Representing Noun Compounds in Semantic Quad-Space

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1. Introduction

Every problem can be reduced to a translation problem. A bold statement – nevertheless, consider that mathematics is the art of translating abstract ideas into a precise language. Computer science has foundations in describing routines for computers to follow in machine language, and the search for better algorithms is simply translating the computation of a quantity from a less efficient process to a more efficient process. The ability to represent what an algorithm means is well-defined. We have the precise language of mathematics to account for all details.

The language with which we speak to each other, as humans, is however not precise. There are many ambiguities. Natural language interacts with reality, and is unavoidably influenced by many aspects of the universe that humans do not yet understand. Our modes of communication are unavoidably imprecise. The lack of precision is amplified by the fact that sometimes we ourselves do not know what we want to convey.

Yet it is very desirable to have a method for automatically and quickly parsing vast amounts of natural language, and understanding what is meant – to reduce the cascades of word phrases and punctuation into concrete, irreducible facts and inferences. Aside from being interesting for its own sake, natural language understanding has multitudes of applications to real world problems.

If computers were able to understand unstructured language, we would be able to build ontology networks of journal articles in the biomedical sciences, and make scientific knowledge more accessible to both researchers and laymen. We would be able to parse the news for the purpose of understanding the impact of world events on the financial markets; we would be able to overcome language barriers with automatic language translation. We would be well on our way to understanding the human mind.

Thus there is both academic and practical desire to solve the problem of representing meaning with numbers.

1.1. Philosophy of Meaning

How can we address the problem of representing concretely the abstract notion of meaning that humans seem to possess? There are two relevant hypotheses that pervade the natural language processing community.

The first is the distributional hypothesis, first posited by Harris in 1954. In short, word meaning is a function of the distribution of a word in all its contexts [**Harris1954**].

Second is the geometric metaphor of meaning. Born from a hypothesis that humans attach a notion of distance to similarity between concepts, the geometric metaphor of meaning posits that meanings are locations in semantic space, and semantic similarities can be represented by geometric distances [**Sahlgren2006**].

Together, these two notions enable the concept of a semantic vector space, which we will define shortly.

1.2. Definitions

Now we take an interlude for a few definitions that will be useful throughout the paper.

Corpus:

A corpus is a body of texts, usually in a single language. They can center around a certain mode of language (for instance, news writing, or blog posts, or television sitcom speech), or they can be inclusive of a whole variety of modes of language.

Semantic Vector Space:

A semantic vector space is a set of words mapped to a set of vectors in $\mathbb{R}^n$. Typically, it is represented as a matrix, where the rows are the individual words or word phrases, and the columns are contexts. This matrix is known as a **word-context** matrix. A context is any sort of pattern associated with the row word. Suppose the row word is "boat". One column context may be the seven words between "boat" and the appearance of the word "water". Another could be simply the word "water" appearing within a radius of 3 words from an instance of the row word "boat". The contexts can be very complicated or very simple. The values contained within a word-context matrix are frequencies. For instance, for the row word "boat" and the column context "water appearing within a three-word radius of the row word", the value in that row and column value of the word-context matrix would be the number of times the word "water" appears within a three-word radius of "boat".

A word-context matrix cannot be described without a corpus. In order to calculate the frequencies of the row words showing up in the various column contexts, we search the corpus for all the instances in which the row-column combination happen. Depending on the contexts, word-context matrices can often be very sparse, necessitating the application various transformations to the original word-context matrix.

Similarity of Words:

From a human's perspective, what does similar mean? In order to evaluate the computational model against real human semantics, we need some ground truth approximation. In this section, we describe and justify what a notion of similarity should be.

Similarity comparisons for a pair of single words depends on the types of word. If both words are nouns, what we may mean by 'similar' is something along the lines of a domain comparison. For instance, we might say that 'car' and 'bus' are similar, since they

are both vehicular modes of transport that both travel by land.

For adjectives (again, comparing a single adjective to another single adjective), the situation may be a bit different. Here we may be more concerned with the aspect the adjectives qualify. For instance, 'ugly' and 'beautiful' both qualify subjective judgements of aesthetic attractiveness. Synonyms and antonyms may both be considered similar.

The list goes on. In this paper, we seek to have a qualitative understanding of the human understanding of similarity between noun compounds, and then convert the qualitiative into the quantitative.

Noun Compound:

A noun compound is a compound word with two components, both of which are nouns themselves: the modifier and the head. For instance, the word "paper cup" is a noun compound with head "cup" and modifier "paper". The head is the base word. It is almost always true that a "paper cup" is a "cup". It is not necessarily true that a "paper cup" is "paper". For instance, consider the noun compound "heart attack". While a "heart attack" is an "attack", it is not a "heart". The modifier qualifies the sense in which the head word is taken to mean. In some cases, a noun compound is an idiom (for instance, a "fire sale" is not a sale of fire, but rather a sale where prices are extremely discounted).

1.3. Paper Objective

The goal of this paper is to provide a semantic vector space model for noun compounds. That is, to quantify the meaning of noun compounds and their interactions with other words and noun compounds. The metric of our success will be comparison to a human judgement of similarity between two noun compounds. Our first step must be to provide a quantitative representation for noun compounds. The second step must be to define an unambiguous method of calculating a similarity score between two such representations. We will have succeeded if together, the two parts of our model are able to reproduce human scores of similarity on pairs of noun compounds.

1.4. Motivation

Why do we focus on representing noun compounds specifically in this paper? First of all, the similarity of word phrases (of length n) is an necessary object to consider in the future study of the quantification of the meaning of language. Noun compounds are a simple case ($n = 2$), yet with sufficient complexities that provide interesting interrelationships between the components of the noun compound.

Noun compounds themselves are interesting in the literature for practical purposes. First of all, standard techniques do not work on them; they cannot be simply ignored in natural language processing (NLP) routines. They are important in machine translation, information retrieval, and information extraction, particularly in medicine, where there are many noun compounds (an example: human colon cancer cell line, which has many possible parsings [Nakov2013]). For a computer doctor, knowing how to comprehend these medical-term noun compounds would be a necessary skill.

1.5.   The Relation of Similarity to Meaning

As we have already noted, a primary goal of computational linguists is to create a computational model of meaning. As 'meaning' is an imprecise term [**Sahlgren2006**], how can we possibly check whether our models are sensical?

One approach, specific to vector-based models, is to cluster vectors and check whether the vectors in the clusters all belong to a certain ontological class. For instance, hierarchies like that of WordNet [**Fellbaum1998**] may be used. Or, if we note that all the words close by are related to the topic of government, we might also say they are similar.

Therefore, similarity is a useful concept in ascertaining whether or not the computational models we build actually map to real-world notions of meaning. Previously we defined a human notion of similarity with respect to words. In this paper, we are concerned with noun compounds, and so take this opportunity to extend our notion of the similarity between word phrases to noun compounds. We pause here to give a brief description of what is meant, and promise to go into more detail in following sections of the paper.

The clustering approach described above is one way of defining what we mean when we say two words are similar. The essence of the clustering definition of similarity boils down to a notion of geometric distance: When we cluster vectors, the vectors are nearby under some metric. Typically, the metric used is that of cosine distance (the dot product of the norms of the vectors).

Before, we were dealing with a single word – we had a vector space representing each word by a vector. What happens when we increase the number of words to two? To n? We need an approach that generalizes word similarities to phrase similarities. In order to arrive at a sensible definition, we must first consider what humans think of as similar sentences.

Computationally, the extension to phrase similarity can take two paths. First, vector compositions. Second, similarity compositions. We will be dealing with noun compounds in this paper, so we are concerned with the case $n = 2$, with the added special property that both words are nouns.

The vector composition approach generally tries to reduce the n vectors into either one vector, or a matrix of some form. Then the idea is to compare the resultant vectors/matrices.

In contrast, the similarity composition approach advocated in [**Turney2012**] tries to first come up with a similarity structure function between two phrases. That is, a function that takes in a set of distance comparisons between the words from first and second phrases, and then acts on them to produce a similarity measure. A similarity structure function allows for more variety in the methods of computing similarity than the vector composition approach when it results in a single vector. The vector composition into matrix approach may be equally expressive; however, the issue is that as n increases, the size and complexity of the representation become prohibitively large. For $n = 2$, there is not too much of problem.

In this paper we compare the dual-space model from [**Fyshe2013**] that uses vector

composition to a new quad-space model that uses similarity function composition.

1.6. Outline

We provide a brief outline of the remainder of the paper.

In **Building the Model**, we provide the methodology and reasoning behind the construction of the vector space model for noun compounds that we implement in this paper. First we briefly describe the space we are attempting to represent, and then plunge into the components of its representation. For each of the four distinct spaces, we describe how it is constructed and the associated rationale. We describe how to construct the final version of each of the spaces after producing each word-context matrix. Then we discuss functions that take as input the representations of two noun compounds and output a similarity measure. This is done in two parts: first we describe the notion of a similarity structure function, and secondly we describe the building blocks of the structure function, the similarity composition functions which compose similarities. Finally we describe the similarity functions we actually used.

We specify our testing scheme in **Model Evaluation**. First we explain the overall testing scheme for the vector space model we built, and how we chose the 99 noun compounds we tested. Then we describe how we acquired the responses from Mechanical Turk: the instructions given to the Turkers, the test data (noun compound pairs), and the actual generation of the responses. After that, we describe the way by which we parsed the data and turned it into a yes/no similarity scores for each noun compound pair. Then we describe which vector spaces we built from the **[Fyshe2013]** paper, and how we went about doing so. At the end, we explain both methodologies we used for scoring the vector space models.

The **Results** section first presents both sets of results, and explains them. We then list the errors each VSM model made.

We then finish the paper by discussing plans for **Future Work**, and providing some **Acknowledgements**.

Following the end of the paper are the four appendices: **Appendix A: Word-Context Matrix Processing Steps**, **Appendix B: Describing the Corpora**, **Appendix C: Implementation Details and Future Usage**, and **Appendix D: Error Data**. We finish with the **References**.

2. BUILDING THE MODEL

We build two versions of our quad-space model, one based on the Corpus of Contemporary American English [**COCA**], and the other based on the Corpus of Global Web-based English [**GloWbE**].

Note that the two models are the same in structure; their only differing feature is the corpus used to create them. In the tests, we will refer to the former as the COCA model, and the latter as the GloWbE model.
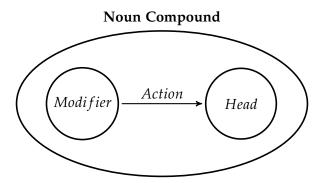
Noun Compound

Figure 1: *Components of the Noun Compound Model*

See **Appendix B: Describing the Corpora** for a more detailed discussion of the corpuses.

Using the COCA corpus, we picked 99 noun compounds to find representations for which we would test, which can be seen in **9.2**. We defer the discussion of how we chose them and why to the **Model Evaluation** section. There were a total of 106 distinct words in these noun compounds. Let $\mathcal{NC}$ describe the space of noun compounds, and $\mathcal{W}$ describe the space of distinct words.

2.1. The Quad-Space Model: An Overview

The component model of a noun compound is described in **Figure 1**. Our goal is to come up with a representation of the noun compound that accurately reflects these components. Then we need to describe a function that is able to output a similarity score for two noun compounds. Our approach is guided by the composition of similarities as opposed to vectors. The similarity function should take as input two representations of two noun compounds, and use the distances between various component pairs as inputs to a similarity structure function, which then composes the input similarities to output an overall similarity score.

Our representation for a single noun-compound will be a 5-tuple of vectors, the components of which live in four distinct vector spaces. We name the four component spaces (giving rise to the quad-space name in the title). They are the domain space $\mathcal{D}$, the action space $\mathcal{A}$, the qualifier-head space $Q_{\mathcal{H}}$, and the qualifier-modifier space $Q_{\mathcal{M}}$. We will provide a full definition in the following sections.

Our 5-tuple can be represented as follows: $(v_1, v_2, v_3, v_4, v_5)$. We have $v_1 \in \mathcal{D}$, $v_2 \in \mathcal{D}$, $v_3 \in \mathcal{A}$, $v_4 \in Q_{\mathcal{H}}$, $v_5 \in Q_{\mathcal{M}}$. v_1 is supposed to be a domain representation of the full noun compound (represented by all contained inside the oval in **Figure 1**). v_2 is a domain representation of only the head component of the noun compound. v_3 is a partial representation of the action component. v_4 is a partial representation of both the action component and the modifier component. v_5 partially describes the modifier component.

Now that we have this model for a noun compound in our minds, let us describe the individual spaces in more detail, and also justify the reasoning behind the quad-space

approach.

2.2. Domain Space $\mathcal{D}$

We take the idea of domain space from [**Turney2012**], and modify it slightly. In Turney's paper, the domain space is part of his dual-space model, and is supposed to represent the subject matter or domain of a word. For this paper, the rows of domain space are single-word nouns or noun compounds ($\mathcal{NC} \cup \mathcal{W}$), and the columns are the set of all nouns closest to the row-word in a window with some radius r. In our construction, we set $r = 4$ (this means our window is four words on both sides of the row-word). Labeling each word from 1 to 9, we seek to find the closest left noun with index i such that $5 - i > 0$ is maximal. For each window, we seek to also find the closest right noun with index j, such that $j - 5 > 0$ is minimal. The left and right nouns get added to the set of words in the columns, and we count frequencies.

The intuition here is that we want a representation of the subject matter of the noun compound, and often, we get a notion of subject matter from other nouns. We restrict the window size to be relatively small so that we stay within bounds and avoid picking up too much noise. We again restrict when we only pick the closest left and right words, to avoid picking up too much noise.

There were two resulting $\mathcal{D}$ spaces. Both $\mathcal{D}$ spaces had $99 + 106 = 205$ rows.

The COCA $\mathcal{D}$ space had 217438 columns, and the GloWbE $\mathcal{D}$ space had 188535 columns.

In our model for the noun compound, we use $\mathcal{D}$ two times: first to capture a representation of the head word, and secondly to capture the domain-meaning of the whole noun compound.

2.3. Action Space $\mathcal{A}$

In the Dual-Space Turney paper, there is a notion of function space [**Turney2012**]. Turney defines function space as intending to represent the relation between two words by using verb contexts. Verb contexts are patterns of words containing the row-word or row-phrase. A verb context might be 'rowed on X', where X is row-word. For instance, suppose that the row-word is 'water'. Then, it is likely that this value of the matrix has a non-zero frequency count, since rowing often takes place on water. The idea is that we can use verbs to understand the functional power of individual words. In Turney's paper, he goes on to calculate this function space for both words in his setup, and combines the similarities in different ways.

We take a slightly different approach, though we retain the notion of using verbs to characterize function. First we introduce the notion of an action for a noun compound. The action is the way the modifier acts upon the head word in the noun compound (see **Figure 1**). For instance, let us consider the noun compound 'air temperature'. We might **measure** the temperature of the air. There is a verb component to understanding the action of 'air' on 'temperature'. We seek to capture this component by looking at

windows of relatively large radius ($r = 14$). Inside this window, every time both words of a noun compound are in the window, we add all of the verbs in the window to the context columns. The phrase regarding 'air temperature' described above would reasonably occur, and we would add the word 'measure' to the column space.

There were two resulting $\mathcal{A}$ spaces. Both $\mathcal{D}$ spaces had 99 rows (we draw from $\mathcal{NC}$ only).

The COCA $\mathcal{A}$ space had 15566 columns, and the GloWbE $\mathcal{A}$ space had 15777 columns.

We use the $\mathcal{A}$ space one time in our noun compound expression, to capture a portion of the notion of the action of the modifier on the head. We can fill out the notion further by turning to adjectives, which we do now.

2.4. Qualifier-Head Space $Q_{\mathcal{H}}$

Turney mentions towards the end of his paper the notion of a quad-space as a possible route for future exploration in the development of semantic vector spaces [Turney2012]. We perform that extension in this paper by turning to adjectives.

The idea of the qualifier-head space is to provide a frame of reference for the modifier word of the noun compound by looking at the head. The modifier sometimes acts like an adjective on the head word of the noun compound. A pertinent example is 'stone bowl'. 'stone' acts like an adjective on bowl (consider 'grey bowl'). Therefore, knowing only the head of the noun compound allows us to gain some knowledge regarding the kinds of adjectives that are used upon it. That is the fundamental idea behind the qualifier-head space. We construct it by considering a half-window of radius $r = 3$ for each individual head word in the noun compounds– that is, we look at the 3 words behind the head word, and search for the closest adjective. Whatever the closest adjective is gets added to the column space.

This space is able to model the modifier to a certain extent (by the substitute words that are adjectives). However, it also contributes to the notion of the action. Verbs are not the only way we can represent the action of the modifier on the head. In fact, treating the modifier like an adjective is a more direct representation of action – a 'stone bowl' is **made of** stone: stone is the **material** (our qualifier) of which the bowl is made, just as 'grey' is the **color** of a 'grey bowl'. Thus, $Q_{\mathcal{H}}$ space can also be said to contribute to the representation of the action.

We use the $Q_{\mathcal{H}}$ space once in our representation of the noun compound: for a given noun compound, we include the $Q_{\mathcal{H}}$ representation of the head word in our 5-tuple.

There were two resulting $Q_{\mathcal{H}}$ spaces. Both $Q_{\mathcal{H}}$ spaces had 106 rows (we draw from $\mathcal{W}$ only).

The COCA $Q_{\mathcal{H}}$ space had 68216 columns, and the GloWbE $Q_{\mathcal{H}}$ space had 59168 columns.

2.5. Qualifier-Modifier Space $Q_{\mathcal{M}}$

We add a second adjective-based space. The qualifier-modifier space is intended to act as a sort of domain-esque model for the modifier word, but instead of being based on nouns, based on adjectives. As we have established, the modifier can sometimes behave like an adjective to the head word. Therefore, we can compare it to a bunch of adjectives that are nearby to develop a model of the kinds of adjectives the modifier is similar to. For instance, consider the phrase 'beautiful, luxurious marble bowl upon which were etched gorgeous scenes'. The $Q_{\mathcal{M}}$ model would then capture the fact that modifier noun 'marble' appears to be associated with the adjectives 'beautiful', 'luxurious', and 'gorgeous'. These are qualities of the descriptor. To build this space, we consider windows with size $r = 10$ around each modifier word, and add all adjectives in the range to the column space.

We use the $Q_{\mathcal{M}}$ space once in our representation of the noun compound: for a given noun compound, we include the $Q_{\mathcal{M}}$ representation of the modifier word in our 5-tuple.

There were two resulting $Q_{\mathcal{M}}$ spaces. Both $Q_{\mathcal{M}}$ spaces had 106 rows (we draw from $\mathcal{W}$ only).

