept of troponymy as many of these senses represent passive constructions ('be composed of' (comprise, consist)[02639437-v]), adjectival constructions ('be loyal to' (stick, adhere, stand by, stick by)[02644714-v]) or other constructions ('be the reason or explanation for' (account for)[02641114-v]). These don't generally pass the substitution test as above[2].

## 4 Methodology

The goal of this work is to improve the verb hierarchy and eliminate isolated verb senses, which are not connected to any other verbs in the resource.

[2] 'Something consists of X' does imply 'something is of X', however, there is a different synset of 'be'[02626667-v] that is relevant for this case

As such, we focused on the verb synsets of OEWN 2023, which did not have a hypernym, which consists of 591 synsets. We then also included all verbs whose hypernym is the copula sense of 'be', due to the fact that we concluded that these senses were nearly all erroneous, which added a further 139 synsets to the analysis, leading to our analysis covering 730 verb synsets (5.2% of all verbs in OEWN 2023).

Initially, we attempted to find an automatic method to help find an initial mapping for these hypernyms. The first approach was to use the first verb mentioned in the definition and apply word sense disambiguation to find the first sense. However, this was found to be highly inaccurate and misleading, firstly as a lot of definitions used the copula 'be', light verbs or the verb 'cause'. An analysis of 100 random verb synsets showed that the hypernym verb only occurs in 35 out of 100 verb definitions. We also considered using a large language model to suggest the hypernyms, however, initial chats with ChatGPT indicated that these systems were not good at this task, frequently suggesting synonyms such as 'merit' for 'deserve' or 'perplex' for 'confuse' or words that are hard to relate, for example, 'owe' for 'obligate'. It is possible that a more refined model such as TaxoLlama (Moskvoretskii et al., 2024), may have performed better.

Given the difficulty of the task, it was decided that this was best conducted by a single highly expert annotator through a simple spreadsheet interface to suggest the most appropriate hypernym and the relevant sense of the hypernym. ChatGPT was used to suggest hypernyms in some cases, however as noted above, these were not frequently found to be useful. While this lacks natural validation, given the challenge of the task, it was concluded that this was the best way to implement the model development. In addition, a number of smaller related issues were discovered with the verbs in OEWN and these were created as issues on the GitHub of the OEWN project[3]. The verbs that were marked as troponyms of the copula 'be' were annotated using the same procedure and only one verb synset was deemed to truly be a hypernym of the copula, namely the verb 'stand'[02617408-v] in sentences such as 'I stand corrected.'

### 4.1 Top Verb Synsets

The following verbs were not judged to have a hypernym, and as such can be seen as top concepts for the verb hierarchy:

**act** ('perform an action')[02372362-v] - 12976 children - This hierarchy is shown in more detail in Figure 1. This sense covers all actions that are carried out by an agent and have some temporal scope.

**happen, occur, ...** ('come to pass')[00340744-v] - 43 children - This is used for events not initiated by a causal agent.

**exist, be** ('have an existance')[02609706-v] - 438 Children - Covering most stative verbs.

**have, have got, hold** ('have or possess, either in a concrete or an abstract sense')[02208144-v] - 233 children - A stative verb of possession. One significant child is 'keep, hold on'[02207166-v] with 145 children.

**know, cognize, cognise** ('be cognizant or aware of a fact or a specific piece of information')[00596016-v] - 55 children - Stative verbs relating to knowing a fact

**relate, pertain, ...** ('be relevant to')[02681865-v] - 153 children - Stative verbs that relate two entities.

**miss, lack** ('be without')[02638434-v] - 6 children - The antonym of 'have', indicating not having.

**be** ('have the quality of being; (copula, used with an adjective or a predicate noun)')[02610777-v] - 1 child - The copula sense of the verb to 'be'.

As we have noted before, there does not seem to be a single verb sense that covers all verb meanings, however as we can see from the size of the graph, the verb 'act' covers the large majority of verbs (93.2%). We also distinguish between event verbs with a causal agent and non-causal events and this is due to the requirement that the subject is not changed by hypernymy. For most causal verbs, the causal agent is the subject, whereas for non-causal verbs the event is the subject. The other top verbs are all stative verbs and these are distinguished between most intransitive verbs under

