Abstract
The study of homonymy is vital to resolving fundamental problems in lexical semantics. In this paper, we propose four hypotheses that characterize the unique behavior of homonyms in the context of translations, discourses, collocations, and sense clusters. We present a new annotated homonym resource that allows us to test our hypotheses on existing WSD resources. The results of the experiments provide strong empirical evidence for the hypotheses. This study represents a step towards a computational method for distinguishing between homonymy and polysemy, and constructing a definitive inventory of coarse-grained senses.

1 Introduction
Many words are semantically ambiguous, in that they have multiple senses. The relationship between two senses of a word is called polysemy if they are semantically related, and homonymy otherwise (Jurafsky and Martin, 2009). The study of homonymy, which is the subject of this paper, is vital to resolving two fundamental problems in lexical semantics: distinguishing between homonymy and polysemy (Utt and Padó, 2011), and defining sense inventories (Snow et al., 2007).

These two open questions are considered crucial not only in NLP, but also in linguistics, psycho-linguistics, and lexicography. In his textbook on semantics, Lyons (1995) devotes an entire chapter to the distinction between homonymy and polysemy, ending with a conclusion that the problem may be “insoluble”, as the intuitions of native speakers cannot be relied upon. Psycholinguistic evidence for a common representation of closely related senses in the mental lexicon is presented by Brown (2008), who observes that NLP applications would benefit from the ability to distinguish homonym-level meaning differences. Mel’čuk (2013) states that the differentiation of homonymous and polysemous word senses is one of the central problems not only of lexicology and lexicography, but also of theoretical semantics.

The question of how to establish the set of senses for a given word is of the utmost importance in word sense disambiguation (WSD), the task of selecting the intended sense of an ambiguous word token. The quality and granularity of the sense inventory greatly influences the design, evaluation, and utility of any WSD system. The standard sense inventory, WordNet (Fellbaum, 1998), makes no distinction between homonymy and polysemy, and is widely considered to be excessively fine-grained for many practical applications (Navigli, 2018), as evidenced by a low inter-annotator agreement (Snyder and Palmer, 2004). This has inspired substantial prior work on clustering fine-grained senses to create more coarse-grained sense inventories (Hovy et al., 2006; Navigli, 2006; Snow et al., 2007; Dandala et al., 2013).

Following the observation of (Resnik and Yarowsky, 1997) that different senses of a word often correspond to distinct words in another language, another branch of prior work has sought to use translations to define sense inventories (Resnik and Yarowsky, 1999; Diab and Resnik, 2002; Ng et al., 2003; Chan et al., 2007; Bansal et al., 2012; Taghipour and Ng, 2015). In order to be successful, such an approach would have to resolve the challenging issues of mapping senses to translations in a set of diverse target languages, as well as projecting them onto a standard sense inventory, such as WordNet.

In summary, clustering fine-grained senses and defining sense distinctions using translations are two competing methodologies for creating coarse-grained sense inventories. Regardless of which one is adopted, an understanding of the nature and characteristics of homonymous senses is a nec-
necessary step toward a principled method of defining senses and sense distinctions. In particular, distinctions between homonymous senses must be preserved in any sense inventory. This motivates our study, which contributes to such an understanding by directly linking homonymy to the concepts of translation and sense clustering, and thus bridging the gap between the two approaches.

The contributions of this work are both theoretical and empirical. The main goal is to create theoretical foundations for the study of homonymy, which could pave the way for developing a computational method for distinguishing between homonymy and polysemy, and facilitate the task of constructing a definitive inventory of coarse-grained senses. We formulate four hypotheses about the unique behavior of homonyms in the context of translations, discourses, collocations, and sense clusters. The hypotheses are formulated using established semantic concepts, and formalized in mathematical notation. Our principal hypothesis, as stated in the title, implies a sufficient condition for polysemy that is observable and replicable.

Apart from formulating the hypotheses, we perform experiments to provide empirical evidence for them. It is clear from prior work that what is true at one level of semantic granularity may not be true at another. For example, the well-known hypotheses of one sense per discourse and one sense per collocation have been found not to hold consistently for WordNet senses. It is critical that all claims be formally stated and experimentally tested, regardless of whether the results are considered surprising. To this end, we create a new annotated resource by identifying nearly two thousand English homonyms, and mapping them onto WordNet senses. The results of our experiments on multiple annotated corpora and language pairs strongly support the validity of our hypotheses.