The COCA $Q_{\mathcal{M}}$ space had 194522 columns, and the GloWbE $Q_{\mathcal{M}}$ space had 114466 columns.

2.6. Processing the Word-Context Matrices

After deriving the word-context matrix for a particular space, each matrix undergoes two transformations. First we do a ppmi transformation of the matrix, and then we do rank-k SVD on the matrix. We choose k by picking the first k singular values that explain 90% of the square-sum of the singular values, which is a standard choice in dimension reduction. We describe the theory behind and benefits of each of these processes in **Appendix A: Word-Context Matrix Processing Steps**.

We provide a list of the resulting dimensions of each space here. The number of singular values kept after dimension reduction is the number of columns in the vector representation.

COCA $\mathcal{D}$: We kept 105 singular values.
GloWbE $\mathcal{D}$: We kept 113 singular values.
COCA $\mathcal{A}$: We kept 50 singular values.
GloWbE $\mathcal{A}$: We kept 48 singular values.
COCA $Q_{\mathcal{H}}$: We kept 78 singular values.
GloWbE $Q_{\mathcal{H}}$: We kept 80 singular values.
COCA $Q_{\mathcal{M}}$: We kept 79 singular values.
GloWbE $Q_{\mathcal{M}}$: We kept 83 singular values.

Note that the GloWbE spaces often ended up having similar dimensions to the COCA space (and sometimes, the original word-context matrix even had fewer columns!), despite the approximate 4 times increase in size, which suggests that the patterns used to generate the columns may have been sparser in the GloWbE corpus.

2.7. Similarity Structure Functions

Now we have defined our four spaces $\mathcal{D}, \mathcal{A}, Q_{\mathcal{H}}, Q_{\mathcal{M}}$. Recall from before we represent a noun compound with a 5-tuple.

Let us call a given noun compound as the tuple (a, b), where a is the modifier word and b is the head word. Then, our representation of the noun compound is given by

$$\mathbf{rep}((a, b)) = \{\mathcal{D}[a, b], \mathcal{D}[b], \mathcal{A}[a, b], Q_{\mathcal{H}}[b], Q_{\mathcal{M}}[a]\} \qquad (1)$$

For future reference, let $\mathbf{proj}(R, i)$ be the projection function that takes in a representation R and an index i and returns the ith term of the representation. Note that $i \in [5]$.

Importantly, this representation of the noun compound is asymmetric: That is, $\mathbf{rep}((a, b)) \neq \mathbf{rep}((b, a))$ due to the usage of $Q_{\mathcal{H}}$ and $Q_{\mathcal{M}}$. Asymmetry is desirable since it is rarely ever true that inverting the head and modifier of a noun compound create a similar noun compound (or even a sensical one). For example, consider 'death wish' and its inversion 'wish death'. A 'death wish' is a 'wish to die', and while 'wish death' is probably much less frequent, could mean something along the lines of 'the death of a wish', which is a different meaning entirely.

Now our goal is to find a function $F : \mathcal{NC} \times \mathcal{NC} \to \mathbb{R}$ that evaluates the similarity of two noun compounds. We will generally refer to the first noun compound in the input to F as (a, b) and the second noun compound in the input to F as (c, d), where a, c are modifiers and b, d are heads.

At this point, there are two approaches we could take: the vector composition approach (taken in [**Fyshe2013**]) or the similarity composition approach (taken in [**Turney2012**]). We choose to take the similarity composition approach. What we mean by this approach is that effectively, F is transformed into a function of type $f : \mathbb{R}^k \to \mathbb{R}$. The input to f is k real values. The k real values are derived by computing distances from components in $\mathbf{rep}((a, b))$ to components in $\mathbf{rep}((c, d))$. We make this explicit in the following equation:

$$F((a, b), (c, d)) = f(l_1, ..., l_k) \qquad (2)$$

where l_i, $i \in [k]$ are the distance, or length values. Two questions now arise: First, how do we compute length? Second, which lengths do we choose as the input to f?

The answer to the first question is cosine distance. It is the most widely used measure of distance in the literature because it is agnostic to magnitude [**Turney2010**]. We are only interested in vectors that are nearby each other angle-wise, or clusters. We make a slight modification of the standard definition: typically, the range is $[-1, 1]$. We modify the function so that if the output is ≤ 0, the output is 0, thus changing the range to $[0, 1]$. We implement this cutoff so that we never have negative terms in our distances. This feature is desirable because negative similarities do not really make sense: either two noun compounds are similar, or they are not. Similar and dissimilar things do not cancel each other out algebraically the way opposites do. In fact, opposites may be considered

similar in the geometric clustering! Therefore, we consider all negative similarity values to mean dissimilar, and set them to 0. The distance function is therefore defined as

$$\mathbf{dist}(\mathbf{v}_1, \mathbf{v}_2) = \begin{cases} \cos(\mathbf{v}_1, \mathbf{v}_2) = \dfrac{\mathbf{v}_1}{||\mathbf{v}_1||} \cdot \dfrac{\mathbf{v}_2}{||\mathbf{v}_2||} & \text{if } \cos(\mathbf{v}_1, \mathbf{v}_2) > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

We will use this measure throughout the rest of the paper: Every time we refer to a distance or length between components of noun compound representations, we will mean the cosine distance. Therefore, note that all lengths and distances are non-negative and in the range $[0, 1]$.

The second question is a bit trickier, and is subject to more creativity. We want to only use the l_i that capture meaningful comparisons between the two noun compound representations. In some cases that might involve cross-terms, as in [**Turney2012**]. However in this paper, we use no cross-terms and only do component-to-component distances. That is, we have precisely 5 distances.

$$l_i = \mathbf{dist}(\mathbf{proj}(\mathbf{rep}(a, b), i), \mathbf{proj}(\mathbf{rep}(c, d), i)) \text{ for all } i \in [5] \tag{4}$$

Now we know the inputs to f, we can define it. Henceforth f shall be known as the similarity structure function, for it tells us how to put together the component similarities to derive the total similarity between two noun compounds.

It is desirable that the structure function follow some rules. We draw from Turney's rules for his structure functions, and add some modifications [**Turney2012**].

The rules that f must satisfy are given by

$$f((a, b), (c, d)) \neq f((b, a), (d, c)) \tag{5}$$

$$f((a, b), (c, d)) = f((c, d), (a, b)) \tag{6}$$

$$f((a, b), (c, d)) \neq f((a, b), (d, c)) \tag{7}$$

$$f((a, b), (c, d)) \neq f((a, d), (c, b)) \tag{8}$$

For the most part, these are identical to those of Turney's with the exception of the first equation. Turney's paper does not focus on noun compounds when dealing with pairs of words. As we saw before, it is not in general true that inverting a noun compound produces a noun compound with a similar set of relations. Therefore, we are more strict. We have already accounted for **Equation 5** when we added our two qualifier spaces: they ensure that the order of terms of the noun compound matter. Similarly, the qualifier spaces solves **Equation 7**. **Equation 8** simply says that we cannot simply swap head words – this rule is inherent in the whole representation of the noun compounds. We must therefore be only careful to follow **Equation 6**, which leaves the noun compounds alone and focuses on the structure of the function itself.

2.8. Similarity Composition Functions

Before we finally describe f, we introduce the notion of similarity composition functions. A similarity composition function g takes as input n lengths $l_1, ..., l_n$ and outputs a unified similarity $l_{composed}$. At first glance, this definition is identical to the previously defined f. We make the distinction as follows: Similarity composition functions will be used as building block tools *inside of* f. In other words, in the structure function, multiple complicated functions are allowed to be used, while for composition functions, we will identify only one function. This setup allows for ease of expression when we describe a structure function in terms of block-like composition functions.

There are two composition functions we use to form our overall similarity function. The first we borrow from [**Turney2012**]: we call it the truncated geometric mean (TGM). We have

$$\mathbf{tgm}(l_1, ..., l_n) = \begin{cases} \left(\prod_{i=1}^{n} l_i\right)^{\frac{1}{n}} & \text{if } l_i > 0 \text{ for each } i \in [n] \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

The idea behind this function is that the combined similarity should be high when component similarities are high, and low when component similarities are low. [**Turney2012**].

Turney notes that there is no set-in-stone reason that this should be the only similarity composition function used, so we also define our own composition function, called the weighted sigmoid arithmetic mean (WSAM). It is defined in two parts. First, we take the arithmetic weighted mean of the input lengths (let the vector with values l_i be defined as $\mathbf{l}$), with respect to some weight vector $\mathbf{w}$. The values of the weight vector must be all non-negative and must sum to 1. Then, we feed the mean to a sigmoid function with a range $[0, 1]$. The idea is we take the mean to get a different estimate of the average from the geometric mean, and then using some guesses regarding the distribution (i.e., we would think that more noun compound pairs are not similar than similar), set a threshold after which the similarity score will spike and flatten to 1 asympotically. A sigmoid function also encapsulates a lower threshold, below which point the similarity score flattens to 0.

$$\mathbf{wsam}(\mathbf{l}, \mathbf{w}) = \frac{a}{a + c * e^{-b(\mathbf{l} \cdot \mathbf{w})}} \tag{10}$$

for some parameters a, b, c.

The specific sigmoid function was given by the equation the parameter choices $a = 0.00007, b = 20, c = 4$, which was found after playing around with parameters. The idea was that we wanted the threshold for having high similarity to be larger than 0.6. The function is plotted in **Figure 2**.
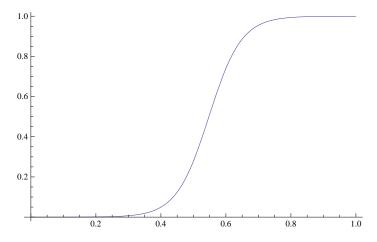
Figure 2: *Plot of the Sigmoid Function*

2.9. Putting Structure and Composition Together

In this section, we describe the similarity functions we test.

We will call the first similarity function **tgm-vanilla**. In this function, we simply return tgm applied to all of the 5 lengths. It is titled vanilla because of how simple it is. Recall that $l_1, ..., l_5$ are the component-wise distances defined for each of the five components that make up the representation of a noun compound.

$$\textbf{tgm-vanilla}((a,b),(c,d)) = \textbf{tgm-vanilla}(l_1, ..., l_5) = \textbf{tgm}(l_1, ..., l_5) \tag{11}$$

The second similarity function we call **weighted-sim**. Based on our understanding of each of the components, we assigned a weight vector for the noun compound structure: $\mathbf{w}_{nc} = \{0.05, 0.2, 0.35, 0.25, 0.15\}$. That is to say, we gave the least importance to the domain of the whole noun compound with a weight of 0.05, assigned a significant amount of weight to components that influence the action of the noun compound (0.35 for $\mathcal{A}$, 0.25 for $Q_{\mathcal{H}}$), and then some weight to domain space for the head 0.2 and a little less weight (0.15) to $Q_{\mathcal{M}}$. The idea was to weight the action the most, and the individual components a fair amount. We assigned the least weight to the domain of the whole structure because the idea is that noun compound similarity depends a lot on the interaction between modifier and head. Thus we simply have

$$\textbf{weighted-sim}((a,b),(c,d)) = \textbf{weighted-sim}(l_1, ..., l_5) = \textbf{wsam}(\{l_1, l_2, l_3, l_4, l_5\}, \mathbf{w}_{nc}) \tag{12}$$

We now introduce the term *linking structure*. A linking structure is a diagram of a comparison of two objects with the same components. Double-sided arrows are drawn between components that are compared. We also label these arrows with the space in which the comparison is happening. $\mathcal{X}\uparrow$ indicates a relation in the space $\mathcal{X}$ where high similarity is desirable.
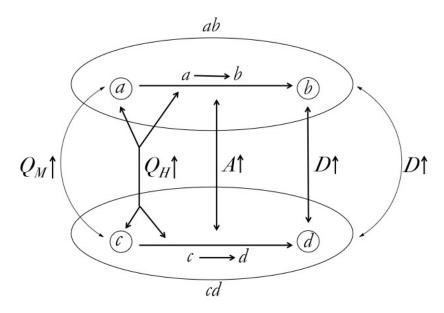
13

Figure 3: *Linking Structure*

We describe a linking structure when comparing a pair of noun compounds in **Figure 3**.

The last similarity function we test we will call **component-sim**. The idea in this function is to follow the linking structure to build component similarities, which we then combine with some composition function. First we combine $\mathcal{A}$ and $Q_{\mathcal{H}}$ with **tgm** to form a function block. Then we combine $Q_{\mathcal{H}}$ and $Q_{\mathcal{M}}$ with **tgm** to form a modifier block. Then we build a noun compound block by first combining the head representation in $\mathcal{D}$ with the modifier block, and then combining that block with the noun compound domain representation to form a total domain block. We return finally a weighted average of the function block and the total domain block, with weights 0.8 and 0.2 respectively. Note that we re-use components: this is ok! The approach we follow here demonstrates the power of using similarity function composition to build a realistic idea of what is going on. The function is given by

$$
\begin{aligned}
\textbf{component-sim}((a,b),(c,d)) &= \textbf{component-sim}(l_1,...,l_5) \\
&= 0.8\textbf{tgm}(l_3,l_4) + 0.2\textbf{tgm}(d_1,\textbf{tgm}(d_2,\textbf{tgm}(d_4,d_5)))
\end{aligned}
\tag{13}
$$

3. Model Evaluation

To evaluate our semantic space models, we require three things: First, a set of noun compound pairs to evaluate the similarities of. Second, a groundtruth dataset of human-decided similarities between these noun compound pairs. Finally, another set of models from a previous paper so that we can compare our approach to those of other researchers

on the same dataset.

We collect our groundtruth dataset from Amazon Mechanical Turk, a website set up to provide human-survey data. The process that occurs is as follows: Survey tasks are provided to a set of workers, known as Turkers. In this case, the survey tasks are pairs of noun compounds, with a request for a classification (similar, not similar, very similar, or unknown). Each Turker thinks about each task (with his/her own human brain). Amazon gets paid a fee for providing the service, and Turkers are paid for each task they complete at a fixed rate.

Using Mechanical Turk to collect this sort of human-survey data has been compared to in-person approaches to gathering survey data, and been found to measure up [Schnoebelen2010].

We get a comparison vector space model from [Fyshe2013], who provided theirs on the internet for download. The Fyshe VSM contains vectors of single words, so composition functions were needed to generate a Fyshe representation for noun compounds. We followed the instructions of their paper to create the vector compositions used.

We then process the Mechanical Turk data to come up with a human-approved similarity rating for each noun compound pair. We simply iterate over all the noun compound pairs and compare each model's similarity score to the human similarity score, and assess each model based on the percent correct (where correct means 'matches the human score').

3.1. Set of Noun Compound Pairs

First we describe how we chose our noun compounds. We picked 99 distinct noun compounds since the number of noun compound pairs resulting is $\binom{99}{2} = 4851$, a number that was within budget to acquire Mechanical Turk answers for. The specific noun compounds used can be viewed in the **List of Noun Compounds Used**.

The way we chose these 99 noun compounds was based on the words in COCA. We looked at the set of noun compounds with frequencies strictly larger than 100 in COCA, and then sorted them into groups by head and by modifier. We then looked at the heads and modifiers with the highest frequencies, and chose from the batch of the top 50 largest head frequencies, and the top 50 largest modifier frequencies. For each head, we chose around $5 - 10$ noun compounds based on the number of noun compounds there were for a given head. We filled in the first 50 of 100 noun compounds in this way. Likewise, for the latter 50, we chose $5 - 10$ noun compounds depending on the number of noun compounds for a given modifier. The noun compounds we chose from each head/modifier were chosen with the intent of having some similar relationships, and some different relationships (across each head/modifier). We also sought to avoid overly generic nouns (like 'system' and 'use'). We then verified that these noun compounds were present in GloWbE and the Fyshe VSM.
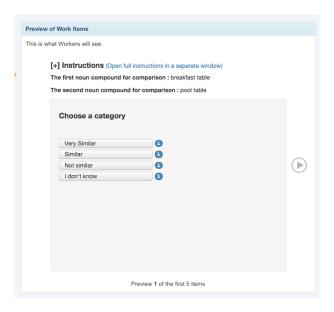
Figure 4: *Sample Mechanical Turk HIT*

3.2.   Building the Mechanical Turk Dataset

In order to provide the Turkers with tasks, we had to first define each task. Each task, or HIT in Mechanical Turk lingo, was a single noun compound pair with a single question, "Is the noun compound pair similar, not similar, very similar, or unknown?", presented in multiple choice format. The nature of Mechanical Turk is that it does not allow you to cleanly specify on one page more than one multiple-choice question. In the interest of making the HITs very clear to the Turkers, we left each HIT as containing a single noun compound comparison task. A sample HIT is presented in **Figure 4**.

We also had to provide the Turkers instructions on how to complete each HIT, which primarily constitutes defining what we mean by similarity between noun compounds. We do not want to give a definition of similarity that permits the Turkers to use an algorithm to find if two noun compounds are similar, for that defeats the purpose of using similarity as a measurement of the ability of the computational model to capture a sense of meaning. We want to know what their gut feeling regarding similarity is as well, and we want to avoid influencing them too much. However, it is no good if every Turker decides their own meaning of the notion of similarity between noun compounds. We need some common ground, so we provide a holistic description of what two noun compounds being similar means. We provided the instructions shown in **Figure 5** to the Turkers.

The inherent difficulty in leaving some leeway in what is meant by similar is that we cannot flat out reject the Turkers' responses so easily without knowing their justification. It is also hard to tell then whether or not the Turkers took their job seriously. To mitigate these concerns, we employed master Turkers (which must be earned by consistently getting > 99% of their work approved) for a slight extra cost. In order to ensure we got different people from perhaps different parts of the world, and not a homogenous Turker

Instructions

You will be provided with a pair of noun compounds. A noun compound has a head and a modifier. For instance, the noun compound "paper cup" has the modifier "paper" and the head "cup".

The goal of each task is to compare the noun compounds in each pair. We want to know if you think they are similar. What does similar mean? Consider the pair ("brain surgeon", "kidney specialist"). We might say these noun compounds are very similar because each is an expert ("surgeon", "specialist") in a part of the body ("brain", "kidney"). Thus, these noun compounds are very similar. Another example of a very similar noun compound pair is "paper cup" and "plastic bowl": Both are vessels for eating/drinking made of a certain material.
Finally, a "stone bowl" and a "wood staff" would be considered only similar: even though bowl and staff are not directly related, a "stone bowl" is a bowl made of the material stone, and a "wood staff" is a staff made out of the material wood.

Essentially, noun compounds are similar if the modifiers act in similar ways on the head, and are very similar if the heads are also related in some classification ("cup" and "bowl" are containers for food and drink).