[3]Issue numbers: #1034, #1035, #1036, #1037, #1038, #1039, #1041, #1042, #1043, #1056

act, move[02372362-v] [12976 children]
↪ interact[02382049-v] [1353 children]
  ↪ treat, handle, do by[02519853-v] [126 children]
  ↪ communicate, intercommunicate[00742582-v] [1097 children]
    ↪ inform[00833312-v] [698 children]
      ↪ tell[00954556-v] [489 children]
        ↪ impart, leave, give, pass on[02301114-v] [419 children]
          ↪ convey[00930591-v] [418 children]
            ↪ express, show, evince[00945869-v] [394 children]
              ↪ express, verbalize, verbalise, utter, give tongue to[00942415-v] [263 children]
                ↪ state, say, tell[01011267-v] [183 children]
    ↪ talk, speak, utter, mouth, verbalize, verbalise[00944022-v] [160 children]
↪ move[01835473-v] [336 children]
↪ travel, go, move, locomote[01839438-v] [751 children]
↪ learn, hear, get word, get wind, pick up, find out, get a line, discover, see[00600349-v] [204 children]
  ↪ perceive, comprehend[02110960-v] [197 children]
    ↪ feel, experience[01775456-v] [138 children]
↪ think, cogitate, cerebrate[00630153-v] [721 children]
  ↪ evaluate, pass judgment, judge[00672179-v] [374 children]
↪ change[00109468-v] [1441 children]
  ↪ change integrity[00139943-v] [169 children]
  ↪ change state, turn[00145958-v] [202 children]
  ↪ change magnitude[00169459-v] [218 children]
    ↪ increase[00156409-v] [151 children]
↪ remove, take, take away, withdraw[00173351-v] [201 children]
↪ touch[01208838-v] [197 children]
↪ cover[01335412-v] [189 children]
↪ connect, link, tie, link up[01357376-v] [267 children]
  ↪ attach[01299048-v] [170 children]
↪ induce, stimulate, cause, have, get, make[00772482-v] [4717 children]
  ↪ make, create[01620211-v] [754 children]
    ↪ re-create, recreate[01622373-v] [135 children]
  ↪ change, alter, modify[00126072-v] [3770 children]
    ↪ move, displace[01854282-v] [1242 children]
      ↪ put, set, place, pose, position, lay[01496967-v] [216 children]
      ↪ separate, disunite, divide, part[01559703-v] [132 children]
      ↪ transfer[02236972-v] [279 children]
        ↪ convey, transmit, communicate[02236443-v] [258 children]
          ↪ communicate, pass on, pass, pass along, put across[00744289-v] [257 children]
            ↪ request, ask for, bespeak, call for, quest[00754770-v] [232 children]
              ↪ ask[00754499-v] [171 children]
                ↪ request[00755473-v] [169 children]
                  ↪ order, tell, enjoin, say[00748704-v] [133 children]
    ↪ affect, impact, bear upon, bear on, touch on, touch[00137133-v] [151 children]
    ↪ better, improve, amend, ameliorate, meliorate[00206293-v] [129 children]
    ↪ transfer[02225243-v] [469 children]
      ↪ give[02204104-v] [386 children]
        ↪ supply, provide, render, furnish, offer[02332196-v] [157 children]
↪ get, acquire[02215637-v] [242 children]

Figure 1: Verb hierarchy of action verbs, including all verbs with more than 120 children

'exist' and relations expressed by 'pertain', with the idea of possession and cognition as top concepts. Finally, not having ('lacking') is a top concept as the opposite of 'having' and the copula is treated as a separate verb.

### 4.2 Evaluation

As the annotation was conducted by a single annotator, it is important to validate the quality of the proposed hierarchy. We do this by comparison with a resource that is specialised in the semantics of verbs, namely SimVerb-3500 (Gerz et al., 2016). We also present some general comparisons of the hierarchy of PWN with the new hierarchy proposed for Open English Wordnet 2024.

#### 4.2.1 Connectedness

A key goal of this work is to create connected components in the graph to ensure that algorithms that use the wordnet structure can capture information. As such, we present the size of the connected components in versions of English Wordnet in Figure 1. We measure the components in terms of the number of components considering only **troponymy** (hypernymy) relations, including other **synset** relations (antonymy and similar) and considering sense level relations such as morphological **derivation** (principally between verbs and nouns). We also state the size of the largest connected component in the graph. As we can see Priceton WordNet versions and previous versions of OEWN have been well-connected in general with most verbs in a large connected component, and only about 80 verbs completely disconnected from any other synset. This work has allowed us to completely connect all the verbs (with morphological derivations) improving the connectedness and usability of the resource.

#### 4.2.2 SimVerb-3500

SimVerb-3500 (Gerz et al., 2016) is a large dataset designed for measuring the semantic similarity between pairs of verbs. It contains 3,500 verb pairs, each annotated with a similarity score that reflects how closely related the meanings of the two verbs are. SimVerb-3500 extends other lexical similarity datasets like WordSim-353, by focusing exclusively on verbs, providing a specialized resource for research in verb semantics, compositionality, and lexical relations. The similarity scores were generated through human judgments.