2 Homonym Hypotheses

In this section, we formally define the notion of a homonym, and formulate our hypotheses using set notation. We start by defining several terms that re-occur throughout the paper. We attempt to keep the notational complexity to a minimum, while at the same time striving to avoid ambiguity in the concepts and hypotheses.

2.1 Preliminaries

Lexemes are units of lexical meaning, the vocabulary items which are listed in the dictionary as lemmas (Katamba, 1993). Words are sets of word-forms that represent lexemes, and are associated with certain morpho-syntactic properties. This definition of words includes compounds, such as 'single out'. We consider both lexemes and words that differ in part of speech as distinct. We write lexemes in capital letters, abstract words in single quotes, actual word-forms in italics, and sense meanings in double quotes. For example, the lexeme CUT is represented by the verb 'cut', with the word-forms cut, cuts, and cutting. A lexeme is called polysemous if it contains multiple senses, and monosemous if it has only a single sense. Senses that belong to the same lexeme are semantically related, and therefore polysemous (Jurafsky and Martin, 2009).

A homonymous word represents more than one lexeme, and those lexemes are called homonyms. For example, 'bank' has two homonyms. Senses associated with distinct homonyms are unrelated and therefore homonymous (Murphy and Koskela, 2010). Consequently, the problem of deciding whether two senses of a homonymous word are polysemous is equivalent to deciding whether they belong to the same lexeme. Furthermore, since a non-homonymous word represents only a single lexeme, all of its senses are polysemous.

We are now ready to formally define homonyms. Let \( \mathcal{L} \) and \( \mathcal{W} \) denote the sets of lexemes and words of a given language, respectively, and let \( w: \mathcal{L} \mapsto \mathcal{W} \) be a function that maps each lexeme to the word that represents it. In later sections, we will use \( w^{-1}: \mathcal{W} \mapsto \mathcal{P}(\mathcal{L}) \) to denote the function which maps each word to the set of lexemes it represents. We define the set of homonymous words \( \mathcal{H} \) as the set of all words that represent multiple lexemes:

\[
\mathcal{H} \overset{\text{def}}{=} \{ W \in \mathcal{W} \mid \exists L, L' \in \mathcal{L} : L \neq L' \land (w(L) = w(L') = W) \}
\]

For example, 'bank' \( \in \mathcal{H} \) because \( w(\text{BANK}_1) = w(\text{BANK}_2) = \text{‘bank’} \).

2.2 One Homonym per Translation

In general, there is no simple correspondence between word senses and their translations: a single sense may be translated by any of several syn-
onyms, and different senses of the same word may have the same translation. Ide and Wilks (2007) observe that cross-lingual distinctions often correspond to homonym-level disambiguation. We posit a direct relationship between translations and homonyms. Intuitively, if we picked two random words from a bilingual dictionary, we would not expect them to have translations in common. The same reasoning applies to homonyms, since they are semantically unrelated lexemes that coincidentally share the same form. We formalize this insight as our principal hypothesis.

Put simply, the one homonym per translation hypothesis (OHPT) states that homonyms have disjoint translation sets. Formally, let $T(L)$ be a set of translations of a lexeme $L$, and let $w$ be defined as in Section 2.1. Then,

$$\forall H \in H : \forall L, L' \in w^{-1}(H) : (L \neq L') \Rightarrow T(L) \cap T(L') = \emptyset$$

For example, the Italian translations of the noun 'yard' can be partitioned into two disjoint sets $T(YARD^n_1) = \{'iarda','yard'\}$ and $T(YARD^n_2) = \{'cortile','giardino'\}$, which correspond to two English homonyms, with the meanings “unit” and “garden”.

This hypothesis implies an important generalization: the existence of a shared translation is a sufficient condition for polysemy. Indeed, for homonymous words, senses that can be translated by the same word must belong to the same lexeme, and so are polysemous. As all other words represent only single lexemes, all their senses are polysemous by definition (Section 2.1). Therefore, we consider the OHPT hypothesis as a major step towards solving the problem of distinguishing between homonymy and polysemy.