An example of two noun compounds that are not similar could be "car sale" and "plastic cup". The notion that a car sale is a "type" of sale and that a plastic cup is a "type" of cup is not enough to say that these noun compounds are similar. A "car sale" is not a sale made out of cars the way a "plastic cup" is a cup made out of plastic. An example of two noun compounds that share the same modifier that are not similar is ("paper cut", "paper cup"): A paper cup is a cup made of paper, while a paper cut is a cut given by paper, not a cut made out of paper. An example of two noun compounds that share the same head that are not similar is ("drinking cup", "paper cup"). A drinking cup is a cup used for drinking, while a paper cup is not a cup used for paper – it is a cup made out of paper.

Selection Criteria

Category	Include	Exclude
Very Similar	noun compounds are very similar if the modifiers act in similar ways on the head, and if the heads are related as well.	a punch line and a telephone line both being "types of" lines is not enough to say they are very similar.
Similar	if the modifiers act on the heads in similar ways (stone bowl, wood staff).	very similar cases: please indicate if the noun compound is very similar separately.
Not similar	if the modifiers act on the heads in different ways (paper cut, paper cup).	the very similar case and the similar case. only choose not similar if the modifiers act on the heads in different ways.
I don't know	only when you truly are unable to figure out if the noun compounds are similar.	most of the time. usually there should be a classification you can perform.

Figure 5: *Instructions provided to the Turkers*

population, we ran the Mechanical Turk experiments at different times of the day. We also performed sanity checks to ensure that the majority of the responses were not answered 'unknown' as an easy way to make money. We also checked the average time to complete each HIT to ensure we were not getting ridiculously quick clickers. If the Turkers spent more than a few seconds on each HIT, we deemed the HITs acceptable since spending ten seconds or more at least suggests that thought was put into completing each HIT.

We wanted to ensure that for each noun compound pair, at least three distinct Turkers had looked at it and assigned a similarity rating. Thus we needed to upload to Mechanical Turk the same set of HITs at least three times. The average times to complete a HIT were 46 seconds for the first time we ran the dataset on Mechanical Turk, 21 seconds for the second time, and 22 seconds for the third time. We also had to block workers in order to get the minimum of three different Turkers to review the same HIT. Some Turkers who responded to the same HIT more than once sometimes responded with different replies (i.e. the first time the Turker said a certain pair of noun compounds was similar, and the second time the same Turker said the pair was not similar!). We called these Turkers 'bad Turkers' and needed to replace all of their work.

For each of the bad Turkers, we did repeat runs in order to replace their work. The first time we did this, the average time to complete each question was 92 seconds, which means the Turkers spent more time on each question. The second time, it was 39 seconds. The third time, it was 13 seconds. If a bad Turker answered a question only twice, we ran the noun compound pair on Turk two more times. If a bad Turker answered a question three times, we ran the noun compound three more times (to completely replace the Turker's work). There was only one Turker who answered multiple questions three times,

and they were also a bad Turker. For the Turkers who answered the same question twice that were not bad Turkers, we kept their answer and just ran the question another single more time to get a new response so that we would have three distinct responses for each noun compound pair. We also classified 268 noun compound pairs ourselves to get a feel for the task and to fill in gaps so that we would have a minimum of three different human ratings for each noun compound.

However, we retain some confidence in the accuracy of the Mechanical Turk results despite some of the mishaps. When we blocked the Turkers, some of the Turkers emailed asking for reasons why their work was rejected, and provided their detailed reasoning for choosing particular answers. So it appears that at the very least a few of them were very earnest and attempting to do a good job.

After we received at least three classifications from distinct humans, we needed to determine what the final classification was. The number of distinct Turkers who answered per noun compound was between 3 and 6 inclusive. There were only four possible classifications. If all classifications were the same, then we did not have to do any extra work. Otherwise, we looked at the classification that the largest percent of the Turkers answered with. If this value was larger than 50%, then that was the classification used. If not, then if any of the Turkers had answered that the noun compounds were very similar, this distinct was removed and very similar was treated as similar. We recalculated the classification that the largest percent of Turkers answered with. If it was still less than 50%, then we said that we did not know what the human classification of the noun compound was.

3.3. Describing the Mechanical Turk Dataset

We provide the statistics of the Mechanical Turk datset below:

```
Mechanical Turk Test Set Statistics:
How many noun compound pairs for each class?
Not similar = 4380
Unknown = 90
Similar = 376
Very similar = 56

% Not Similar: 89.3%
% Unknown: 1.8%
% Similar: 7.7%
% Very Similar: 1.1%
```

Listing 1: *Mechanical Turk Dataset Statistics*

3.4. Building the Fyshe Vector Space

We downloaded Fyshe's VSM from the website specified in [**Fyshe2013**]. The VSM came in a Matlab file, in which were encoded a matrix with 55000 rows and 2000 columns.

The first 1000 columns specify Document space, and the second 1000 columns specify Dependency space. Document space is created by finding word counts in individual documents drawn from the 50 million document ClueWeb09 data set, and Dependency space represents each word with a vector where each column is a context in which the word appears (for instance, for word w, the word w is the subject of the verb 'eat') [Fyshe2013]. The rows are nouns and adjective noun phrases.

One task Fyshe et. al addressed was using the VSM to decide if two adjective-noun phrases were similar, compared against a groundtruth dataset of human assessments, which is very similar to the noun compound similarity task (the only differences are noun compound versus adjective-noun, and the fact that they used a Likert scale of $1-7$ instead of the $-1, 0, 1, 2$ scale we used).

Their best results on this task used vectors built from the first 25 Document columns concatenated with the first 600 Dependency columns to represent individual words. To assess phrase similarity, Fyshe et. al used vector composition instead of similarity composition. Fyshe found that the two best approaches for vector composition were quite simple: a vector sum of the phrase components, and a dilated vector sum of the phrase components. The dilated vector sum is just a vector sum with the adjective vector multiplied by a factor of $\gamma = 16.7$, derived based from previous work.

We implemented these two approaches for comparison purposes.

3.5.   Testing Procedure

To evaluate our semantic vector models, we calculated a model similarity score and the Turk classification for each noun compound pair. The model similarity score was in the range $[0, 1]$. If the score was ≤ 0.4, the model classification was designated 'not similar'. If the score was < 0.4 and ≤ 0.6, the model classification was designated 'unknown'. If the score was > 0.6 and ≤ 0.9999, the classification was 'similar'. Finally, if the score was > 0.9999, the classification was 'very similar'. This translation from similarity score to classification was based on the principle that there should be a small window around 0.5 which should be considered too unclear to tell. We made that window symmetric and with radius 0.1. Therefore, for each model and for each noun compound pair, we had a model classification and a Turk classification. If either of the classifications was 'unknown', then we skipped that noun compound pair. Otherwise, we checked if the two classifications were the same. If they were the same, we recorded the model as getting the correct response on that noun compound pair. Otherwise, we recorded the model as getting the incorrect response on that noun compound pair. Then we sorted the models by the percentage of noun compound pairs they solved correctly.

Since there are large number of 'not-similar' ratings, we also examined the how the models perform over the subset of the Turk dataset for which Turkers rated the noun compound pairs as 'similar'. We performed exactly the same steps as before, just with a reduced list of noun compound pairs.

Finally, we examined the errors each model made and analyzed them manually.

4. RESULTS

We discuss the general meanings of the rankings of the vector spaces for the Fyshe, COCA, and GloWbE models.

4.1. Results

Here we have the results for all vector space models.

```
Mechanical Turk Test Results


Ranked by % correct on all noun compound pairs:

--------------------------------
Fyshe Dilation Model:
# Correct: 4252
# Incorrect: 396
# Skipped: 254
--------------------------------
Fyshe Sum Model:
# Correct: 4313
# Incorrect: 389
# Skipped: 200
--------------------------------
COCA Weighted Model:
# Correct: 4384
# Incorrect: 385
# Skipped: 133
--------------------------------
COCA Vanilla Model:
# Correct: 4369
# Incorrect: 385
# Skipped: 148
--------------------------------
GloWbE Weighted Model:
# Correct: 4378
# Incorrect: 389
# Skipped: 135
--------------------------------
GloWbE Component Model:
# Correct: 4358
# Incorrect: 385
# Skipped: 159
--------------------------------
COCA Component Model:
# Correct: 4360
# Incorrect: 384
# Skipped: 158
--------------------------------
GloWbE Vanilla Model:
# Correct: 4350
```

```
# Incorrect: 381
# Skipped: 171
#####################################
Summary (sorted by % correct):
---------------------------------
COCA Weighted Model: 89.4328845369%

GloWbE Weighted Model: 89.3104855161%

COCA Vanilla Model: 89.1268869849%

COCA Component Model: 88.9432884537%

GloWbE Component Model: 88.9024887801%

GloWbE Vanilla Model: 88.7392900857%

Fyshe Sum Model: 87.984496124%

Fyshe Dilation Model: 86.7401060792%

Ranked by % correct on noun compound pairs that Mechanical Turk labeled
    'Similar':

---------------------------------
Fyshe Dilation Model:
# Correct: 81
# Incorrect: 337
# Skipped: 14
---------------------------------
Fyshe Sum Model:
# Correct: 125
# Incorrect: 262
# Skipped: 45
---------------------------------
COCA Weighted Model:
# Correct: 85
# Incorrect: 317
# Skipped: 30
---------------------------------
COCA Vanilla Model:
# Correct: 9
# Incorrect: 382
# Skipped: 41
---------------------------------
GloWbE Weighted Model:
# Correct: 82
# Incorrect: 320
# Skipped: 30
---------------------------------
GloWbE Component Model:
# Correct: 52
```

```
     # Incorrect: 337
95   # Skipped: 43
     ------------------------------------
     COCA Component Model:
     # Correct: 52
     # Incorrect: 337
100  # Skipped: 43
     ------------------------------------
     GloWbE Vanilla Model:
     # Correct: 5
     # Incorrect: 377
105  # Skipped: 50
     ####################################
     Summary (sorted by % correct):
     ------------------------------------
     Fyshe Sum Model: 28.9351851852%
110
     COCA Weighted Model: 19.6759259259%

     GloWbE Weighted Model: 18.9814814815%

115  Fyshe Dilation Model: 18.75%

     GloWbE Component Model: 12.037037037%

     COCA Component Model: 12.037037037%
120
     COCA Vanilla Model: 2.08333333333%

     GloWbE Vanilla Model: 1.15740740741%
```

Listing 2: *Performance of the VSM Models*

We have two sets of results: results over all the noun compound pairs, and results over only the similar-Turk-ranked noun compound pairs. We denote the former as the comprehensive test set, and the latter as the similar-only testset.

We first note that there is very small variation in the scores in the comprehensive set $(86.7\% - 89.4\%)$ compared to the similar-only testset $(1.1\% - 28.9\%)$. A possible reason for this result is the large number of noun compounds ranked not-similar. The models all seem to be biased towards ranking not-similar, and thus do well at that job, but not quite as well on the similar-only task.

All our models performed better than the Fyshe VSM models did when we consider the whole noun compound pair testset, with the winner being the COCA Weighted model, followed close behind by the GloWbE Weighted model. The COCA Vanilla model came close behind, followed by the Component Models, with GloWbE Vanilla model performing the worst of our models. However, again, this result may only be an indication of a stronger bias in our models towards rating 'not similar', especially since the model that used the least amount of the structure developed got the best score.

It is also worth noting that the Vanilla Models are more biased towards giving a 'not similar'response, since the way they are constructed requires only one component of the model to have a score of 0 to send the whole similarity score to 0. Since there is no weighting, a very high score in one component may not outperform middle-low scores in all the other components, even if the component that has the high score is an action-space component. It is also interested to note that the COCA versions outperformed their GloWbE counterparts in all cases. The reason for this remains to be seen. However, the fact remains that the performances were all very similar. What we can conclude is that COCA seems to perform at least equally as well as GloWbE on this dataset for the similarity functions used.

Thus we turn our attention to the similar-only testset. The choice of corpus did not seem to affect the performance of our models very much for each choice of type of model. The Fyshe Sum model performed the best on this portion of the corpus with a score of 28.9%. This model was the better of the two in the original Fyshe paper as well. The COCA Weighted and GloWbE Weighted performed the best of our models and succeeded at beating the Fyshe Dilated Sum model, weighing in at 19.6% and 19.0% respectively. The Fyshe Dilated Sum model was close behind at 18.8%. The COCA and GloWbE Component models are next with scores of 12.0% and 12.0% respectively. Finally at the very end, the COCA Vanilla and GloWbE Vanilla models had scores of 2.1% and 1.1% respectively. In the similar-only task, the COCA and GloWbE models for each type of model (Vanilla, Component, Weighted) perform very similarly, with COCA being only slightly better than GloWbE on all models. This result is not surprising due to the fact that COCA and GloWbE had similar vector spaces dimension sizes, though of course the columns may have had different contexts. Since GloWbE was such a large corpus however, it is likely that a fair portion of the column contexts were the same or very similar, especially since the SVD step of dimension reduction culled a lot of the low-frequency contexts. This result suggests that more creative uses of the columnspace need to be made in order to gain more from size-increases in the corpus used.

In the similar-only task, it becomes evident that the approach used for the similarity structure function is crucial in determining whether or not a noun compound pair is similar. The weighted and component models significantly outperformed the vanilla model, suggesting that the machinery built into those two models is doing some work to distinguish similar from not-similar noun compound pairs. It appears that the type of model used, not the corpus is the significant feature in the models we constructed.

4.2. Errors Made

For a list of all the errors made by each VSM, see **Section 10**.

5. FUTURE WORK

This project has a lot of extensions that could be pursued as future work.

5.1. Improving the Model: Parameter Learning

One thing we could attempt to improve the model is the implementation of parameter tuning. There are multiple parameters we could have fiddled with but did not. The first is the p parameter used in [**Turney2012**]. The singular value matrix resultant from the SVD is raised to the pth power, and grid search is performed to optimize the value to get the best row vectors for comparison. In this paper we simply set $p = 1$. In that paper k, the number of singular values, is chosen in a similar manner. In this paper we chose the popular adhoc rule of retaining singular values until we have explained at least 90% of the square-sum of singular values.

For the Weighted Model, we could also attempt to optimize the parameters of the sigmoid function, either by using a method along the lines of grid-search, or by potentially utilizing neural nets to learn the best function. We can also extend this approach to learning the weights in the weighted model. The weighted similarity structure function (see **Equation 12**) therefore generalizes itself well to unsupervised learning procedures, which could be an interesting approach to take to develop more similarity functions.

5.2. Improving the Mechanical Turk Test Set

We believe the test set we use could also be improved if there were more funding to test more noun compound pairs. We could also increase the number of distinct Turkers who provide classifications for each noun compound pair. Ideally, we could also get more feedback regarding the task description (see **Figure 5**). Finally, an interesting approach to human survey data collection is provided by Crowdflower, which provides quality control for these kinds of surveys.

5.3. More Experiments

There are also more experiments we can do with our VSMs. We list a few of them below:

1. Build and test vector composition models in addition to similarity composition models with our VSMs.

2. Explore the clustering properties of quad-space vectors.

3. Test our model on other established datasets: particularly, WordSim-353, a standard dataset that includes human similarity judgements on pairs of words would be interesting [**Huang2012**].

4. Construct more of our own different data sets to test: instead of from Mech Turk, use WordNet to generate noun pairs that would be considered similar [**Fellbaum1998**].

5. Compare the VSMs we generated to each other, and see if they rate words the same or differently. Possibly, also implement a majority model that does a majority vote across a few of the models that we created (for instance, pick the most common classification across the Vanilla Model, the Component Model, and the Weighted Model).

6. Acknowledgements

7. Appendix A: Word-Context Matrix Processing Steps

7.1. Pointwise Positive Mutual Information

ppmi is a smoothing technique applied to a word-context matrix. We apply the **pmi** function to each element of the word-context matrix. If the **pmi** value is ≤ 0, we set the value of the matrix at that location to 0.

We have the definition of the **pmi** function below:

$$\mathbf{pmi}_{ij} = \log\left(\frac{p_{ij}}{p_{i*}p_{*j}}\right) \tag{14}$$

Here, p_{ij} is the estimated probability that word w_i occurs in context c_j, p_{i*} is the probability of the word w_i, and p_{j*} is the probability of the context c_j [**Turney2012**].

7.2. Singular Value Decomposition and Rank-*k* Approximation

One of the most important aspects of the algorithm to generate a word space is the dimension reduction step. In this paper, we use Singular Value Decomposition (SVD) to split the vector space matrix into 3 factors, U, D, V. U and V are orthogonal matrices, and D is diagonal with elements known as the singular values. We perform dimension reduction by retaining only k of the singular values and deleting the related columns of U, and then multiplying U by D to obtain the reduced vector space. SVD has the side-effect property of smoothing out the matrix even further. It does not, however, guarantee anything about the positivity or negativity of the values.

8. Appendix B: Describing the Corpora

The COCA corpus was split into 5 different files, and the GloWbE corpus was split into 23 different files. The corpora files used in this paper were of the Word-Lemma-Part of Speech format. Database and Raw Text versions were also provided, but not used in this paper. In the Word-Lemma-Pos format, the parts of speech were tagged by the CLAWS7 tagger using the **UCREL CLAWS7 tagset** tagset. For more information see the FAQ.