In order to examine the effectiveness of the new hierarchy we compared the Spearman's correlation of wordnet-based similarity metrics to the SimVerb-3500 correlation scores. We examined two metrics the Wu-Palmer metric (Wu and Palmer, 1994) and path distance. We selected only these two metrics out of our analysis as the other metrics either could not easily be applied to verb similarity, as they relied on a single super-concept, which does not exist for verbs, (Leacock-Chodorow (Leacock et al., 1998)) or on information content (such as Resnik (Resnik, 1995)), which is largely incomplete for verbs[4].

The results of the analysis are presented in Table 2, where the correlations are presented according to each resource. Surprisingly the correlations for the new hierarchy were actually not different to the original hierarchy, slightly decreasing for path similarity and increasing for Wu-Palmer similarity. This was in spite of the fact that the scores for the new hierarchy were far more informative, for example, for the PWN hierarchy 1,196 (34.2%) of the scores were zero indicating that the terms had no connection whereas the new hierarchy only 84 (2.4%) of scores were zero. To further examine this we examined the classification of the verb relations given in SimVerb-3500, which are based on the relations in PWN, in this case, we see the new hierarchy improving on many of these classes[5]. Of particular importance to note is the antonym class where the previous hierarchy had no correlation and the new hierarchy has a negative correlation. This is due to the instruction of the dataset to assign low scores to antonyms, and the negative correlation can be seen as an improvement in the new hierarchy. As clarified by the authors of the dataset "evaluation based on Spearman's $\rho$ may be problematic ... with antonyms." (Gerz et al., 2016), and a quick examination of the 'none' category in the data indicates that there are many antonyms not identified by PWN or OEWN that have a low score in this resource. As such, we can say that overall the similarities in the new hierarchy are more useful in most situations.

## 5 Discussion

This work on verbs has highlighted a number of directions that could further improve the verb hier-

[4]In all cases, we used the implementation provided by the WN library https://wn.readthedocs.io/en/latest/api/wn.similarity.html

[5]Note we excluded synonyms as they did not have meaningful correlations in either resource

| Resource | Troponym Components | Synset Components | Deriv. Components | Largest Component |
|---|---|---|---|---|
| PWN 3.0 | 540 | 207 | 86 | 13,421 |
| PWN 3.1 | 545 | 210 | 87 | 13,423 |
| OEWN 2019 | 545 | 210 | 87 | 13,423 |
| OEWN 2020 | 552 | 214 | 88 | 13,494 |
| OEWN 2021 | 552 | 216 | 89 | 13,478 |
| OEWN 2022 | 552 | 216 | 89 | 12,481 |
| OEWN 2023 | 542 | 211 | 83 | 13,475 |
| OEWN 2024 | 8 | 4 | 1 | 14,010 |

Table 1: Analysis of the size of the connected components in the graphs of WordNet versions

| Method | Co-hyponyms | Antonyms | Hypernyms | None | All |
|---|---|---|---|---|---|
| Princeton WordNet 3.0 | | | | | |
| Wu-Palmer | 0.226 | -0.01 | 0.244 | 0.165 | 0.483 |
| Path | 0.205 | -0.03 | 0.281 | 0.166 | 0.487 |
| Open English WordNet 2024 | | | | | |
| Wu-Palmer | 0.215 | -0.117 | 0.278 | 0.188 | 0.485 |
| Path | 0.224 | -0.105 | 0.279 | 0.167 | 0.473 |
| Size | 190 | 111 | 800 | 2093 | 3500 |

Table 2: Pearson Correlation of metrics using OEWN 2024 and PWN 3.0 hierarchy with SimVerb-3500

archy and as such we consider some ways in which the organisation of verbs could be further improved in future versions of wordnets

### 5.1 Frames

Princeton WordNet introduced syntactic frames to each of the verbs that indicate whether a verb has a transitive or intransitive usage and other kinds of arguments such as prepositional or clausal arguments. In addition, it is indicated whether the subject and direct object of the frame can be animate or inanimate. Many lexicographic resources, for example, Merriam-Webster, sort verbs into intransitive and transitive frames before indicating different senses of the verbs. OEWN currently has 1,466 verb senses, which have both a transitive and intransitive frame. We distinguish two types of relationships between the senses of transitive and intransitive verbs:

**Object-Drop Verbs** In this case, the intransitive sense of the verb has the same meaning as the transitive sense, with the object replaced with an existential word. For example, "X eats" ⇒ "X eats something"

**Labile Verbs** Here the intransitive sense of the verb has a similar meaning except that the object of the transitive verb becomes the subject of the intransitive verb. For example. "X changes Y" ⇒ "Y changes".