### 2.3 One Homonym per Discourse

The one sense per discourse (OSPD) hypothesis was introduced in the seminal paper of Gale et al. (1992). They observe that “well-written discourses tend to avoid multiple senses of a polysemous word”, and confirm that the property holds with high probability on a set of 82 instance pairs involving 9 ambiguous words. However, Krovetz (1998) reports that OSPD holds for only 67% of ambiguous words in SemCor, and conjectures that the hypothesis may only apply to homonymous senses.

We formulate Krovetz’s conjecture as the one homonym per discourse hypothesis (OHPD), which can be viewed as a specialization of OSPD to homonyms. The hypothesis states that all occurrences of a homonymous word in a discourse represent the same homonym. A possible explanation of this phenomenon is that writers avoid the use of homonyms in order to reduce ambiguity in a discourse. For example, one of the occurrences of the word bank in the phrase construction of a bank on the river bank could be replaced by a synonym during the writing process.

Our formulation of the OHPD hypothesis states that no more than one lexeme of a homonymous word occurs in any given discourse. Formally, let $D$ be the set of lexemes that occur in a discourse, and let $w$ be again the function that maps lexemes to words. Then,

$$\forall L, L' \in D : (w(L) = w(L')) \Rightarrow (L = L')$$

We close this section by considering the relationship between OHPD and the one translation per discourse (OTPD) hypothesis of Carpuat (2009). They report that approximately 80% of French words have a single English translation per document, which they interpret as strong support for their hypothesis. We note that the conjunction of our OHPT and OHPD hypotheses does not imply OTPD. Indeed, consider the example in Figure 1, which shows how the occurrence of three Spanish translations of the homonymous noun ‘span’ in two different documents leads to a violation of OTPD, but not of OHPD or OHPT.

### 2.4 One Homonym per Collocation

Yarowsky (1993) proposes the one sense per collocation (OSPC) hypothesis, broadly defining a
collocation as “the co-occurrence of two words in some defined relationship”. Yarowsky reports that the hypothesis holds with the average 95% precision on a sample of words of an unreported size. However, Martinez and Agirre (2000) find much weaker evidence for OSPC on WordNet senses, with precision values rarely exceeding 70%.

The explicit focus of Yarowsky (1993) is on the most coarse-grained sense distinctions. Their word sample includes homographs, homophones, translation distinctions, OCR ambiguities, and pseudo-words. All these types of words can be viewed as approximations of homonymy, as they involve pairs of distinct lexemes. We formalize this notion with the one homonym per collocation (OHPC) hypothesis, which states that only one homonym of a word should appear in any given collocation.

Formally, given a corpus of text, let \( R \) be the set of all collocations. For lexeme \( L \in \mathcal{L} \), and collocation \( r \in R \), let \( C_r(L) \) be a proposition which is true if and only if \( w(L) \) occurs in collocation \( r \) in the corpus. Then,

\[
\forall H \in H : \forall L, L' \in w^{-1}(H) : \forall r \in R : (C_r(L) \land C_r(L')) \Rightarrow (L = L')
\]

For example, if BANK\(_n\) (“repository”) is found to occur in the collocation [word-to-right = hired] then BANK\(_n\) (“ridge”) is unlikely to occur in this collocation.

### 2.5 One Homonym per Sense Cluster

**Sense clustering** is the task of grouping together senses that are closely related (Dandala et al., 2013). Although the criteria for eliminating sense distinctions vary depending on the purpose of the sense inventory, a common motivation is to reduce the excessive granularity of WordNet (Snow et al., 2007). In particular, a manual clustering of WordNet senses was created as part of the OntoNotes project, with the objective of increasing the inter-annotator agreement on WSD to 90% (Hovy et al., 2006). Sense clustering has been shown to improve performance on a number of NLP tasks (Pilehvar et al., 2017), and can serve as an extrinsic evaluation for learned representations of senses (Mancini et al., 2017).