8.1. Corpus of Contemporary American English (COCA)

We calculated some noun compound-related statistics of the COCA corpus for general interest purposes [**COCA**].

```
#=========COCA INFO============#
Some statistics on COCA corpus:
Number of distinct noun compounds: 10032
Number of distinct heads: 3046
Number of distinct modifiers: 2256
Total Number of times a noun compound shows up: 3015413
Approximate fraction of places in corpus that begin with a noun
    compound: 0.00685321137921
50 Most Common Head words and their frequencies:
    room: 42753
    care: 35657
    system: 34649
    members: 24866
    rate: 18315
    program: 17875
    industry: 17283
    programs: 16665
    group: 15743
    rates: 15119
    students: 14887
    education: 14253
    officials: 14153
    market: 14146
    companies: 13528
    groups: 13518
    director: 13409
    use: 13120
    company: 12700
    table: 12374
    door: 12326
    force: 12092
    team: 11863
    station: 11782
    process: 11668
    cancer: 11608
    level: 11158
    game: 10782
    line: 10595
    school: 10573
    control: 10293
    center: 10087
    systems: 9921
    store: 9891
    service: 9863
    plan: 9758
    prices: 9622
    insurance: 9418
```

```
      show: 9376
      tax: 9246
      officer: 9222
50    reform: 9217
      life: 8801
      juice: 8497
      enforcement: 8385
      time: 8327
55    point: 8236
      conference: 8217
      member: 8173
      services: 8098
   50 Most Common Modifier words and their frequencies:
60    school: 63347
      health: 62043
      family: 32908
      tax: 28271
      state: 26247
65    drug: 24218
      business: 23265
      phone: 22376
      police: 21988
      college: 21958
70    government: 21601
      home: 20760
      law: 20424
      community: 19525
      air: 17952
75    news: 17866
      security: 17430
      research: 17145
      food: 17048
      heart: 16869
80    water: 16504
      oil: 16383
      computer: 15391
      education: 15153
      world: 15028
85    back: 15009
      blood: 14890
      care: 14654
      executive: 14457
      music: 14432
90    student: 14122
      life: 13621
      living: 12973
      energy: 12958
      art: 12738
95    power: 12709
      insurance: 11978
      death: 11834
      child: 11681
```

```
      television: 11564
100   credit: 10902
      stock: 10897
      interest: 10811
      time: 10681
      job: 10661
105   car: 10647
      trade: 10523
      body: 10496
      cell: 10264
      defense: 10259
```

Listing 3: *COCA Statistics*

8.2. Corpus of Global Web-Based English (GloWbE)

We calculated some noun compound-related statistics of the GloWbE corpus for general interest purposes [**GloWbE**].

```
#=========GloWbE INFO==================#
Some statistics on GloWbE corpus:
Number of distinct noun compounds: 8880852
Number of distinct heads: 281268
5   Number of distinct modifiers: 255147
Total Number of times a noun compound shows up: 65280084
Approximate fraction of places in corpus that begin with a noun
    compound: 0.0343579389474
50 Most Common Head words and their frequencies:
    system: 411983
10    state: 363720
    service: 336363
    program: 294855
    group: 251454
    time: 249432
15    company: 249155
    rate: 245762
    center: 243544
    member: 234212
    people: 228247
20    game: 195068
    york: 191445
    cent: 191020
    team: 186826
    day: 183696
25    level: 183516
    area: 180968
    industry: 178364
    site: 176769
    city: 175018
30    market: 174124
```

```
zealand: 160964
project: 158635
change: 157836
house: 156601
management: 154091
page: 153384
card: 150690
process: 149214
university: 146909
government: 145858
price: 145564
africa: 144942
school: 143986
policy: 141003
room: 139926
point: 139061
line: 137187
plan: 136943
number: 128563
party: 128059
development: 127997
post: 127858
law: 127663
lanka: 126548
report: 125876
issue: 125005
act: 124153
station: 122610
50 Most Common Modifier words and their frequencies:
new: 437329
world: 395479
business: 371368
us: 337535
health: 335423
time: 272285
south: 258904
mr: 257921
government: 248396
united: 245119
state: 233444
family: 225606
john: 218736
school: 212160
million: 205978
president: 197533
service: 197281
home: 197016
per: 189919
tax: 187231
security: 183940
food: 174182
media: 171043
```

```
        web: 169550
        water: 166168
85      development: 154512
        year: 153949
        research: 152993
        city: 150873
        day: 150104
90      north: 147233
        sri: 147220
        energy: 146720
        life: 143689
        police: 139986
95      community: 139526
        power: 139454
        david: 137920
        market: 133621
        news: 132406
100     internet: 131692
        air: 127667
        west: 127198
        dr.-i: 126387
        management: 124964
105     climate: 122367
        party: 118667
        credit: 117562
        quality: 115548
        de: 112622
```

Listing 4: *GloWbE Statistics*

9. APPENDIX C: IMPLEMENTATION DETAILS AND FUTURE USAGE

9.1. Libraries Used

Here is a link to the **Github repository**. Here is a link to **Dropbox** containing all the files, but not including the corpora as it is licensed.

All the code was written in Python, and Numpy was used significantly throughout the project. We also used the h5py module to build the Fyshe vector space from the provided Matlab file.

9.2. List of Noun Compounds Used

Here we provide the list of 99 noun compounds that were used for model creation and testing.

By accident, we included one noun compound ('life force') twice for a total of 100 noun compounds in the original list (repeated). Because we generated the noun compound pairs from this list, there were in fact $\binom{100}{2} = 4950$ noun compound pairs provided to Turkers, and as a result some of the noun compound pairs were solved more

30

than once. We also had ('life force', 'life force') as a noun compound pair presented to Turkers as a result.

```
     breakfast table
     pool table
     bargaining table
     card table
 5   oak table
     assembly line
     cruise line
     party line
     story line
10   telephone line
     punch line
     water line
     tree line
     trend line
15   goal line
     air force
     brute force
     life force
     task force
20   invasion force
     grad students
     art students
     women students
     law students
25   minority students
     bus station
     police station
     space station
     television station
30   train station
     weather station
     gas station
     subway station
     power station
35   research station
     reading room
     hotel room
     computer room
     dorm room
40   living room
     wiggle room
     chat room
     dance company
     finance company
45   parent company
     adult life
     animal life
     sex life
     love life
```

```
50  shelf life
    water fountain
    water availability
    water glass
    water heater
55  water hole
    water lilies
    water vapor
    water temperature
    water rights
60  water pressure
    blood vessel
    blood type
    blood pressure
    blood bank
65  blood test
    blood flow
    air temperature
    air space
    air service
70  air flow
    air travel
    air mattress
    air fare
    heart attack
75  heart monitor
    heart disease
    heart pounding
    heart rate
    death wish
80  death penalty
    death sentence
    death toll
    death camp
    death certificate
85  death squads
    life events
    life expectancy
    life sciences
    life savings
90  life span
    life skills
    life support
    life style
    life jacket
95  time zone
    time interval
    time period
    time machine
    time limit
```

Listing 5: *The 99 Noun Compounds*

9.3. Corpus-Parsing Algorithm

COCA and GloWbE are both very large data sets on the order of 0.5 billion and 2 billion words, so efficiency was important in guiding the algorithm design.

The main idea is to build a generic corpus tracer, which takes in some values (including a function), and at each step of the trace, executes the function with the right parameters.

The functions that were passed to the tracer were designed to calculate frequencies for specific contexts. There were four contexts (one each for $\mathcal{D}, \mathcal{A}, Q_{\mathcal{H}}, Q_{\mathcal{M}}$).

A window of fixed size is maintained as the tracer steps through the corpus in order to allow for exactly one corpus traversal, and in order to save space.

9.4. Potential as a Module

Other students at Princeton University may desire to use the COCA and GloWbE corpuses as well, now that they have been made available to all students. The code used in this project, after a little clean-up, should serve as a starting point for a Python module made available by the University alongside the corpora.

10. APPENDIX D: ERROR DATA

All the listed classification mistakes are provided in the following table.

```
--------------------------------------------------------

Fyshe Dilation Model guessed Similar when Mechanical Turk answered
    Unknown for the following noun compound pairs:

['water line|water fountain', 'death toll|death certificate', 'blood
    test|blood flow', 'death penalty|death toll', 'water heater|water
    hole', 'water hole|water rights', 'water hole|water pressure', '
    life force|life sciences', 'life savings|life style', 'life force|
    life skills', 'water fountain|water pressure', 'air temperature|air
     space', 'air space|air service', 'life events|life force', 'time
    zone|time limit', 'life force|life jacket', 'death penalty|death
    squads']
--------------------------------------------------------


--------------------------------------------------------

Fyshe Dilation Model guessed Very Similar when Mechanical Turk answered
    Similar for the following noun compound pairs:

['death toll|death squads', 'time interval|time limit', 'water fountain
    |water heater', 'water fountain|water hole', 'water fountain|water
    vapor', 'water hole|water lilies', 'water lilies|water vapor', '
    water heater|water vapor', 'time zone|time interval']
--------------------------------------------------------
```

```
-------------------------------------------------------

Fyshe Dilation Model guessed Similar when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['life skills|life jacket', 'dorm room|wiggle room', 'life expectancy|
    life sciences', 'water availability|water temperature', 'death toll
    |death camp', 'water lilies|water pressure', 'death certificate|
    death squads', 'life force|life style', 'death penalty|death
    certificate', 'time machine|time limit', 'water temperature|water
    pressure', 'time interval|time machine', 'water availability|water
    vapor', 'life span|life jacket', 'life style|life jacket', 'life
    savings|life support', 'life expectancy|life savings', 'air force|
    air mattress', 'air mattress|air fare', 'life sciences|life skills'
    , 'life sciences|life support', 'heart monitor|heart rate', 'water
    fountain|water temperature', 'water line|water availability', 'air
    temperature|air fare', 'water glass|water vapor', 'life savings|
    life jacket', 'blood type|blood bank', 'air temperature|air
    mattress', 'water line|water rights', 'life sciences|life savings',
     'air travel|air mattress', 'water glass|water rights', 'water line
    |water lilies', 'life events|life jacket', 'life support|life style
    ', 'water temperature|water rights', 'water vapor|water rights', '
    air service|air mattress', 'death camp|death certificate', 'life
    expectancy|life jacket', 'time period|time machine', 'life sciences
    |life span', 'life events|life savings', 'water vapor|water
    temperature', 'water glass|water temperature', 'air service|air
    flow', 'water availability|water glass', 'life sciences|life jacket
    ', 'air space|air mattress', 'air force|air fare', 'water fountain|
    water availability', 'air temperature|air travel', 'life events|
    life sciences', 'water hole|water temperature']
-------------------------------------------------------

-------------------------------------------------------

Fyshe Dilation Model guessed Very Similar when Mechanical Turk answered
    Not similar for the following noun compound pairs:

['water availability|water lilies', 'water hole|water vapor', 'water
    fountain|water lilies', 'water heater|water lilies']
-------------------------------------------------------

-------------------------------------------------------

Fyshe Dilation Model guessed Unknown when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['air force|water hole', 'water pressure|blood vessel', 'air force|
    water rights', 'water rights|air flow', 'water vapor|air flow', '
    water vapor|blood test', 'water fountain|air temperature', 'water
    line|air temperature', 'water temperature|blood type', 'water
    availability|air space', 'water hole|blood type', 'water
```

availability|blood vessel', 'water temperature|blood bank', 'water pressure|air fare', 'gas station|air service', 'water hole|air temperature', 'air force|water fountain', 'water pressure|blood test', 'water lilies|blood test', 'parent company|adult life', 'water hole|air space', 'water vapor|air temperature', 'water fountain|blood vessel', 'water availability|air travel', 'water glass|air mattress', 'water availability|blood pressure', 'water rights|air service', 'water line|blood test', 'water heater|air travel', 'water rights|blood flow', 'water hole|air fare', 'water lilies|blood pressure', 'water heater|air mattress', 'water glass|blood type', 'water lilies|blood bank', 'water rights|air fare', 'water glass|blood pressure', 'water rights|blood vessel', 'water vapor|air fare', 'water temperature|air space', 'water fountain|air space', 'water lilies|air space', 'water heater|blood vessel', 'water glass|air service', 'air force|water availability', 'water glass|air travel', 'water rights|blood test', 'water availability|air fare', 'water hole|air service', 'space station|wiggle room', 'water line|air travel', 'water line|air fare', 'water vapor|blood pressure', 'water heater|blood pressure', 'water lilies|blood flow', 'air force|gas station', 'water pressure|blood flow', 'water heater|air flow', 'water fountain|blood pressure', 'water lilies|air travel', 'water availability|blood bank', 'gas station|air temperature', 'water rights|air mattress', 'water line|blood bank', 'water lilies|blood vessel', 'water heater|air fare', 'water temperature|air travel', 'water hole|air travel', 'water availability|air mattress', 'water fountain|blood type', 'water line|air service', 'water temperature|air mattress', 'water line|air mattress', 'air force|water temperature', 'water rights|air temperature', 'water availability|blood test', 'water fountain|blood bank', 'water line|blood flow', 'water pressure|air mattress', 'water vapor|blood bank', 'water heater|blood flow', 'water line|air force', 'water rights|blood pressure', 'water glass|air temperature', 'water hole|air mattress', 'water pressure|air service', 'water lilies|blood type', 'water fountain|air fare', 'gas station|air space', 'gas station|air flow', 'water hole|blood bank', 'air force|water lilies', 'water pressure|blood type', 'water temperature|air service', 'water hole|blood flow', 'water hole|blood test', 'water vapor|air service', 'telephone line|television station', 'water heater|blood bank', 'water availability|air flow', 'water lilies|air fare', 'water pressure|air travel', 'water vapor|blood type', 'water heater|blood type', 'water glass|blood vessel', 'water glass|air flow', 'water hole|blood pressure', 'water lilies|air temperature', 'water glass|blood bank', 'water hole|air flow', 'water lilies|air service', 'water fountain|blood flow', 'water glass|air fare', 'water lilies|air mattress', 'water rights|air travel', 'water fountain|air flow', 'water fountain|air service', 'water glass|blood test', 'water fountain|blood test', 'water availability|air service', 'air force|water heater', 'air force|water pressure', 'water temperature|blood flow', 'water glass|air space', 'water availability|air temperature', 'water rights|blood type', 'water heater|air space', 'water temperature|blood test', 'water temperature|blood pressure', 'water availability|

```
    blood type', 'air force|water glass', 'water vapor|air travel', '
    water glass|blood flow', 'water pressure|air space', 'water rights|
    air space', 'water line|blood vessel', 'air force|water vapor', '
    gas station|air mattress', 'water line|blood type', 'water heater|
    air service', 'water fountain|air travel', 'gas station|air travel'
    , 'water temperature|air fare', 'water lilies|air flow', 'water
    temperature|air flow', 'water temperature|blood vessel', 'water
    heater|blood test', 'water pressure|blood bank', 'water vapor|air
    mattress', 'water vapor|blood vessel']
------------------------------------------------------
```
35
```
------------------------------------------------------

Fyshe Dilation Model guessed Not similar when Mechanical Turk answered
    Very Similar for the following noun compound pairs:
```
40
```
['blood pressure|heart rate', 'blood flow|heart pounding', 'women
    students|law students', 'grad students|law students', 'art students
    |law students', 'air force|task force', 'police station|subway
    station', 'party line|chat room', 'animal life|life force', '
    breakfast table|oak table', 'breakfast table|card table', 'reading
    room|living room', 'death sentence|life span', 'life expectancy|
    time limit', 'life expectancy|time period', 'shelf life|life
    expectancy', 'love life|life events', 'grad students|women students
    ', 'heart disease|death sentence', 'gas station|subway station', '
    blood pressure|air flow', 'power station|research station', 'grad
    students|art students', 'hotel room|dorm room', 'death toll|life
    support', 'life span|time period', 'sex life|love life', 'finance
    company|parent company', 'death wish|life span']
------------------------------------------------------

------------------------------------------------------
```
45
```
Fyshe Dilation Model guessed Similar when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

['water rights|water pressure', 'heart attack|heart pounding', 'blood
    vessel|blood type', 'blood pressure|blood flow', 'heart attack|
    heart monitor', 'time interval|time period', 'blood bank|blood flow
    ', 'water heater|water temperature', 'life force|life span', 'death
    penalty|death sentence', 'blood vessel|blood pressure', 'air force
    |air service', 'heart attack|heart rate', 'heart attack|heart
    disease', 'bus station|train station', 'death penalty|death camp',
    'air service|air travel', 'air force|air temperature', 'blood
    pressure|blood test', 'time period|time limit', 'death wish|death
    sentence', 'train station|subway station', 'bus station|subway
    station', 'heart disease|heart pounding']
------------------------------------------------------
```
50
```
------------------------------------------------------

Fyshe Dilation Model guessed Unknown when Mechanical Turk answered Very
```

```
        Similar for the following noun compound pairs:

['water temperature|air temperature']
--------------------------------------------------------


--------------------------------------------------------

Fyshe Dilation Model guessed Not similar when Mechanical Turk answered
    Unknown for the following noun compound pairs:

['bargaining table|death wish', 'blood vessel|heart rate', 'blood
    pressure|death toll', 'cruise line|space station', 'invasion force|
    water rights', 'blood flow|life sciences', 'animal life|life
    support', 'tree line|water lilies', 'adult life|time interval', '
    research station|time period', 'train station|power station', 'air
    temperature|life span', 'life force|air service', 'death squads|
    life span', 'cruise line|water rights', 'air service|life force', '
    party line|air flow', 'task force|invasion force', 'story line|tree
     line', 'blood vessel|life support', 'air force|police station', '
    goal line|water hole', 'heart attack|death certificate', 'life
    force|death toll', 'trend line|water temperature', 'death sentence|
    life force', 'heart attack|life expectancy', 'story line|telephone
    line', 'water line|life force', 'animal life|love life', 'dorm room
    |air space', 'life force|time interval', 'water availability|life
    span', 'brute force|life force', 'blood type|heart pounding', '
    shelf life|time limit', 'goal line|life savings', 'water
    temperature|life force', 'party line|reading room', 'gas station|
    research station', 'party line|water line', 'gas station|death camp
    ', 'air force|life support', 'subway station|hotel room', 'power
    station|reading room', 'party line|blood bank', 'blood bank|life
    savings', 'space station|life support', 'life force|blood pressure'
    , 'adult life|life span', 'life force|time period', 'goal line|life
     events', 'breakfast table|water glass', 'dorm room|death camp', '
    train station|blood vessel', 'heart disease|life support', 'hotel
    room|chat room', 'pool table|television station', 'television
    station|animal life', 'invasion force|police station', 'heart
    disease|time period', 'sex life|life skills', 'heart pounding|life
    expectancy', 'weather station|living room', 'shelf life|death
    certificate', 'subway station|computer room', 'brute force|heart
    rate', 'blood test|death certificate', 'cruise line|life events', '
    television station|research station', 'story line|goal line']
--------------------------------------------------------


--------------------------------------------------------

Fyshe Dilation Model guessed Unknown when Mechanical Turk answered
    Similar for the following noun compound pairs:

['water pressure|air flow', 'water pressure|air temperature', 'water
    fountain|air mattress', 'water availability|blood flow', 'water
    vapor|blood flow', 'water heater|air temperature', 'water line|air
    space', 'water vapor|air space', 'water line|air flow', 'water hole
```

```
      |blood vessel', 'water line|blood pressure', 'water pressure|blood
      pressure', 'grad students|minority students']
-----------------------------------------------------------
```

```
-----------------------------------------------------------

Fyshe Dilation Model guessed Not similar when Mechanical Turk answered
      Similar for the following noun compound pairs:

['death sentence|time limit', 'bargaining table|oak table', 'breakfast
      table|subway station', 'gas station|power station', 'cruise line|
      water lilies', 'bus station|air space', 'water line|death
      certificate', 'dance company|sex life', 'assembly line|power
      station', 'life force|task force', 'tree line|goal line', 'assembly
       line|life skills', 'telephone line|chat room', 'assembly line|task
       force', 'water line|space station', 'card table|oak table', '
      police station|power station', 'air flow|heart disease', 'police
      station|death squads', 'police station|research station', 'air flow
      |life sciences', 'life force|death certificate', 'heart monitor|
      time interval', 'reading room|dorm room', 'dance company|parent
      company', 'air force|heart rate', 'finance company|adult life', '
      blood pressure|heart pounding', 'weather station|water temperature'
      , 'gas station|water fountain', 'blood vessel|heart monitor', '
      brute force|heart attack', 'subway station|chat room', 'hotel room|
      living room', 'life force|air space', 'party line|animal life', '
      space station|gas station', 'blood type|heart disease', 'sex life|
      heart monitor', 'love life|life skills', 'blood flow|heart disease'
      , 'blood flow|life span', 'blood pressure|heart monitor', 'cruise
      line|finance company', 'weather station|air space', 'love life|life
       force', 'heart pounding|life force', 'love life|life style', '
      police station|reading room', 'love life|shelf life', 'death wish|
      life support', 'weather station|air service', 'heart pounding|death
       wish', 'research station|reading room', 'blood bank|heart disease'
      , 'police station|train station', 'blood bank|heart monitor', '
      blood test|life events', 'adult life|life events', 'pool table|
      bargaining table', 'heart rate|time period', 'train station|water
      hole', 'water fountain|life jacket', 'bus station|gas station', '
      tree line|animal life', 'life force|death penalty', 'police station
      |computer room', 'heart monitor|life support', 'trend line|life
      expectancy', 'life force|heart rate', 'hotel room|air mattress', '
      television station|power station', 'train station|air service', '
      art students|women students', 'space station|time zone', 'subway
      station|water hole', 'life savings|time period', 'train station|gas
       station', 'women students|minority students', 'weather station|
      life sciences', 'cruise line|dance company', 'weather station|
      subway station', 'life force|heart pounding', 'assembly line|story
      line', 'computer room|chat room', 'research station|chat room', '
      heart attack|life force', 'blood type|heart attack', 'police
      station|weather station', 'subway station|research station', 'water
       pressure|heart attack', 'women students|water rights', 'brute
      force|invasion force', 'blood vessel|heart disease', 'air service|
      time interval', 'task force|research station', 'hotel room|computer
```