We analysed the case where two verb senses (with the same lemma) exclusively use either transitive or intransitive frames and found 10,088 such pairs. We analysed a random sample of 500 of these pairs and found that 475 senses were not related (95.0%), 22 were labile verbs (4.4%), 2 had errors in the frame data and only 1 instance was an object-drop verb (namely 'spat'[01240625-v] and 'spat'[02763140-v]). As such, we conclude that the current modelling in WordNet separates labile verbs but not object-drop verbs.

We also observed a number of labile verb pairs of senses of verbs that are normally object-drop due to a systematic polysemy. An example of this is the verb 'clean', which is primarily an object-drop verb, but has a sense[02747835-v] defined as 'be cleanable' and with 'This stove cleans easily' as an example, which is a labile verb of the most frequent sense of 'clean'. It is not clear if these

| Resource | Same Lexfile | Diff. Lexfile | Percent |
|---|---|---|---|
| PWN Verbs | 11637 | 1619 | 12.2% |
| OEWN Verbs | 11824 | 2040 | 14.7% |
| OEWN Nouns | 2527 | 76002 | 3.2% |

Table 3: Number of hypernym links between synsets in different lexicographer files

senses should be included in the resource or if they could be included under the primary sense.

### 5.2 New Relations

In order to further increase the density of the connections between verbs in the resource, it would be good to include more links between synsets. This could be done by adding new relation types that better capture the semantics of verbs. The following have been frequently observed in the resource

**Labile verb** As discussed above, labile verbs are common in the resource and connecting these would help to associate verbs together

**Transitive Causative Alternations** This is the case where two transitive verb senses have an alternation like a labile verb, but the subject and object are reversed.

**Adjectival Links** Quite a few senses are defined as simply 'be ADJ', for example, 'fall (be due)'[02667093-v] or 'press (be open)'[02728657-v]. It would be good to introduce a link between verbs and adjectives where the meaning is directly connected like this.

**Causes** The cause relation is already present for some verbs, however, there are many verbs that are defined as 'cause to VERB' but there is no connection, e.g., 'protuberate (cause to bulge out or project)'[02720606-v].

### 5.3 Supersenses

The lexicographer files are used to group the senses of words into broad categories and were part of the annotation process in the creation of Princeton WordNet. These lexicographer files, thus provide broad semantic categories that can be used to group the senses of words. For verbs, the following lexicographer files exist:

**Body** 552 Synsets
**Change** 2,393 Synsets
**Cognition** 698 Synsets
**Communication** 1,563 Synsets
**Competition** 459 Synsets
**Consumption** 247 Synsets
**Contact** 2,204 Synsets
**Creation** 699 Synsets
**Emotion** 346 Synsets
**Motion** 1,411 Synsets
**Perception** 465 Synsets
**Possession** 849 Synsets
**Social** 1,112 Synsets
**Stative** 758 Synsets
**Weather** 80 Synsets

These lexicographer files for verbs are quite varied in size and moreover as shown in Table 3 a substantial number of these verbs are not in the same lexicographer file as their hypernym, which is not the same as the lexicographer file as the hyponym. This is markedly higher than the nouns and the hierarchy introduced in this paper further increases the number of cross-lexicographer-file hypernyms. To further examine this we looked at the verbs that were declared to be 'stative' verbs, which are verbs that describes a state rather than an action and should correspond to most of the top verbs in Section 4.1, except for 'act'[02372362-v] and 'happen'[00340744-v] which are dynamic verbs, and 'have'[02208144-v] and 'know'[00596016-v], which are stative but associated with `possession` and `cognition` lexicographer files. We found 36 verb synsets that were in the `stative` lexicographer but were not stative verbs, of these 34 were better suited to the `social` lexicographer file, one to `change` and one to `possession`. Most of these verbs were indicated as hyponyms of the copula sense of the verb 'be'. We also found 37 verbs that were hyponyms of one of the stative top-level verbs but were not in the `stative` lexicographer file. We observed that 6 of them had incorrect hypernyms (in PWN 3.1) and have been changed in the OEWN 2024 release. The remaining 32 synsets (86.5%) were in fact stative verbs and should probably be included in this lexicographer file.