Since homonyms are distinct lexemes, we posit that any well-grounded clustering approach must avoid merging homonymous senses. Formally, let \( C \) be a sense clustering, a set of disjoint sets of senses, and let \( S(L) \) be the set of senses of lexeme \( L \). Then,

\[
\forall C \in C : \exists L \in \mathcal{L} : C \subseteq S(L)
\]

In plain words, while the senses of a homonym may be divided between multiple clusters, no cluster should contain senses from different homonyms.

### 3 Homonym Data

In order to provide experimental evidence for our homonym hypotheses, we need a large set of “gold” homonyms, as well as a mapping between those homonyms and the sense annotations in existing corpora. Since no such resource is publicly available, we construct a list of English homonyms that includes nearly two thousand entries (see Table 1). In this section, we present a binary typology of homonyms, our methodology for creating the list of homonyms, and the method for mapping those homonyms onto the WordNet sense inventory.

#### 3.1 Typology of Homonyms

There are generally two ways of defining homonyms. In linguistics (and in this paper), homonyms are considered to be distinct lexemes that happen to share the same form (Murphy and Koskela, 2010). In lexicography, homonymy is sometimes defined more narrowly, by additionally requiring the etymological origins of the lexemes to be different (Stevenson, 2010). Homonyms can therefore be divided into two types: those that satisfy the requirement of different origins, and those that do not. Due to the lack of commonly-accepted terminology, we refer to these two types of homonyms simply as Type A and Type B, respectively.

The two types of homonyms, which are schematically illustrated in Figure 2, stem from different diachronic phenomena. Type A homonyms arise from a convergence of distinct words into a single form. This can occur through the process of sound change or inter-lingual borrowing. For example, both the Old English word cæg “locking implement” and the 17th-century Spanish borrowing cayo “island” evolved into the modern English key. Type B homonyms, on the other hand, arise when a single lexeme splits into two lexemes due to the process of semantic drift. For example, the two meanings of staff, “pole” and
“people”, have developed from a single etymon, which is attested in Old English as *stæf*. Importantly, as native speakers are generally unaware of the etymological history of words, these two types of homonyms are indistinguishable in the synchronic analysis of languages (Lyons, 1995).

The crucial methodological advantage of Type A homonyms is that they can be objectively identified by consulting existing etymological dictionaries. Even though the process of compiling an exhaustive list of Type A homonyms for any language is time-consuming, it is still much easier and less controversial than conducting psychological experiments with human subjects (e.g. Brown (2008)), or obtaining consensus within teams of linguistic experts (e.g. Weischedel et al. (2013)).

We have accomplished this task for English by creating a homonym resource that we describe next.

### 3.2 List of Type A Homonyms

We introduce a novel resource that enables us to empirically test the homonym hypotheses. The resource contains a list of words that represent multiple lexemes with distinct etymological origins. We created the list by consulting existing etymological dictionaries, including the English Oxford Living Dictionary\(^1\) and the Concise Oxford Dictionary of English Etymology\(^2\). We include all homonyms that at some point during language evolution existed as separate words, even those that can be traced to a single proto-word. For example, we include the homonyms of the noun *sole* (“undersurface” vs. “fish”) because of their distinct histories, even though both ultimately come from Latin *solea* “sandal”.

\(^1\)https://en.oxforddictionaries.com
\(^2\)http://www.oxfordreference.com

Table 1 shows a sample entry from our resource. The list contains 1967 Type A homonyms that are represented by 804 homonymous words, and correspond to 2748 distinct lexeme/POS pairs. The number of homonyms per word ranges from two to six, with the average of 2.45. Each homonym entry includes a list of possible parts of speech (noun, verb, adjective, adverb), as well as the language of origin and the form it had in that language. For the purpose of disambiguation in the subsequent stages of annotation, each homonym was manually assigned a brief English gloss, as well as a single French translation. We excluded from our list all proper nouns and abbreviations.

Although we make no claim about the completeness of our homonym resource, we consider it to be representative of English homonyms in general. This is based on the fact that Type A and Type B homonyms cannot be distinguished without access to etymological expertise.