room', 'space station|subway station', 'trend line|time interval',
'adult life|animal life', 'task force|law students', 'power
station|water hole', 'space station|television station', 'heart
attack|life sciences', 'party line|dance company', 'reading room|
chat room', 'chat room|sex life', 'subway station|dorm room', '
living room|chat room', 'television station|weather station', 'grad
students|adult life', 'heart monitor|time limit', 'cruise line|
party line', 'cruise line|air fare', 'law students|reading room', '
life force|space station', 'blood flow|heart monitor', 'death
penalty|life support', 'heart disease|life span', 'gas station|
finance company', 'cruise line|hotel room', 'life force|heart
attack', 'blood pressure|heart attack', 'assembly line|water line',
'card table|computer room', 'air temperature|time interval', '
death toll|life savings', 'power station|life sciences', 'space
station|power station', 'power station|chat room', 'research
station|computer room', 'blood test|heart monitor', 'reading room|
hotel room', 'trend line|air temperature', 'adult life|heart
pounding', 'blood type|heart rate', 'trend line|power station', '
trend line|heart monitor', 'breakfast table|pool table', 'space
station|air space', 'life force|gas station', 'adult life|time
period', 'air force|blood flow', 'hotel room|sex life', 'invasion
force|death sentence', 'adult life|life expectancy', 'weather
station|power station', 'water pressure|heart pounding', 'reading
room|computer room', 'water line|life support', 'shelf life|life
span', 'television station|gas station', 'party line|time zone', '
heart rate|life force', 'women students|adult life', 'space station
|dorm room', 'research station|life sciences', 'heart monitor|life
sciences', 'adult life|love life', 'bus station|space station', '
cruise line|subway station', 'trend line|research station', 'dorm
room|living room', 'space station|air service', 'death certificate|
life support', 'space station|train station', 'breakfast table|
living room', 'wiggle room|chat room', 'heart rate|life support', '
death sentence|life jacket', 'power station|life force', 'space
station|air travel', 'space station|research station', 'grad
students|research station', 'tree line|trend line', 'art students|
dance company', 'story line|trend line', 'telephone line|water line
', 'police station|death sentence', 'death toll|life span', 'police
station|space station', 'death sentence|life style', 'heart
pounding|death penalty', 'cruise line|train station', 'bus station|
air service', 'water availability|time limit', 'space station|
weather station', 'assembly line|party line', 'task force|death
squads', 'cruise line|story line', 'heart disease|life expectancy',
'television station|subway station', 'death sentence|life support'
, 'blood pressure|air temperature', 'brute force|task force', '
trend line|life span', 'love life|life expectancy', 'air force|
brute force', 'life force|blood test', 'blood flow|heart rate', '
air force|invasion force', 'pool table|oak table', 'life span|time
interval', 'wiggle room|time period', 'telephone line|finance
company', 'death penalty|time limit', 'telephone line|computer room
', 'research station|life support', 'grad students|dorm room', '
invasion force|death squads', 'adult life|sex life', 'death penalty
|life skills', 'party line|trend line', 'blood type|life sciences',

```
        'finance company|death camp', 'water pressure|heart monitor', 'art
         students|minority students', 'air flow|heart rate', 'death
        certificate|life style', 'space station|death camp', 'blood vessel|
        life force', 'task force|dance company', 'life force|invasion force
        ', 'finance company|life savings', 'blood pressure|life sciences',
        'air space|time interval', 'adult life|death certificate', 'card
        table|chat room', 'living room|air temperature', 'death sentence|
        life expectancy', 'blood test|time limit', 'air flow|time interval'
        , 'television station|finance company', 'blood test|heart attack',
        'weather station|research station', 'bus station|hotel room', '
        adult life|life skills', 'law students|dorm room', 'blood test|
        heart disease', 'blood flow|air flow', 'blood flow|life force', '
        weather station|air temperature', 'subway station|power station', '
        telephone line|tree line', 'death camp|life events', 'law students|
        minority students', 'blood pressure|air service', 'water line|tree
        line', 'bargaining table|computer room', 'bargaining table|chat
        room', 'story line|life events', 'party line|dorm room', 'blood
        flow|heart attack', 'assembly line|invasion force', 'computer room|
        blood bank', 'water temperature|time period', 'trend line|life
        savings', 'trend line|time period', 'death penalty|life events', '
        television station|computer room', 'party line|telephone line', '
        heart attack|death toll', 'story line|power station', 'love life|
        time period', 'death squads|life events', 'power station|computer
        room', 'card table|reading room', 'task force|air service', 'air
        fare|time interval', 'invasion force|death penalty', 'blood
        pressure|heart disease', 'blood vessel|heart attack', 'life force|
        water availability', 'water vapor|life sciences', 'death wish|life
        expectancy']
-------------------------------------------------------

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Fyshe Sum Model guessed Similar when Mechanical Turk answered Unknown
    for the following noun compound pairs:

['water line|water fountain', 'death toll|death certificate', 'death
    penalty|death toll', 'water heater|water hole', 'water hole|water
    rights', 'task force|invasion force', 'water hole|water pressure',
    'story line|telephone line', 'life force|life sciences', 'animal
    life|love life', 'life savings|life style', 'water fountain|water
    pressure', 'air temperature|air space', 'adult life|life span', '
    hotel room|chat room', 'sex life|life skills', 'time zone|time
    limit', 'television station|research station', 'life force|life
    jacket', 'story line|goal line', 'death penalty|death squads']
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Fyshe Sum Model guessed Similar when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['life skills|life jacket', 'television station|train station', '
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telephone line|trend line', 'shelf life|life style', 'dorm room|
chat room', 'dorm room|wiggle room', 'life expectancy|life sciences
', 'water availability|water temperature', 'shelf life|life force',
 'death toll|death camp', 'shelf life|life jacket', 'trend line|
goal line', 'water lilies|water pressure', 'punch line|trend line',
 'love life|life jacket', 'death certificate|death squads', 'shelf
life|life support', 'love life|life savings', 'animal life|life
sciences', 'water line|trend line', 'punch line|goal line', 'cruise
 line|goal line', 'death penalty|death certificate', 'cruise line|
punch line', 'sex life|life sciences', 'time machine|time limit', '
water temperature|water pressure', 'life force|shelf life', '
telephone line|goal line', 'assembly line|goal line', 'story line|
punch line', 'sex life|life expectancy', 'time interval|time
machine', 'dance company|finance company', 'police station|gas
station', 'life force|love life', 'water availability|water vapor',
 'life span|life jacket', 'life savings|life support', 'reading
room|wiggle room', 'life expectancy|life savings', 'air force|air
mattress', 'air mattress|air fare', 'party line|punch line', 'life
sciences|life skills', 'assembly line|trend line', 'life sciences|
life support', 'living room|wiggle room', 'bus station|weather
station', 'water availability|water lilies', 'water fountain|water
temperature', 'water line|water availability', 'shelf life|life
skills', 'air temperature|air fare', 'water glass|water vapor', '
life savings|life jacket', 'party line|story line', 'bus station|
research station', 'adult life|life force', 'blood type|blood bank'
, 'air temperature|air mattress', 'assembly line|cruise line', '
water line|water rights', 'water hole|water vapor', 'life force|sex
 life', 'shelf life|life savings', 'life sciences|life savings', '
love life|life span', 'love life|life support', 'bus station|
television station', 'air travel|air mattress', 'sex life|life
jacket', 'breakfast table|bargaining table', 'bargaining table|card
 table', 'animal life|life savings', 'water glass|water rights', '
train station|research station', 'sex life|life force', 'adult life
|life sciences', 'assembly line|telephone line', 'water fountain|
water lilies', 'cruise line|water line', 'punch line|water line', '
life force|animal life', 'water line|water lilies', 'adult life|
shelf life', 'animal life|life skills', 'adult life|life jacket', '
water temperature|water rights', 'water vapor|water rights', 'death
 camp|death certificate', 'life expectancy|life jacket', 'train
station|weather station', 'assembly line|punch line', 'time period|
time machine', 'adult life|life savings', 'life sciences|life span'
, 'party line|goal line', 'water vapor|water temperature', 'water
glass|water temperature', 'cruise line|trend line', 'bus station|
police station', 'sex life|life savings', 'sex life|life span', '
water line|goal line', 'telephone line|punch line', 'police station
|television station', 'pool table|card table', 'water availability|
water glass', 'animal life|sex life', 'hotel room|wiggle room', '
water heater|water lilies', 'life sciences|life jacket', 'animal
life|life expectancy', 'animal life|life jacket', 'sex life|shelf
life', 'air space|air mattress', 'air force|air fare', 'shelf life|
life sciences', 'cruise line|telephone line', 'water fountain|water
 availability', 'air temperature|air travel', 'love life|life

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        sciences', 'animal life|life span', 'water hole|water temperature',
        'life force|adult life', 'animal life|shelf life']
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Fyshe Sum Model guessed Unknown when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['water pressure|blood vessel', 'water vapor|air flow', 'sex life|life
    events', 'water availability|blood vessel', 'water temperature|
    blood bank', 'water pressure|air fare', 'punch line|tree line', '
    water vapor|air temperature', 'water fountain|blood vessel', 'life
    force|life style', 'cruise line|tree line', 'shelf life|life events
    ', 'water hole|air fare', 'water heater|air mattress', 'water
    lilies|blood bank', 'animal life|life events', 'water rights|blood
    vessel', 'water vapor|air fare', 'wiggle room|air space', 'life
    style|life jacket', 'adult life|life support', 'water heater|blood
    vessel', 'sex life|life style', 'water availability|air fare', '
    water pressure|blood flow', 'water heater|air flow', 'heart monitor
    |heart rate', 'water rights|air mattress', 'water lilies|blood
    vessel', 'invasion force|life force', 'water heater|air fare', '
    water availability|air mattress', 'water temperature|air mattress',
     'task force|life force', 'water fountain|blood bank', 'water
    pressure|air mattress', 'water vapor|blood bank', 'water hole|air
    mattress', 'animal life|life style', 'water fountain|air fare', '
    water availability|air flow', 'water lilies|air fare', 'life events
    |life jacket', 'story line|water line', 'water lilies|air
    temperature', 'water hole|air flow', 'water lilies|air mattress', '
    life events|life savings', 'adult life|life style', 'air force|
    water pressure', 'water temperature|blood flow', 'bus station|power
     station', 'water availability|air temperature', 'water temperature
    |blood pressure', 'party line|tree line', 'sex life|life support',
    'water temperature|air fare', 'water lilies|air flow', 'water
    temperature|air flow', 'water temperature|blood vessel', 'water
    pressure|blood bank', 'weather station|gas station', 'life events|
    life sciences', 'water vapor|air mattress', 'water vapor|blood
    vessel']
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Fyshe Sum Model guessed Not similar when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

['blood pressure|heart rate', 'blood flow|heart pounding', 'party line|
    chat room', 'death sentence|life span', 'life expectancy|time limit
    ', 'air force|air service', 'life expectancy|time period', 'heart
    disease|death sentence', 'heart attack|heart rate', 'heart attack|
    heart disease', 'air service|air travel', 'power station|research
    station', 'blood pressure|blood test', 'death toll|life support', '
    life span|time period', 'death wish|life span']
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Fyshe Sum Model guessed Similar when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

['water rights|water pressure', 'women students|law students', 'heart
    attack|heart pounding', 'blood vessel|blood type', 'blood pressure|
    blood flow', 'heart attack|heart monitor', 'grad students|law
    students', 'time interval|time period', 'blood bank|blood flow', '
    water heater|water temperature', 'art students|law students', '
    police station|subway station', 'life force|life span', 'animal
    life|life force', 'death penalty|death sentence', 'breakfast table|
    oak table', 'breakfast table|card table', 'reading room|living room
    ', 'blood vessel|blood pressure', 'shelf life|life expectancy', '
    grad students|women students', 'bus station|train station', 'death
    penalty|death camp', 'gas station|subway station', 'air force|air
    temperature', 'grad students|art students', 'hotel room|dorm room',
     'time period|time limit', 'life expectancy|life span', 'death wish
    |death sentence', 'sex life|love life', 'finance company|parent
    company', 'train station|subway station', 'bus station|subway
    station']
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Fyshe Sum Model guessed Unknown when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

['air force|task force', 'love life|life events', 'water temperature|
    air temperature', 'blood pressure|air flow', 'heart disease|heart
    pounding']
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Fyshe Sum Model guessed Not similar when Mechanical Turk answered
    Unknown for the following noun compound pairs:

['bargaining table|death wish', 'blood vessel|heart rate', 'blood
    pressure|death toll', 'cruise line|space station', 'invasion force|
    water rights', 'blood flow|life sciences', 'tree line|water lilies'
    , 'adult life|time interval', 'research station|time period', 'air
    temperature|life span', 'life force|air service', 'death squads|
    life span', 'cruise line|water rights', 'air service|life force', '
    party line|air flow', 'blood vessel|life support', 'air force|
    police station', 'goal line|water hole', 'heart attack|death
    certificate', 'life force|death toll', 'trend line|water
    temperature', 'death sentence|life force', 'heart attack|life
    expectancy', 'water line|life force', 'life force|time interval', '
    water availability|life span', 'blood type|heart pounding', 'shelf
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       life|time limit', 'goal line|life savings', 'water temperature|life
        force', 'party line|reading room', 'gas station|death camp', 'air
       force|life support', 'subway station|hotel room', 'power station|
       reading room', 'party line|blood bank', 'blood bank|life savings',
       'space station|life support', 'life force|blood pressure', 'air
       space|air service', 'life force|time period', 'goal line|life
       events', 'breakfast table|water glass', 'dorm room|death camp', '
       train station|blood vessel', 'heart disease|life support', 'pool
       table|television station', 'television station|animal life', '
       invasion force|police station', 'heart disease|time period', 'heart
        pounding|life expectancy', 'weather station|living room', 'shelf
       life|death certificate', 'subway station|computer room', 'gas
       station|air fare', 'brute force|heart rate', 'blood test|death
       certificate', 'cruise line|life events', 'water rights|blood bank']
125 --------------------------------------------------------


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    Fyshe Sum Model guessed Unknown when Mechanical Turk answered Similar
        for the following noun compound pairs:
130
    ['gas station|power station', 'water pressure|air flow', 'life force|
       task force', 'tree line|goal line', 'police station|power station',
        'blood type|blood pressure', 'water pressure|air temperature', '
       space station|gas station', 'love life|life style', 'water fountain
       |air mattress', 'adult life|life events', 'television station|power
        station', 'water vapor|blood flow', 'water heater|air temperature'
       , 'blood type|blood test', 'life skills|life style', 'life force|
       life events', 'space station|air space', 'weather station|power
       station', 'life sciences|life style', 'life support|life jacket', '
       air force|air space', 'water hole|blood vessel', 'space station|
       research station', 'tree line|trend line', 'blood vessel|blood test
       ', 'water pressure|blood pressure', 'space station|weather station'
       , 'life skills|life support', 'blood pressure|air temperature', '
       life events|life expectancy', 'life force|life support', 'heart
       monitor|heart disease', 'life force|invasion force', 'weather
       station|research station', 'subway station|power station', '
       telephone line|tree line', 'life events|life span', 'heart pounding
       |heart rate', 'blood bank|blood test']
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135
    Fyshe Sum Model guessed Not similar when Mechanical Turk answered
        Similar for the following noun compound pairs:

    ['death sentence|time limit', 'air service|air fare', 'breakfast table|
       subway station', 'cruise line|water lilies', 'bus station|air space
       ', 'water line|death certificate', 'dance company|sex life', '
       assembly line|power station', 'assembly line|life skills', 'life
       events|life style', 'telephone line|chat room', 'assembly line|task
        force', 'water line|space station', 'air flow|heart disease', '
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44

police station|death squads', 'air flow|life sciences', 'life force|death certificate', 'heart monitor|time interval', 'air force|heart rate', 'finance company|adult life', 'blood pressure|heart pounding', 'weather station|water temperature', 'gas station|water fountain', 'blood vessel|heart monitor', 'brute force|heart attack', 'subway station|chat room', 'life force|air space', 'party line|animal life', 'blood type|heart disease', 'sex life|heart monitor', 'blood flow|heart disease', 'blood flow|life span', 'blood pressure|heart monitor', 'cruise line|finance company', 'weather station|air space', 'heart pounding|life force', 'police station|reading room', 'death wish|life support', 'weather station|air service', 'heart pounding|death wish', 'research station|reading room', 'blood bank|heart disease', 'blood bank|heart monitor', 'blood test|life events', 'water availability|blood flow', 'heart rate|time period', 'train station|water hole', 'water fountain|life jacket', 'tree line|animal life', 'life force|death penalty', 'police station|computer room', 'heart monitor|life support', 'trend line|life expectancy', 'life force|heart rate', 'hotel room|air mattress', 'train station|air service', 'space station|time zone', 'subway station|water hole', 'life savings|time period', 'life events|life skills', 'weather station|life sciences', 'cruise line|dance company', 'life force|heart pounding', 'computer room|chat room', 'research station|chat room', 'heart attack|life force', 'blood type|heart attack', 'water pressure|heart attack', 'women students|water rights', 'blood vessel|heart disease', 'air service|time interval', 'task force|research station', 'hotel room|computer room', 'trend line|time interval', 'task force|law students', 'power station|water hole', 'heart attack|life sciences', 'party line|dance company', 'chat room|sex life', 'subway station|dorm room', 'water line|air space', 'grad students|adult life', 'heart monitor|time limit', 'cruise line|air fare', 'law students|reading room', 'life force|space station', 'blood flow|heart monitor', 'water vapor|air space', 'death penalty|life support', 'heart disease|life span', 'gas station|finance company', 'cruise line|hotel room', 'life force|heart attack', 'blood pressure|heart attack', 'air temperature|air service', 'card table|computer room', 'air temperature|time interval', 'death toll|life savings', 'power station|life sciences', 'space station|power station', 'power station|chat room', 'research station|computer room', 'blood test|heart monitor', 'trend line|air temperature', 'adult life|heart pounding', 'blood type|heart rate', 'trend line|power station', 'trend line|heart monitor', 'life force|gas station', 'adult life|time period', 'water line|air flow', 'air force|blood flow', 'hotel room|sex life', 'invasion force|death sentence', 'water pressure|heart pounding', 'reading room|computer room', 'water line|life support', 'party line|time zone', 'heart rate|life force', 'women students|adult life', 'space station|dorm room', 'research station|life sciences', 'heart monitor|life sciences', 'cruise line|subway station', 'trend line|research station', 'space station|air service', 'death certificate|life support', 'breakfast table|living room', 'heart rate|life support', 'death sentence|life jacket', 'power station|life force', 'space station|air travel', 'grad students|

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      research station ', 'water line|blood pressure ', 'art students|dance
       company ', 'police station|death sentence ', 'death toll|life span ',
       'heart disease|heart rate ', 'death sentence|life style ', 'heart
      pounding|death penalty ', 'cruise line|train station ', 'bus station|
      air service ', 'water availability|time limit ', 'task force|death
      squads ', 'heart disease|life expectancy ', 'death sentence|life
      support ', 'trend line|life span ', 'life force|blood test ', 'blood
      flow|heart rate ', 'life span|time interval ', 'wiggle room|time
      period ', 'telephone line|finance company ', 'death penalty|time
      limit ', 'telephone line|computer room ', 'research station|life
      support ', 'grad students|dorm room ', 'invasion force|death squads ',
       'death penalty|life skills ', 'blood type|life sciences ', 'finance
      company|death camp ', 'water pressure|heart monitor ', 'air flow|
      heart rate ', 'death certificate|life style ', 'space station|death
      camp ', 'blood vessel|life force ', 'task force|dance company ', '
      finance company|life savings ', 'blood pressure|life sciences ', 'air
       space|time interval ', 'adult life|death certificate ', 'card table|
      chat room ', 'living room|air temperature ', 'death sentence|life
      expectancy ', 'blood test|time limit ', 'air flow|time interval ', '
      television station|finance company ', 'blood test|heart attack ', '
      bus station|hotel room ', 'life events|life support ', 'law students|
      dorm room ', 'blood test|heart disease ', 'blood flow|life force ', '
      weather station|air temperature ', 'death camp|life events ', 'blood
      pressure|air service ', 'water line|tree line ', 'bargaining table|
      computer room ', 'bargaining table|chat room ', 'story line|life
      events ', 'party line|dorm room ', 'blood flow|heart attack ', '
      assembly line|invasion force ', 'computer room|blood bank ', 'water
      temperature|time period ', 'trend line|life savings ', 'trend line|
      time period ', 'death penalty|life events ', 'television station|
      computer room ', 'heart attack|death toll ', 'story line|power
      station ', 'love life|time period ', 'death squads|life events ', '
      power station|computer room ', 'card table|reading room ', 'task
      force|air service ', 'air fare|time interval ', 'invasion force|death
       penalty ', 'blood pressure|heart disease ', 'blood vessel|heart
      attack ', 'life force|water availability ', 'water vapor|life
      sciences ', 'death wish|life expectancy ']
      --------------------------------------------------------
140

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      COCA Weighted Model guessed Similar when Mechanical Turk answered
          Unknown for the following noun compound pairs:

145   ['death toll|death certificate ', 'death penalty|death toll ', 'water
          heater|water hole ', 'task force|invasion force ', 'story line|tree
          line ', 'story line|telephone line ', 'brute force|life force ', '
          party line|water line ', 'hotel room|chat room ', 'television station
          |research station ', 'story line|goal line ', 'death penalty|death
          squads ']
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150  COCA Weighted Model guessed Similar when Mechanical Turk answered Not
         similar for the following noun compound pairs:

     ['television station|train station', 'telephone line|trend line', 'dorm
         room|chat room', 'dorm room|wiggle room', 'life expectancy|life
         sciences', 'water availability|water temperature', 'trend line|goal
          line', 'punch line|trend line', 'death certificate|death squads',
         'punch line|tree line', 'water line|trend line', 'punch line|goal
         line', 'cruise line|tree line', 'cruise line|goal line', 'death
         penalty|death certificate', 'cruise line|punch line', 'telephone
         line|goal line', 'assembly line|goal line', 'story line|punch line'
         , 'dance company|finance company', 'police station|gas station', '
         water availability|water vapor', 'reading room|wiggle room', 'life
         expectancy|life savings', 'party line|punch line', 'computer room|
         wiggle room', 'life sciences|life skills', 'assembly line|trend
         line', 'living room|wiggle room', 'bus station|weather station', '
         water availability|water lilies', 'invasion force|life force', '
         party line|story line', 'task force|life force', 'assembly line|
         cruise line', 'life sciences|life savings', 'bus station|television
          station', 'breakfast table|bargaining table', 'bargaining table|
         card table', 'air force|life force', 'assembly line|telephone line'
         , 'water fountain|water lilies', 'cruise line|water line', 'punch
         line|water line', 'adult life|shelf life', 'story line|water line',
          'computer room|dorm room', 'train station|weather station', '
         assembly line|punch line', 'party line|goal line', 'water vapor|
         water temperature', 'cruise line|trend line', 'bus station|police
         station', 'water line|goal line', 'telephone line|punch line', '
         police station|television station', 'pool table|card table', '
         animal life|sex life', 'hotel room|wiggle room', 'water heater|
         water lilies', 'sex life|shelf life', 'party line|tree line', '
         computer room|living room', 'cruise line|telephone line', 'water
         fountain|water availability', 'weather station|gas station', 'life
         events|life sciences', 'animal life|shelf life']
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155  --------------------------------------------------------

     COCA Weighted Model guessed Unknown when Mechanical Turk answered Not
         similar for the following noun compound pairs:

     ['time machine|time limit', 'life style|life jacket', 'air mattress|air
          fare', 'life savings|life jacket', 'bus station|research station',
          'water hole|water vapor', 'train station|research station', 'water
          vapor|water rights', 'life expectancy|life jacket', 'time period|
         time machine', 'life sciences|life span', 'life events|life savings
         ', 'bus station|power station']
160  --------------------------------------------------------

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     COCA Weighted Model guessed Not similar when Mechanical Turk answered
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     Very Similar for the following noun compound pairs:

['blood pressure|heart rate', 'blood flow|heart pounding', 'heart
    attack|heart pounding', 'blood vessel|blood type', 'blood pressure|
    blood flow', 'heart attack|heart monitor', 'blood bank|blood flow',
     'life force|life span', 'party line|chat room', 'animal life|life
    force', 'death sentence|life span', 'life expectancy|time limit', '
    blood vessel|blood pressure', 'air force|air service', 'life
    expectancy|time period', 'shelf life|life expectancy', 'love life|
    life events', 'heart disease|death sentence', 'heart attack|heart
    rate', 'heart attack|heart disease', 'death penalty|death camp', '
    air service|air travel', 'blood pressure|air flow', 'air force|air
    temperature', 'blood pressure|blood test', 'death toll|life support
    ', 'life span|time period', 'heart disease|heart pounding', 'death
    wish|life span']
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COCA Weighted Model guessed Similar when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

['women students|law students', 'grad students|law students', 'time
    interval|time period', 'life force|life force', 'water heater|water
     temperature', 'art students|law students', 'air force|task force',
     'police station|subway station', 'death penalty|death sentence', '
    breakfast table|oak table', 'breakfast table|card table', 'reading
    room|living room', 'grad students|women students', 'water
    temperature|air temperature', 'bus station|train station', 'gas
    station|subway station', 'grad students|art students', 'hotel room|
    dorm room', 'life expectancy|life span', 'death wish|death sentence
    ', 'sex life|love life', 'finance company|parent company', 'train
    station|subway station', 'bus station|subway station']
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COCA Weighted Model guessed Unknown when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

['water rights|water pressure', 'power station|research station', 'time
     period|time limit']
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COCA Weighted Model guessed Not similar when Mechanical Turk answered
    Unknown for the following noun compound pairs:

['bargaining table|death wish', 'blood vessel|heart rate', 'blood
    pressure|death toll', 'water line|water fountain', 'cruise line|
    space station', 'invasion force|water rights', 'blood test|blood
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flow', 'blood flow|life sciences', 'animal life|life support', '
tree line|water lilies', 'adult life|time interval', 'research
station|time period', 'air temperature|life span', 'life force|air
service', 'death squads|life span', 'cruise line|water rights', '
air service|life force', 'party line|air flow', 'blood vessel|life
support', 'air force|police station', 'goal line|water hole', '
heart attack|death certificate', 'life force|death toll', 'trend
line|water temperature', 'death sentence|life force', 'heart attack
|life expectancy', 'water hole|water pressure', 'water line|life
force', 'life force|life sciences', 'dorm room|air space', 'life
force|time interval', 'water availability|life span', 'blood type|
heart pounding', 'shelf life|time limit', 'life force|life skills',
 'goal line|life savings', 'water temperature|life force', 'party
line|reading room', 'water fountain|water pressure', 'gas station|
death camp', 'air force|life support', 'subway station|hotel room',
 'power station|reading room', 'party line|blood bank', 'blood bank
|life savings', 'space station|life support', 'life force|blood
pressure', 'air temperature|air space', 'adult life|life span', '
air space|air service', 'life force|time period', 'goal line|life
events', 'breakfast table|water glass', 'life events|life force', '
dorm room|death camp', 'train station|blood vessel', 'heart disease
|life support', 'pool table|television station', 'television
station|animal life', 'invasion force|police station', 'heart
disease|time period', 'sex life|life skills', 'heart pounding|life
expectancy', 'weather station|living room', 'shelf life|death
certificate', 'subway station|computer room', 'gas station|air fare
', 'brute force|heart rate', 'blood test|death certificate', '
cruise line|life events', 'life force|life jacket', 'water rights|
blood bank']
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COCA Weighted Model guessed Unknown when Mechanical Turk answered
    Similar for the following noun compound pairs:

['time zone|time period', 'life events|life style', 'police station|
    power station', 'life span|life style', 'heart monitor|heart
    pounding', 'police station|research station', 'life savings|life
    skills', 'water line|water heater', 'time zone|time machine', 'life
     events|life skills', 'water vapor|water pressure', 'life skills|
    life style', 'time interval|time limit', 'water fountain|water
    rights', 'water fountain|water hole', 'life savings|life span', '
    water hole|water lilies', 'water lilies|water rights', 'police
    station|space station', 'death sentence|death toll', 'time zone|
    time interval', 'water heater|water pressure', 'death sentence|
    death certificate', 'water heater|water rights', 'death camp|death
    squads', 'life events|life span', 'water availability|water hole']
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COCA Weighted Model guessed Not similar when Mechanical Turk answered
    Similar for the following noun compound pairs:

['death sentence|time limit', 'air service|air fare', 'breakfast table|
    subway station', 'cruise line|water lilies', 'water pressure|air
    flow', 'bus station|air space', 'water line|death certificate', '
    dance company|sex life', 'assembly line|power station', 'assembly
    line|life skills', 'telephone line|chat room', 'assembly line|task
    force', 'water line|space station', 'water line|water hole', 'air
    flow|heart disease', 'police station|death squads', 'air flow|life
    sciences', 'water glass|water hole', 'life force|death certificate'
    , 'heart monitor|time interval', 'air force|heart rate', 'water
    line|water glass', 'air space|air flow', 'finance company|adult
    life', 'blood pressure|heart pounding', 'blood type|blood pressure'
    , 'weather station|water temperature', 'gas station|water fountain'
    , 'blood vessel|heart monitor', 'brute force|heart attack', 'subway
     station|chat room', 'life force|air space', 'water pressure|air
    temperature', 'party line|animal life', 'blood type|heart disease',
     'sex life|heart monitor', 'love life|life skills', 'blood flow|
    heart disease', 'blood flow|life span', 'blood pressure|heart
    monitor', 'cruise line|finance company', 'weather station|air space
    ', 'love life|life force', 'heart pounding|life force', 'love life|
    life style', 'water glass|water heater', 'police station|reading
    room', 'blood type|blood flow', 'water fountain|air mattress', '
    death wish|life support', 'weather station|air service', 'air force
    |air travel', 'heart pounding|death wish', 'research station|
    reading room', 'blood bank|heart disease', 'blood bank|heart
    monitor', 'blood test|life events', 'water availability|blood flow'
    , 'adult life|life events', 'heart rate|time period', 'life force|
    life savings', 'train station|water hole', 'water fountain|life
    jacket', 'water line|water temperature', 'life span|life support',
    'tree line|animal life', 'life force|death penalty', 'police
    station|computer room', 'air travel|air fare', 'water glass|water
    lilies', 'heart monitor|life support', 'air space|air travel', '
    trend line|life expectancy', 'life force|heart rate', 'water glass|
    water pressure', 'hotel room|air mattress', 'train station|air
    service', 'space station|time zone', 'blood vessel|blood flow', '
    subway station|water hole', 'life savings|time period', 'weather
    station|life sciences', 'water vapor|blood flow', 'cruise line|
    dance company', 'water heater|air temperature', 'life force|heart
    pounding', 'blood type|blood test', 'research station|chat room', '
    heart attack|life force', 'blood type|heart attack', 'water
    pressure|heart attack', 'women students|water rights', 'life force|
    life expectancy', 'blood vessel|heart disease', 'air service|time
    interval', 'task force|research station', 'trend line|time interval
    ', 'task force|law students', 'power station|water hole', 'heart
    attack|life sciences', 'party line|dance company', 'chat room|sex
    life', 'subway station|dorm room', 'water line|air space', 'grad
    students|adult life', 'heart monitor|time limit', 'air flow|air
    travel', 'cruise line|air fare', 'law students|reading room', 'air
    space|air fare', 'life force|space station', 'blood flow|heart
    monitor', 'water vapor|air space', 'death penalty|life support', '
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heart disease|life span', 'gas station|finance company', 'life force|life events', 'cruise line|hotel room', 'life force|heart attack', 'blood pressure|heart attack', 'air temperature|air service', 'card table|computer room', 'air temperature|time interval', 'death toll|life savings', 'power station|life sciences', 'power station|chat room', 'research station|computer room', 'blood test|heart monitor', 'trend line|air temperature', 'adult life|heart pounding', 'blood type|heart rate', 'trend line|power station', 'trend line|heart monitor', 'space station|air space', 'life force|gas station', 'adult life|time period', 'water line|air flow', 'air force|blood flow', 'hotel room|sex life', 'invasion force|death sentence', 'adult life|life expectancy', 'water pressure|heart pounding', 'water line|life support', 'shelf life| life span', 'party line|time zone', 'life support|life jacket', 'heart rate|life force', 'women students|adult life', 'space station |dorm room', 'research station|life sciences', 'air force|air space ', 'heart monitor|life sciences', 'death wish|death camp', 'cruise line|subway station', 'trend line|research station', 'space station |air service', 'death certificate|life support', 'breakfast table| living room', 'heart rate|life support', 'death sentence|death camp ', 'death sentence|life jacket', 'power station|life force', 'water hole|blood vessel', 'water line|water vapor', 'space station|air travel', 'blood vessel|blood bank', 'grad students|research station ', 'water line|blood pressure', 'art students|dance company', ' police station|death sentence', 'blood vessel|blood test', 'death toll|life span', 'heart disease|heart rate', 'death sentence|life style', 'heart pounding|death penalty', 'cruise line|train station' , 'bus station|air service', 'water availability|time limit', 'task force|death squads', 'heart disease|life expectancy', 'life skills |life support', 'death sentence|life support', 'blood pressure|air temperature', 'trend line|life span', 'love life|life expectancy', 'life force|blood test', 'blood flow|heart rate', 'life expectancy| life support', 'life span|time interval', 'life force|life support' , 'wiggle room|time period', 'telephone line|finance company', ' death penalty|time limit', 'telephone line|computer room', 'air flow|air fare', 'research station|life support', 'grad students| dorm room', 'invasion force|death squads', 'heart monitor|heart disease', 'water lilies|water temperature', 'death penalty|life skills', 'blood pressure|blood bank', 'air temperature|air flow', ' blood type|life sciences', 'finance company|death camp', 'water pressure|heart monitor', 'air flow|heart rate', 'death certificate| life style', 'space station|death camp', 'blood vessel|life force', 'task force|dance company', 'finance company|life savings', 'blood pressure|life sciences', 'air space|time interval', 'adult life| death certificate', 'card table|chat room', 'air force|air flow', ' living room|air temperature', 'death sentence|life expectancy', ' blood test|time limit', 'air flow|time interval', 'television station|finance company', 'blood test|heart attack', 'bus station| hotel room', 'life events|life support', 'adult life|life skills', 'law students|dorm room', 'life span|life skills', 'blood test| heart disease', 'blood flow|life force', 'weather station|air temperature', 'death camp|life events', 'air flow|air mattress', '