The lexicographer files defined are mostly well-mapped to the hierarchy in Figure 1, with several of our top-level verb synsets mapping well to lexicographer files, e.g., 'know'[00596016-v] corresponding strongly to the `cognition` verbs. Most of the significant verbs in the new hierarchy are strongly

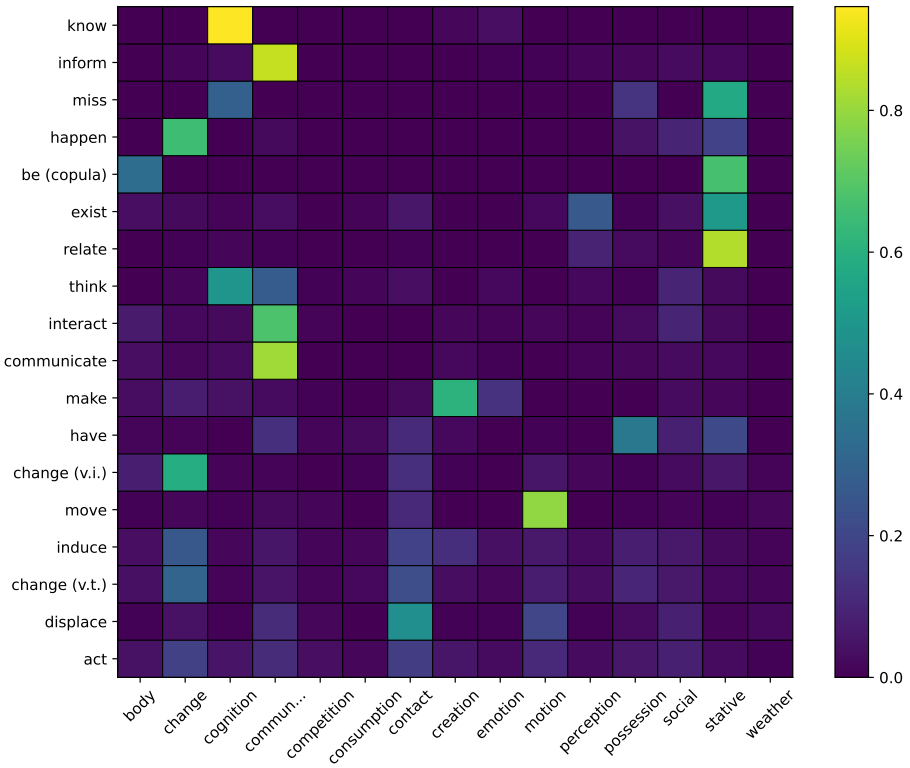


Figure 2: The relative distribution of children of the most significant[6] synsets between lexicographer files

associated with a single lexicographer file. However, we do also note that some lexicographer files do not seem to be strongly associated with any top-level verbs, in particular, the files for `competition`, `consumption` and `weather` are probably not useful categorisations and are also among the smallest files.

### 5.4 Comparison to Frame Resources

The improvement of the verb hierarchy would be helpful in the organisation of frames and help to bring English Wordnet closer to frame resources such as FrameNet, VerbNet or PropBank. While this work does not attempts to merging the efforts of VerbNet similar projects with English Wordnet, subcategorization is considered as described in Section 5.1. Current mappings between English Wordnet and frame reosources such as SemLink have only a few mappings and these are mostly to high-level concepts and as such there are only minor improvements possible. We also analysed the resource relative to VerbAtlas (Di Fabio et al., 2019), which covers nearly all the English Wordnet synsets, however, we were surprised to find that the majority of hypernyms were in different frames in VerbAtlas (6,766/13,186, 51.3%) in OEWN 2023 and this new hierarchy further increased this (7,244/13,738, 52.7%). This is surprising as the organisation of VerbAtlas claims to group verbs which have similar meanings into frames. We analysed the reason on 50 randomly chosen synsets for this and it was concluded that in most cases (54%) the wordnet sense was incompatible with the key sense in VerbAtlas and in only 6% of the cases the error was in English Wordnet; the remainder of the cases involved co-hyponyms or ambiguous senses.

## 6 Conclusion

In this work, we have connected the English Wordnet verb hierarchy by defining top-level synsets for verbs and linking up over 600 verbs that were isolated in the Princeton WordNet hierarchy. This has led to a resource that is more connected and we showed that this is useful for semantic similarity and potentially for applications based on this. In this work, we have used SimVerb-3500 to measure this, however we note that the calculation of similarity without context could be misleading

and a more comprehensive approach using corpora and subcategorization resources would further improve the verb hierarchy. As such, we have still not reached a resource that has a broad-coverage and high-accuracy description of English verbs and there is a need for more kinds of links and more robust representation of frames to produce a resource that can serve linguistic data science applications. This work provides a step in this direction by improving on the previous hierarchies in English Wordnet.

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