### 3.3 Mapping WordNet Senses to Homonyms

In order to test our homonym hypotheses, we must be able to convert the existing word sense annotations into homonym annotations. For example, we need to know that a word token *spans* which is sense-annotated in some corpus as “two items of the same kind” corresponds to our homonym #1682. The standard sense inventory for WSD is WordNet. In this section, we describe our method of mapping the homonyms in our new resource to WordNet senses.

Because of the great number of fine-grained senses in WordNet, we decided to derive the mapping by composing two annotation projections: an existing clustering of WordNet senses (Navigli, 2006), and a newly-created mapping between those sense clusters and our homonyms. The clustering in question was created by automatically mapping WordNet 2.1 senses to more coarse-grained senses defined by the Oxford Dictionary of English (ODE). Our 804 homonymous words correspond to 2644 sense clusters, which contain 5361 senses. We then manually mapped each clus-
ter of senses to a single homonym on the basis of their WordNet sense glosses.

The resulting mapping is imperfect for two reasons. First, the ODE clustering itself (being automated) is not always correct, which sometimes results in homonymous senses being placed in the same cluster. Second, our annotator (being human) made some errors in mapping clusters to homonyms. We performed the following validation experiment in order to estimate the accuracy of the overall mapping. A second annotator performed a direct mapping of 268 WordNet senses corresponding to a random sample of 77 homonymous words, without any reference to the ODE clustering. We found that the two independent mappings of the 268 senses differed in only 17 instances, which implies that the overall error rate has an upper bound of 6%.

The errors in the sense-to-homonym mapping are a source of “false alarms” in the experiments described in Section 4. We are confident in our ability to determine which of the apparent exceptions are actual exceptions to our hypotheses by careful analysis of the available data. While the distinction between homonymy and polysemy can be highly subjective, the mapping of WordNet senses to known homonyms is much easier, as confirmed by our validation experiment described above.

We will publish our homonym resource, including the WordNet mapping, as well as our error analyses, on a publicly available website.

4 Homonym Evidence

In this section, we describe the experiments that test the four hypotheses formulated in Section 2 using our new homonym resource from Section 3.

4.1 SemCor and Translations

For testing the OHPD and OHPC hypotheses, we use SemCor (Miller et al., 1993), a large sense-annotated English corpus which was created as part of the WordNet project (Petrolito and Bond, 2014). In particular, we adapt the version of SemCor from Raganato et al. (2017).

For testing the OHPT hypothesis, we require not only sense annotations, but also the corresponding translations. At the minimum, we need a large word-aligned bitext that has both sense and part-of-speech annotations on the source side, and lemma annotations on both sides. In addition, the sense inventory has to be the same as the one in our homonym resource. Although such resources are rare, we managed to adapt two bitexts to meet these requirements: MultiSemCor (Bentivogli and Pianta, 2005), and JSemCor (Bond et al., 2012). These corpora, which we refer to as MSC and JSC, contain partial, word-aligned translations of SemCor into Italian and Japanese, respectively.

4.2 WordNet

The use of WordNet presents a number of technical challenges. For the purpose of replicability, we describe here two major issues.

The first issue concerns two distinct conventions for referring to individual WordNet senses: sense keys (used in SemCor, JSC, and ODE clustering) and sense numbers (used in MSC and OntoNotes). We converted the former into the latter using the WordNet::SenseKey package.\(^4\) Because the mapping is not always one-to-one, 16 out of 60,655 WordNet senses in the ODE clustering had to be excluded; however, none of the affected words occur in our homonym resource.

The second issue is the mapping between different WordNet versions. We converted the sense keys from WordNet 2.1 to WordNet 3.0 using WordNetMapper.\(^5\) The package failed to map 551 out of 60,655 senses in the ODE clustering, which resulted in 22 WordNet senses being excluded from our homonym resource.

4.3 One Homonym per Translation

The OHPT hypothesis (Section 2.2) characterizes the relationship between homonymous words and their translations in another language. We validate the hypothesis on two language pairs using the annotated bitexts described in Section 4.1.