```
blood pressure|air service', 'bargaining table|computer room', '
bargaining table|chat room', 'story line|life events', 'party line|
dorm room', 'blood flow|heart attack', 'assembly line|invasion
force', 'computer room|blood bank', 'water temperature|time period'
, 'trend line|life savings', 'heart pounding|heart rate', 'trend
line|time period', 'death penalty|life events', 'television station
|computer room', 'water line|water pressure', 'heart attack|death
toll', 'story line|power station', 'love life|time period', 'blood
bank|blood test', 'death squads|life events', 'power station|
computer room', 'card table|reading room', 'task force|air service'
, 'air fare|time interval', 'invasion force|death penalty', 'blood
pressure|heart disease', 'blood vessel|heart attack', 'life force|
water availability', 'water vapor|life sciences', 'death wish|life
expectancy', 'life expectancy|life force']
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COCA Vanilla Model guessed Similar when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['dorm room|chat room', 'dorm room|wiggle room', 'hotel room|wiggle
    room']
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COCA Vanilla Model guessed Unknown when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['life expectancy|life sciences', 'trend line|goal line', 'death
    certificate|death squads', 'cruise line|punch line', 'dance company
    |finance company', 'reading room|wiggle room', 'life expectancy|
    life savings', 'computer room|wiggle room', 'invasion force|life
    force', 'breakfast table|bargaining table', 'bargaining table|card
    table', 'assembly line|telephone line', 'water fountain|water
    lilies', 'computer room|dorm room', 'water vapor|water temperature'
    , 'telephone line|punch line', 'pool table|card table']
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COCA Vanilla Model guessed Not similar when Mechanical Turk answered
    Very Similar for the following noun compound pairs:

['blood pressure|heart rate', 'blood flow|heart pounding', 'water
    rights|water pressure', 'heart attack|heart pounding', 'blood
    vessel|blood type', 'blood pressure|blood flow', 'heart attack|
    heart monitor', 'time interval|time period', 'blood bank|blood flow
    ', 'art students|law students', 'air force|task force', 'life force
    |life span', 'party line|chat room', 'animal life|life force', '
    reading room|living room', 'death sentence|life span', 'life
```

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         expectancy|time limit', 'blood vessel|blood pressure', 'air force|
         air service', 'life expectancy|time period', 'shelf life|life
         expectancy', 'love life|life events', 'heart disease|death sentence
         ', 'heart attack|heart rate', 'heart attack|heart disease', 'death
         penalty|death camp', 'air service|air travel', 'blood pressure|air
         flow', 'power station|research station', 'air force|air temperature
         ', 'blood pressure|blood test', 'time period|time limit', 'death
         wish|death sentence', 'death toll|life support', 'life span|time
         period', 'heart disease|heart pounding', 'death wish|life span']
    -------------------------------------------------------
225 -------------------------------------------------------

    COCA Vanilla Model guessed Similar when Mechanical Turk answered Very
        Similar for the following noun compound pairs:

    ['grad students|law students', 'hotel room|dorm room', 'train station|
        subway station', 'bus station|subway station']
230 -------------------------------------------------------

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    COCA Vanilla Model guessed Unknown when Mechanical Turk answered Very
        Similar for the following noun compound pairs:
235
    ['women students|law students', 'water heater|water temperature', '
        police station|subway station', 'death penalty|death sentence', '
        breakfast table|oak table', 'breakfast table|card table', 'grad
        students|women students', 'water temperature|air temperature', 'bus
         station|train station', 'gas station|subway station', 'grad
        students|art students', 'life expectancy|life span', 'sex life|love
         life', 'finance company|parent company']
    -------------------------------------------------------

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240
    COCA Vanilla Model guessed Not similar when Mechanical Turk answered
        Unknown for the following noun compound pairs:

    ['bargaining table|death wish', 'blood vessel|heart rate', 'blood
        pressure|death toll', 'water line|water fountain', 'cruise line|
        space station', 'invasion force|water rights', 'death toll|death
        certificate', 'blood test|blood flow', 'blood flow|life sciences',
        'animal life|life support', 'tree line|water lilies', 'adult life|
        time interval', 'research station|time period', 'train station|
        power station', 'air temperature|life span', 'life force|air
        service', 'death penalty|death toll', 'water heater|water hole', '
        death squads|life span', 'cruise line|water rights', 'air service|
        life force', 'party line|air flow', 'water hole|water rights', '
        story line|tree line', 'blood vessel|life support', 'air force|
        police station', 'goal line|water hole', 'heart attack|death
        certificate', 'life force|death toll', 'trend line|water
```

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        temperature ', 'death sentence|life force ', 'heart attack|life
        expectancy ', 'water hole|water pressure ', 'water line|life force ',
        'life force|life sciences ', 'animal life|love life ', 'dorm room|air
         space ', 'life force|time interval ', 'water availability|life span '
        , 'life savings|life style ', 'blood type|heart pounding ', 'shelf
        life|time limit ', 'life force|life skills ', 'goal line|life savings
        ', 'water temperature|life force ', 'party line|reading room ', 'gas
        station|research station ', 'water fountain|water pressure ', 'party
        line|water line ', 'gas station|death camp ', 'air force|life support
        ', 'subway station|hotel room ', 'power station|reading room ', '
        party line|blood bank ', 'blood bank|life savings ', 'space station|
        life support ', 'life force|blood pressure ', 'air temperature|air
        space ', 'adult life|life span ', 'air space|air service ', 'life
        force|time period ', 'goal line|life events ', 'breakfast table|water
         glass ', 'life events|life force ', 'dorm room|death camp ', 'train
        station|blood vessel ', 'heart disease|life support ', 'pool table|
        television station ', 'television station|animal life ', 'invasion
        force|police station ', 'heart disease|time period ', 'sex life|life
        skills ', 'heart pounding|life expectancy ', 'weather station|living
        room ', 'shelf life|death certificate ', 'subway station|computer
        room ', 'time zone|time limit ', 'gas station|air fare ', 'brute force
        |heart rate ', 'blood test|death certificate ', 'cruise line|life
        events ', 'television station|research station ', 'life force|life
        jacket ', 'water rights|blood bank ', 'story line|goal line ']
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COCA Vanilla Model guessed Unknown when Mechanical Turk answered
        Similar for the following noun compound pairs:

['bargaining table|oak table ', 'card table|oak table ', 'pool table|
        bargaining table ', 'weather station|subway station ', 'computer room
        |chat room ', 'space station|subway station ', 'adult life|animal
        life ', 'reading room|chat room ', 'death wish|death squads ', '
        breakfast table|pool table ', 'water fountain|water heater ', '
        reading room|computer room ', 'life expectancy|life skills ', 'dorm
        room|living room ', 'space station|weather station ', 'television
        station|subway station ', 'life events|life expectancy ', 'air force|
        invasion force ', 'pool table|oak table ', 'life expectancy|life
        style ', 'adult life|sex life ', 'art students|minority students ', '
        life force|invasion force ', 'telephone line|tree line ', 'death camp
        |death squads ', 'water line|tree line ', 'party line|telephone line '
        ]
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COCA Vanilla Model guessed Not similar when Mechanical Turk answered
        Similar for the following noun compound pairs:

['death sentence|time limit ', 'air service|air fare ', 'time zone|time
```

period', 'breakfast table|subway station', 'gas station|power station', 'cruise line|water lilies', 'water pressure|air flow', 'bus station|air space', 'water line|death certificate', 'dance company|sex life', 'assembly line|power station', 'life force|task force', 'tree line|goal line', 'assembly line|life skills', 'life events|life style', 'telephone line|chat room', 'assembly line|task force', 'water line|space station', 'police station|power station', 'water line|water hole', 'air flow|heart disease', 'life span|life style', 'heart monitor|heart pounding', 'police station|death squads', 'police station|research station', 'air flow|life sciences', 'water glass|water hole', 'life force|death certificate', 'heart monitor|time interval', 'dance company|parent company', 'air force|heart rate', 'water line|water glass', 'air space|air flow', 'water availability|water rights', 'finance company|adult life', 'blood pressure|heart pounding', 'blood type|blood pressure', 'weather station|water temperature', 'gas station|water fountain', 'blood vessel|heart monitor', 'brute force|heart attack', 'subway station|chat room', 'hotel room|living room', 'life force|air space', 'water pressure|air temperature', 'party line|animal life', 'space station|gas station', 'blood type|heart disease', 'sex life|heart monitor', 'love life|life skills', 'blood flow|heart disease', 'blood flow|life span', 'blood pressure|heart monitor', 'cruise line|finance company', 'weather station|air space', 'love life|life force', 'heart pounding|life force', 'love life|life style', 'water glass|water heater', 'police station|reading room', 'blood type|blood flow', 'water fountain|air mattress', 'life savings|life skills', 'water line|water heater', 'love life|shelf life', 'death wish|life support', 'weather station|air service', 'air force|air travel', 'heart pounding|death wish', 'water availability|water pressure', 'research station|reading room', 'blood bank|heart disease', 'police station|train station', 'blood bank|heart monitor', 'blood test|life events', 'water availability|blood flow', 'adult life|life events', 'heart rate|time period', 'life force|life savings', 'train station|water hole', 'water fountain|life jacket', 'water line|water temperature', 'bus station|gas station', 'life span|life support', 'tree line|animal life', 'life force|death penalty', 'police station|computer room', 'air travel|air fare', 'water glass|water lilies', 'heart monitor|life support', 'air space|air travel', 'trend line|life expectancy', 'death wish|death penalty', 'life force|heart rate', 'time zone|time machine', 'water glass|water pressure', 'hotel room|air mattress', 'television station|power station', 'train station|air service', 'art students|women students', 'space station|time zone', 'blood vessel|blood flow', 'subway station|water hole', 'life savings|time period', 'life events|life skills', 'train station|gas station', 'weather station|life sciences', 'water vapor|blood flow', 'cruise line|dance company', 'water heater|air temperature', 'life force|heart pounding', 'death wish|death certificate', 'assembly line|story line', 'blood type|blood test', 'research station|chat room', 'heart attack|life force', 'blood type|heart attack', 'police station|weather station', 'subway station|research station', 'water pressure|heart attack', 'water availability|water heater', 'women

students|water rights', 'life force|life expectancy', 'blood vessel
|heart disease', 'air service|time interval', 'task force|research
station', 'hotel room|computer room', 'trend line|time interval', '
water vapor|water pressure', 'task force|law students', 'power
station|water hole', 'space station|television station', 'heart
attack|life sciences', 'party line|dance company', 'chat room|sex
life', 'subway station|dorm room', 'water line|air space', 'living
room|chat room', 'television station|weather station', 'grad
students|adult life', 'heart monitor|time limit', 'life skills|life
 style', 'cruise line|party line', 'air flow|air travel', 'cruise
line|air fare', 'law students|reading room', 'air space|air fare',
'life force|space station', 'blood flow|heart monitor', 'water
vapor|air space', 'death penalty|life support', 'heart disease|life
 span', 'gas station|finance company', 'life force|life events', '
cruise line|hotel room', 'life force|heart attack', 'blood pressure
|heart attack', 'assembly line|water line', 'time interval|time
limit', 'air temperature|air service', 'card table|computer room',
'air temperature|time interval', 'death toll|life savings', 'power
station|life sciences', 'space station|power station', 'power
station|chat room', 'research station|computer room', 'blood test|
heart monitor', 'reading room|hotel room', 'trend line|air
temperature', 'adult life|heart pounding', 'blood type|heart rate',
 'trend line|power station', 'trend line|heart monitor', 'space
station|air space', 'life force|gas station', 'adult life|time
period', 'water line|air flow', 'air force|blood flow', 'hotel room
|sex life', 'invasion force|death sentence', 'adult life|life
expectancy', 'weather station|power station', 'water fountain|water
 rights', 'water pressure|heart pounding', 'life sciences|life
style', 'water line|life support', 'shelf life|life span', '
television station|gas station', 'party line|time zone', 'life
support|life jacket', 'heart rate|life force', 'women students|
adult life', 'water fountain|water hole', 'space station|dorm room'
, 'research station|life sciences', 'air force|air space', 'heart
monitor|life sciences', 'adult life|love life', 'bus station|space
station', 'death wish|death camp', 'cruise line|subway station', '
trend line|research station', 'death wish|death toll', 'life
savings|life span', 'space station|air service', 'death certificate
|life support', 'space station|train station', 'breakfast table|
living room', 'heart rate|life support', 'death sentence|death camp
', 'death sentence|life jacket', 'water fountain|water vapor', '
power station|life force', 'water hole|blood vessel', 'water line|
water vapor', 'water hole|water lilies', 'space station|air travel'
, 'space station|research station', 'water lilies|water rights', '
blood vessel|blood bank', 'grad students|research station', 'water
line|blood pressure', 'tree line|trend line', 'art students|dance
company', 'story line|trend line', 'telephone line|water line', '
police station|death sentence', 'blood vessel|blood test', 'death
toll|life span', 'heart disease|heart rate', 'police station|space
station', 'water pressure|blood pressure', 'death sentence|life
style', 'heart pounding|death penalty', 'cruise line|train station'
, 'bus station|air service', 'water availability|time limit', '
water lilies|water vapor', 'assembly line|party line', 'task force|

```
      death squads', 'cruise line|story line', 'heart disease|life
      expectancy', 'life skills|life support', 'death sentence|life
      support', 'blood pressure|air temperature', 'brute force|task force
      ', 'trend line|life span', 'love life|life expectancy', 'air force|
      brute force', 'life force|blood test', 'blood flow|heart rate', '
      life expectancy|life support', 'life span|time interval', 'life
      force|life support', 'wiggle room|time period', 'telephone line|
      finance company', 'death penalty|time limit', 'telephone line|
      computer room', 'air flow|air fare', 'research station|life support
      ', 'grad students|dorm room', 'invasion force|death squads', 'death
       sentence|death toll', 'time zone|time interval', 'heart monitor|
      heart disease', 'death sentence|death squads', 'water heater|water
      pressure', 'water lilies|water temperature', 'death penalty|life
      skills', 'party line|trend line', 'blood pressure|blood bank', 'air
       temperature|air flow', 'death sentence|death certificate', 'blood
      type|life sciences', 'finance company|death camp', 'water pressure|
      heart monitor', 'air flow|heart rate', 'death certificate|life
      style', 'space station|death camp', 'blood vessel|life force', '
      task force|dance company', 'finance company|life savings', 'blood
      pressure|life sciences', 'air space|time interval', 'adult life|
      death certificate', 'card table|chat room', 'air force|air flow', '
      water heater|water rights', 'living room|air temperature', 'death
      sentence|life expectancy', 'blood test|time limit', 'air flow|time
      interval', 'television station|finance company', 'blood test|heart
      attack', 'weather station|research station', 'bus station|hotel
      room', 'life events|life support', 'adult life|life skills', 'law
      students|dorm room', 'life span|life skills', 'blood test|heart
      disease', 'blood flow|air flow', 'blood flow|life force', 'weather
      station|air temperature', 'subway station|power station', 'death
      camp|life events', 'air flow|air mattress', 'life events|life span'
      , 'blood pressure|air service', 'bargaining table|computer room', '
      bargaining table|chat room', 'story line|life events', 'party line|
      dorm room', 'blood flow|heart attack', 'assembly line|invasion
      force', 'computer room|blood bank', 'water temperature|time period'
      , 'trend line|life savings', 'heart pounding|heart rate', 'trend
      line|time period', 'death penalty|life events', 'television station
      |computer room', 'water line|water pressure', 'heart attack|death
      toll', 'story line|power station', 'love life|time period', 'blood
      bank|blood test', 'death squads|life events', 'power station|
      computer room', 'card table|reading room', 'task force|air service'
      , 'air fare|time interval', 'invasion force|death penalty', 'water
      availability|water hole', 'blood pressure|heart disease', 'blood
      vessel|heart attack', 'life force|water availability', 'water vapor
      |life sciences', 'death wish|life expectancy', 'life expectancy|
      life force']
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GloWbE Weighted Model guessed Similar when Mechanical Turk answered
      Unknown for the following noun compound pairs:
```

```
['death toll|death certificate', 'death penalty|death toll', 'task
    force|invasion force', 'story line|tree line', 'story line|
    telephone line', 'brute force|life force', 'gas station|research
    station', 'party line|water line', 'hotel room|chat room', '
    television station|research station', 'story line|goal line']
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GloWbE Weighted Model guessed Similar when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['television station|train station', 'telephone line|trend line', 'dorm
    room|chat room', 'dorm room|wiggle room', 'life expectancy|life
    sciences', 'water availability|water temperature', 'trend line|goal
    line', 'punch line|trend line', 'death certificate|death squads',
    'punch line|tree line', 'water line|trend line', 'punch line|goal
    line', 'cruise line|tree line', 'cruise line|goal line', 'death
    penalty|death certificate', 'cruise line|punch line', 'telephone
    line|goal line', 'assembly line|goal line', 'story line|punch line'
    , 'dance company|finance company', 'water availability|water vapor'
    , 'reading room|wiggle room', 'life expectancy|life savings', '
    party line|punch line', 'computer room|wiggle room', 'life sciences
    |life skills', 'assembly line|trend line', 'living room|wiggle room
    ', 'bus station|weather station', 'water availability|water lilies'
    , 'invasion force|life force', 'water glass|water vapor', 'party
    line|story line', 'task force|life force', 'assembly line|cruise
    line', 'life sciences|life savings', 'bus station|television
    station', 'breakfast table|bargaining table', 'bargaining table|
    card table', 'air force|life force', 'assembly line|telephone line'
    , 'water fountain|water lilies', 'cruise line|water line', 'punch
    line|water line', 'adult life|shelf life', 'story line|water line',
     'computer room|dorm room', 'train station|weather station', '
    assembly line|punch line', 'life sciences|life span', 'party line|
    goal line', 'life events|life savings', 'water vapor|water
    temperature', 'cruise line|trend line', 'water line|goal line', '
    telephone line|punch line', 'police station|television station', '
    pool table|card table', 'animal life|sex life', 'hotel room|wiggle
    room', 'water heater|water lilies', 'sex life|shelf life', 'party
    line|tree line', 'computer room|living room', 'cruise line|
    telephone line', 'water fountain|water availability', 'weather
    station|gas station', 'life events|life sciences', 'animal life|
    shelf life']
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GloWbE Weighted Model guessed Unknown when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['time machine|time limit', 'water temperature|water pressure', 'time
    interval|time machine', 'police station|gas station', 'life span|
```

58

```
        life jacket', 'life style|life jacket', 'air mattress|air fare', '
        life savings|life jacket', 'bus station|research station', 'water
        hole|water vapor', 'train station|research station', 'life events|
        life jacket', 'bus station|police station', 'bus station|power
        station', 'water availability|water glass']
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        GloWbE Weighted Model guessed Not similar when Mechanical Turk answered
            Very Similar for the following noun compound pairs:
```