In the experimental evaluation, we compute the percentage of type-level instances that are consistent with the OHPT hypothesis. For each English word (i.e. lemma/POS pair) that appears in our homonym resource, we identify the set of its translations on the target side of the bitext. Each unique word/translation pair constitutes a single instance. An instance is consistent with the OHPT hypothesis if and only if all of its occurrences in the bitext represent the same homonym. For example, the Italian translation ‘gioco’ corresponds to three

\(^3\)http://lcl.uniroma1.it/wsdeval

\(^4\)https://metacpan.org/release/LINAS/WordNet-SenseKey-1.03

\(^5\)https://github.com/clt/WordNetMapper
| Hypothesis | Corpus     | Instances | Support |
|------------|------------|-----------|---------|
| OHPT       | MSC (Italian) | 1093      | 99.9    |
| OHPT       | JSC (Japanese) | 1093      | 99.8    |
| OHPD       | SemCor     | 2126      | 99.6    |
| OHPC       | SemCor     | 522       | 97.9    |
| OHPSC      | OntoNotes  | 1578      | 99.9    |

Table 2: Summary of the evidence for the homonym hypotheses from our five experiments.

different senses of the noun ‘game’ in MSC, but since all of them belong to the same homonym, this instance is consistent with OHPT.

The results of the evaluation on the MSC and JSC bitexts are shown in Rows 1 and 2 of Table 2. Coincidentally, MSC and JSC have the same number of unique word/translation pairs (1093). We found only 3 actual exceptions to OHPT across the two corpora; the remaining 7 apparent exceptions are caused by data errors, which we discuss in the next paragraph. The single actual exception in MSC involves the homonyms represented by the noun ‘band’ which is often translated in Italian as ‘banda’. In this unusual case, the homonymy in English (‘ring’ vs. ‘group’) is mirrored by an analogous case of homonymy in Italian. The two actual exceptions in JSC involve the English lexical loans ‘case’ and ‘club’, which have the same Katakana written form regardless of the homonym they represent. These exceptions show that homonymy can occasionally be transferred into another language in the process of lexical borrowing.

The data errors that result in apparent exceptions to OHPT can be divided into four categories: 1) incorrect sense annotations in SemCor, e.g. “the case of Jupiter” annotated with the sense of “container”; 2) an incorrect sense translation in MSC: flag in the sense of “flower” translated as bandiera instead of iride; 3) errors in the ODE clustering, e.g. two homonymous senses of ‘club’ (“team” and “playing card”) in the same cluster; 4) an error in our manual mapping between the ODE clustering and the homonyms: ‘light’ in the sense of “free from troubles” being mapped to the homonym “not dark”. We conclude that the OHPT hypothesis is supported in over 99.8% of instances in either bitext.

4.4 One Homonym per Discourse

The OHPD hypothesis predicts that all tokens of a given homonymous word in a discourse correspond to the same homonym. We validate the hypothesis on English SemCor (Section 4.1), taking each of its documents as a single discourse.

In the experimental evaluation, we compute the percentage of type-level instances that are consistent with the OHPD hypothesis. For each English word (i.e. lemma/POS pair) that appears in our homonym resource, we identify all its occurrences in the corpus. Each unique word/document pair constitutes a single instance. An instance is consistent with the OHPD hypothesis if and only if all of the occurrences of the word in the document represent the same homonym.

When a homonymous word occurs only once in a document, there is of course no possibility of an actual OHPD violation. However, we consider those instances to support the hypothesis as well, because the writer may have chosen to replace a homonym with one of its synonyms in order to avoid potential ambiguity.

The results of the evaluation are shown in Row 3 of Table 2. SemCor is divided into 352 documents, with an average of 642 sense-annotated open-class words per document. A careful analysis of the 14 apparent exceptions reveals that four of them are caused by sense annotation errors in SemCor (e.g., sharp bow of a skiff is annotated as “weapon for shooting arrows”), and one results from an error in the ODE clustering. The 9 actual exceptions involve the homonymous nouns ‘bank’, ‘lead’, ‘list’, ‘port’, ‘rest’, and ‘yard’, as well as the verb ‘lie’. We conclude that fewer than 0.5% of instances in SemCor contradict the OHPD hypothesis.

4.5 One Homonym per Collocation

The OHPC hypothesis predicts that only one homonym of a word appears in any given collocation. Due to the broad definition, wide variety, and large number of possible collocations, it is difficult to definitively establish the extent to which the OHPC hypothesis holds for a given corpus. Instead, we follow the methodology of Yarowsky (1993) and Martínez and Agirre (2000), who test the OSPC hypothesis by analyzing the performance of a supervised WSD system in which each feature corresponds to a distinct type of a collocation. The rationale is that the accuracy of the WSD system indicates the level of support for the hypothesis in the training corpus.

For the experimental evaluation, we adopt the IMS system of Zhong and Ng (2010). IMS learns a separate classification model for each ambiguous
word in the training data, with each class corresponding to one sense of the word. The system employs three types of features, which broadly correspond to different kinds of collocations: 1) the presence of specific content words in specific positions relative to the focus word; 2) the set of POS tags in the context of the focus word; 3) the presence of specific content words in the bag-of-words context of the focus word. We train IMS on English SemCor, and test on the concatenation of five benchmark datasets of Raganato et al. (2017).

The results of the experiment strongly support the OHPC hypothesis. The test set contains 528 occurrences of words from our homonym resource. Six of those words, each appearing in one instance, are not attested at all in SemCor. IMS selects a sense of the correct homonym in 506 out of the remaining 522 instances. Three of the 16 classification mistakes are attributable to errors in the ODE clustering, while two of them are due to the WordNet mapping issues that we describe in Section 4.2. Thus, the effective accuracy of IMS on the homonymous words in the test set is 97.9%.

Analysis of the remaining 11 errors made by IMS shows that their principal cause is insufficient training data. For example, the noun ‘match’ in the sense of “piece of wood” occurs only once in the entire SemCor corpus, which prevents IMS from reliably recognizing this sense. Other obvious mistakes, such as “follow the lead” misclassified as “metal,” are explained by the lack of training examples involving the collocations that occur in the test set. We conclude that the IMS accuracy on the test set should be interpreted as a lower bound for the applicability of OHPC.

4.6 One Homonym per Sense Cluster

We test our fourth hypothesis, OHPSC, by searching an existing resource for clusters that contain senses from distinct homonyms. Note that we cannot perform this experiment on the ODE clustering because we use it to derive our mapping from WordNet senses to homonyms (Section 3.3). Instead, we run it on the high-quality, manual OntoNotes clustering, which was used as a gold-standard by Snow et al. (2007). The clustering includes 439 of the 804 homonymous words that are listed in our homonym resource. Those words involve 2467 WordNet senses that are grouped into 1578 clusters, of which 1555 (98.5%) are found to involve only polysemous senses, as our hypothesis predicts.

We manually analyze the 23 clusters that appear to combine senses from distinct homonyms. The vast majority (21) of these apparent exceptions are artifacts of errors in the ODE clustering. Those errors, which were originally made by a clustering algorithm, are easy to spot by native speakers because senses within a single cluster clearly correspond to distinct coarse-grained senses in ODE. In the remaining two cases, OntoNotes clusters two pairs of homonymous senses: (1) the noun ‘tap’ as “the sound made by a gentle blow” and “a faucet for drawing water,” and (2) the verb ‘pose’ as “introduce” and “be a mystery to.” Even though we find these two clustering decisions somewhat debatable, we accept them as actual exceptions to our hypothesis. We conclude that the OHPSC hypothesis is corroborated in over 99.8% of the OntoNotes clusters.

5 Conclusion

We have investigated the concept of homonymy, formulating four hypotheses that follow a common pattern. Taken together, our hypotheses suggest that, figuratively speaking, homonyms seem to repel each other, like particles with the same electric charge. The experiments performed using our new resource confirm that distinct homonyms are rarely observed in connection with a single translation, discourse, collocation, or sense cluster. In addition, they demonstrate that contraventions of the empirical predictions made by our theory more often than not identify errors in the existing annotated data sets.

We envisage several directions for building upon the theoretical basis established in this paper. In order to extend our homonym resource, we plan to develop an operational method for identifying Type B homonyms on the basis of translation sets involving multiple languages. We anticipate that translations extracted from parallel corpora will facilitate the creation of high-quality coarse-grained sense inventories via sense clustering. As a step towards this goal, we will investigate the problem of automated mapping between senses and translations.
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