```
        ['blood pressure|heart rate', 'blood flow|heart pounding', 'water
            rights|water pressure', 'heart attack|heart pounding', 'blood
            vessel|blood type', 'blood pressure|blood flow', 'heart attack|
            heart monitor', 'blood bank|blood flow', 'life force|life span', '
            party line|chat room', 'animal life|life force', 'death penalty|
            death sentence', 'death sentence|life span', 'life expectancy|time
            limit', 'blood vessel|blood pressure', 'air force|air service', '
            life expectancy|time period', 'shelf life|life expectancy', 'love
            life|life events', 'heart disease|death sentence', 'heart attack|
            heart rate', 'heart attack|heart disease', 'death penalty|death
            camp', 'air service|air travel', 'blood pressure|air flow', 'air
            force|air temperature', 'blood pressure|blood test', 'death wish|
            death sentence', 'death toll|life support', 'life span|time period'
            , 'heart disease|heart pounding', 'death wish|life span']
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        GloWbE Weighted Model guessed Similar when Mechanical Turk answered
            Very Similar for the following noun compound pairs:
```

```
        ['women students|law students', 'grad students|law students', 'life
            force|life force', 'water heater|water temperature', 'art students|
            law students', 'air force|task force', 'police station|subway
            station', 'breakfast table|oak table', 'breakfast table|card table'
            , 'reading room|living room', 'grad students|women students', '
            water temperature|air temperature', 'bus station|train station', '
            gas station|subway station', 'grad students|art students', 'hotel
            room|dorm room', 'life expectancy|life span', 'sex life|love life',
             'finance company|parent company', 'train station|subway station',
            'bus station|subway station']
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        --------------------------------------------------------

        GloWbE Weighted Model guessed Unknown when Mechanical Turk answered
            Very Similar for the following noun compound pairs:
```

```
        ['time interval|time period', 'power station|research station', 'time
            period|time limit']
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300   --------------------------------------------------------


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      GloWbE Weighted Model guessed Not similar when Mechanical Turk answered
          Unknown for the following noun compound pairs:
305
      ['bargaining table|death wish', 'blood vessel|heart rate', 'blood
          pressure|death toll', 'water line|water fountain', 'cruise line|
          space station', 'invasion force|water rights', 'blood test|blood
          flow', 'blood flow|life sciences', 'animal life|life support', '
          tree line|water lilies', 'adult life|time interval', 'research
          station|time period', 'air temperature|life span', 'life force|air
          service', 'death squads|life span', 'cruise line|water rights', '
          air service|life force', 'party line|air flow', 'blood vessel|life
          support', 'air force|police station', 'goal line|water hole', '
          heart attack|death certificate', 'life force|death toll', 'trend
          line|water temperature', 'death sentence|life force', 'heart attack
          |life expectancy', 'water line|life force', 'life force|life
          sciences', 'dorm room|air space', 'life force|time interval', '
          water availability|life span', 'blood type|heart pounding', 'shelf
          life|time limit', 'life force|life skills', 'goal line|life savings
          ', 'water temperature|life force', 'party line|reading room', 'gas
          station|death camp', 'air force|life support', 'subway station|
          hotel room', 'power station|reading room', 'party line|blood bank',
           'blood bank|life savings', 'space station|life support', 'life
          force|blood pressure', 'air temperature|air space', 'adult life|
          life span', 'air space|air service', 'life force|time period', '
          goal line|life events', 'breakfast table|water glass', 'life events
          |life force', 'dorm room|death camp', 'train station|blood vessel',
           'heart disease|life support', 'pool table|television station', '
          television station|animal life', 'invasion force|police station', '
          heart disease|time period', 'sex life|life skills', 'heart pounding
          |life expectancy', 'weather station|living room', 'shelf life|death
           certificate', 'subway station|computer room', 'gas station|air
          fare', 'brute force|heart rate', 'blood test|death certificate', '
          cruise line|life events', 'life force|life jacket', 'water rights|
          blood bank']
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310
      GloWbE Weighted Model guessed Unknown when Mechanical Turk answered
          Similar for the following noun compound pairs:

      ['time zone|time period', 'gas station|power station', 'life span|life
          style', 'heart monitor|heart pounding', 'police station|research
          station', 'life savings|life skills', 'love life|shelf life', '
          police station|train station', 'death wish|death penalty', 'time
          zone|time machine', 'water glass|water pressure', 'television
          station|power station', 'life events|life skills', 'water vapor|
          water pressure', 'life skills|life style', 'time interval|time
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limit', 'space station|power station', 'life sciences|life style',
        'life expectancy|life skills', 'police station|space station', '
        life events|life expectancy', 'life expectancy|life style', 'time
        zone|time interval', 'life span|life skills', 'death camp|death
        squads', 'life events|life span', 'water availability|water hole']

GloWbE Weighted Model guessed Not similar when Mechanical Turk answered
        Similar for the following noun compound pairs:

['death sentence|time limit', 'air service|air fare', 'breakfast table|
        subway station', 'cruise line|water lilies', 'water pressure|air
        flow', 'bus station|air space', 'water line|death certificate', '
        dance company|sex life', 'assembly line|power station', 'assembly
        line|life skills', 'telephone line|chat room', 'assembly line|task
        force', 'water line|space station', 'police station|power station',
         'water line|water hole', 'air flow|heart disease', 'police station
        |death squads', 'air flow|life sciences', 'life force|death
        certificate', 'heart monitor|time interval', 'air force|heart rate'
        , 'water line|water glass', 'air space|air flow', 'finance company|
        adult life', 'blood pressure|heart pounding', 'blood type|blood
        pressure', 'weather station|water temperature', 'gas station|water
        fountain', 'blood vessel|heart monitor', 'brute force|heart attack'
        , 'subway station|chat room', 'life force|air space', 'water
        pressure|air temperature', 'party line|animal life', 'blood type|
        heart disease', 'sex life|heart monitor', 'love life|life skills',
        'blood flow|heart disease', 'blood flow|life span', 'blood pressure
        |heart monitor', 'cruise line|finance company', 'weather station|
        air space', 'love life|life force', 'heart pounding|life force', '
        love life|life style', 'police station|reading room', 'blood type|
        blood flow', 'water fountain|air mattress', 'water line|water
        heater', 'death wish|life support', 'weather station|air service',
        'air force|air travel', 'heart pounding|death wish', 'research
        station|reading room', 'blood bank|heart disease', 'blood bank|
        heart monitor', 'blood test|life events', 'water availability|blood
         flow', 'adult life|life events', 'heart rate|time period', 'life
        force|life savings', 'train station|water hole', 'water fountain|
        life jacket', 'water line|water temperature', 'life span|life
        support', 'tree line|animal life', 'life force|death penalty', '
        police station|computer room', 'air travel|air fare', 'heart
        monitor|life support', 'air space|air travel', 'trend line|life
        expectancy', 'life force|heart rate', 'hotel room|air mattress', '
        train station|air service', 'space station|time zone', 'blood
        vessel|blood flow', 'subway station|water hole', 'life savings|time
         period', 'weather station|life sciences', 'water vapor|blood flow'
        , 'cruise line|dance company', 'water heater|air temperature', '
        life force|heart pounding', 'blood type|blood test', 'research
        station|chat room', 'heart attack|life force', 'blood type|heart
        attack', 'water pressure|heart attack', 'women students|water
        rights', 'life force|life expectancy', 'blood vessel|heart disease'

61

, 'air service|time interval', 'task force|research station', 'trend line|time interval', 'task force|law students', 'power station|water hole', 'heart attack|life sciences', 'party line|dance company', 'chat room|sex life', 'subway station|dorm room', 'water line|air space', 'grad students|adult life', 'heart monitor|time limit', 'air flow|air travel', 'cruise line|air fare', 'law students|reading room', 'air space|air fare', 'life force|space station', 'blood flow|heart monitor', 'water vapor|air space', 'death penalty|life support', 'heart disease|life span', 'gas station|finance company', 'life force|life events', 'cruise line|hotel room', 'life force|heart attack', 'blood pressure|heart attack', 'air temperature|air service', 'card table|computer room', 'air temperature|time interval', 'death toll|life savings', 'power station|life sciences', 'power station|chat room', 'research station|computer room', 'blood test|heart monitor', 'trend line|air temperature', 'adult life|heart pounding', 'blood type|heart rate', 'trend line|power station', 'trend line|heart monitor', 'space station|air space', 'life force|gas station', 'adult life|time period', 'water line|air flow', 'air force|blood flow', 'hotel room|sex life', 'invasion force|death sentence', 'adult life|life expectancy', 'water fountain|water rights', 'water pressure|heart pounding', 'water line|life support', 'shelf life|life span', 'party line|time zone', 'life support|life jacket', 'heart rate|life force', 'women students|adult life', 'space station|dorm room', 'research station|life sciences', 'air force|air space', 'heart monitor|life sciences', 'death wish|death camp', 'cruise line|subway station', 'trend line|research station', 'space station|air service', 'death certificate|life support', 'breakfast table|living room', 'heart rate|life support', 'death sentence|death camp', 'death sentence|life jacket', 'power station|life force', 'water hole|blood vessel', 'water line|water vapor', 'space station|air travel', 'water lilies|water rights', 'blood vessel|blood bank', 'grad students|research station', 'water line|blood pressure', 'art students|dance company', 'police station|death sentence', 'blood vessel|blood test', 'death toll|life span', 'heart disease|heart rate', 'death sentence|life style', 'heart pounding|death penalty', 'cruise line|train station', 'bus station|air service', 'water availability|time limit', 'task force|death squads', 'heart disease|life expectancy', 'life skills|life support', 'death sentence|life support', 'blood pressure|air temperature', 'trend line|life span', 'love life|life expectancy', 'life force|blood test', 'blood flow|heart rate', 'life expectancy|life support', 'life span|time interval', 'life force|life support', 'wiggle room|time period', 'telephone line|finance company', 'death penalty|time limit', 'telephone line|computer room', 'air flow|air fare', 'research station|life support', 'grad students|dorm room', 'invasion force|death squads', 'death sentence|death toll', 'heart monitor|heart disease', 'death sentence|death squads', 'water lilies|water temperature', 'death penalty|life skills', 'blood pressure|blood bank', 'air temperature|air flow', 'death sentence|death certificate', 'blood type|life sciences', 'finance company|death camp', 'water pressure|heart monitor', 'air flow|heart rate', '

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      death certificate|life style', 'space station|death camp', 'blood
      vessel|life force', 'task force|dance company', 'finance company|
      life savings', 'blood pressure|life sciences', 'air space|time
      interval', 'adult life|death certificate', 'card table|chat room',
      'air force|air flow', 'water heater|water rights', 'living room|air
       temperature', 'death sentence|life expectancy', 'blood test|time
      limit', 'air flow|time interval', 'television station|finance
      company', 'blood test|heart attack', 'bus station|hotel room', '
      life events|life support', 'adult life|life skills', 'law students|
      dorm room', 'blood test|heart disease', 'blood flow|life force', '
      weather station|air temperature', 'death camp|life events', 'air
      flow|air mattress', 'blood pressure|air service', 'bargaining table
      |computer room', 'bargaining table|chat room', 'story line|life
      events', 'party line|dorm room', 'blood flow|heart attack', '
      assembly line|invasion force', 'computer room|blood bank', 'water
      temperature|time period', 'trend line|life savings', 'heart
      pounding|heart rate', 'trend line|time period', 'death penalty|life
       events', 'television station|computer room', 'water line|water
      pressure', 'heart attack|death toll', 'story line|power station', '
      love life|time period', 'blood bank|blood test', 'death squads|life
       events', 'power station|computer room', 'card table|reading room',
       'task force|air service', 'air fare|time interval', 'invasion
      force|death penalty', 'blood pressure|heart disease', 'blood vessel
      |heart attack', 'life force|water availability', 'water vapor|life
      sciences', 'death wish|life expectancy', 'life expectancy|life
      force']
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GloWbE Component Model guessed Similar when Mechanical Turk answered
      Unknown for the following noun compound pairs:

['task force|invasion force', 'story line|telephone line', 'brute force
      |life force', 'hotel room|chat room']
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GloWbE Component Model guessed Similar when Mechanical Turk answered
      Not similar for the following noun compound pairs:

['telephone line|trend line', 'dorm room|chat room', 'dorm room|wiggle
      room', 'trend line|goal line', 'punch line|trend line', 'punch line
      |tree line', 'water line|trend line', 'punch line|goal line', '
      cruise line|tree line', 'cruise line|goal line', 'cruise line|punch
       line', 'telephone line|goal line', 'assembly line|goal line', '
      story line|punch line', 'dance company|finance company', 'water
      availability|water vapor', 'reading room|wiggle room', 'life
      expectancy|life savings', 'party line|punch line', 'computer room|
      wiggle room', 'assembly line|trend line', 'living room|wiggle room'
      , 'bus station|weather station', 'invasion force|life force', 'task
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      force|life force', 'assembly line|cruise line', 'bus station|
      television station', 'breakfast table|bargaining table', '
      bargaining table|card table', 'assembly line|telephone line', '
      water fountain|water lilies', 'cruise line|water line', 'punch line
      |water line', 'adult life|shelf life', 'computer room|dorm room', '
      train station|weather station', 'assembly line|punch line', 'cruise
       line|trend line', 'water line|goal line', 'telephone line|punch
      line', 'pool table|card table', 'animal life|sex life', 'hotel room
      |wiggle room', 'sex life|shelf life', 'computer room|living room',
      'cruise line|telephone line', 'weather station|gas station', '
      animal life|shelf life']
335 ------------------------------------------------------

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    GloWbE Component Model guessed Unknown when Mechanical Turk answered
        Not similar for the following noun compound pairs:
340
    ['television station|train station', 'life expectancy|life sciences', '
        water availability|water temperature', 'death certificate|death
        squads', 'death penalty|death certificate', 'sex life|life
        expectancy', 'police station|gas station', 'life sciences|life
        skills', 'water availability|water lilies', 'water glass|water
        vapor', 'party line|story line', 'bus station|research station', '
        life sciences|life savings', 'train station|research station', 'air
         force|life force', 'story line|water line', 'life sciences|life
        span', 'party line|goal line', 'water vapor|water temperature', '
        bus station|police station', 'police station|television station', '
        bus station|power station', 'water heater|water lilies', 'animal
        life|life expectancy', 'party line|tree line', 'water fountain|
        water availability']
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345
    GloWbE Component Model guessed Not similar when Mechanical Turk
        answered Very Similar for the following noun compound pairs:

    ['blood pressure|heart rate', 'blood flow|heart pounding', 'water
        rights|water pressure', 'heart attack|heart pounding', 'blood
        vessel|blood type', 'blood pressure|blood flow', 'heart attack|
        heart monitor', 'time interval|time period', 'blood bank|blood flow
        ', 'life force|life span', 'party line|chat room', 'animal life|
        life force', 'death penalty|death sentence', 'death sentence|life
        span', 'life expectancy|time limit', 'blood vessel|blood pressure',
         'air force|air service', 'life expectancy|time period', 'love life
        |life events', 'heart disease|death sentence', 'heart attack|heart
        rate', 'heart attack|heart disease', 'death penalty|death camp', '
        air service|air travel', 'blood pressure|air flow', 'air force|air
        temperature', 'blood pressure|blood test', 'time period|time limit'
        , 'death wish|death sentence', 'death toll|life support', 'life
        span|time period', 'heart disease|heart pounding', 'death wish|life
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      span']
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GloWbE Component Model guessed Similar when Mechanical Turk answered
    Very Similar for the following noun compound pairs:

['grad students|law students', 'breakfast table|oak table', 'breakfast
    table|card table', 'reading room|living room', 'grad students|women
     students', 'water temperature|air temperature', 'bus station|train
     station', 'gas station|subway station', 'grad students|art
    students', 'hotel room|dorm room', 'finance company|parent company'
    , 'train station|subway station', 'bus station|subway station']
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GloWbE Component Model guessed Unknown when Mechanical Turk answered
    Very Similar for the following noun compound pairs:

['women students|law students', 'water heater|water temperature', 'art
    students|law students', 'air force|task force', 'police station|
    subway station', 'shelf life|life expectancy', 'power station|
    research station', 'life expectancy|life span', 'sex life|love life
    ']
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GloWbE Component Model guessed Not similar when Mechanical Turk
    answered Unknown for the following noun compound pairs:

['bargaining table|death wish', 'blood vessel|heart rate', 'blood
    pressure|death toll', 'water line|water fountain', 'cruise line|
    space station', 'invasion force|water rights', 'blood test|blood
    flow', 'blood flow|life sciences', 'animal life|life support', '
    tree line|water lilies', 'adult life|time interval', 'research
    station|time period', 'train station|power station', 'air
    temperature|life span', 'life force|air service', 'water heater|
    water hole', 'death squads|life span', 'cruise line|water rights',
    'air service|life force', 'party line|air flow', 'water hole|water
    rights', 'blood vessel|life support', 'air force|police station', '
    goal line|water hole', 'heart attack|death certificate', 'life
    force|death toll', 'trend line|water temperature', 'death sentence|
    life force', 'heart attack|life expectancy', 'water hole|water
    pressure', 'water line|life force', 'life force|life sciences', '
    dorm room|air space', 'life force|time interval', 'water
    availability|life span', 'life savings|life style', 'blood type|
    heart pounding', 'shelf life|time limit', 'life force|life skills',
     'goal line|life savings', 'water temperature|life force', 'party
    line|reading room', 'water fountain|water pressure', 'gas station|
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      death camp', 'air force|life support', 'subway station|hotel room',
       'power station|reading room', 'party line|blood bank', 'blood bank
      |life savings', 'space station|life support', 'life force|blood
      pressure', 'air temperature|air space', 'adult life|life span', '
      air space|air service', 'life force|time period', 'goal line|life
      events', 'breakfast table|water glass', 'life events|life force', '
      dorm room|death camp', 'train station|blood vessel', 'heart disease
      |life support', 'pool table|television station', 'television
      station|animal life', 'invasion force|police station', 'heart
      disease|time period', 'sex life|life skills', 'heart pounding|life
      expectancy', 'weather station|living room', 'shelf life|death
      certificate', 'subway station|computer room', 'time zone|time limit
      ', 'gas station|air fare', 'brute force|heart rate', 'blood test|
      death certificate', 'cruise line|life events', 'life force|life
      jacket', 'water rights|blood bank']
370   -------------------------------------------------------


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      GloWbE Component Model guessed Unknown when Mechanical Turk answered
          Similar for the following noun compound pairs:
375
      ['gas station|power station', 'water availability|water rights', 'hotel
          room|living room', 'space station|gas station', 'water glass|water
           heater', 'love life|shelf life', 'water availability|water
          pressure', 'police station|train station', 'bus station|gas station
          ', 'water glass|water lilies', 'television station|power station',
          'art students|women students', 'train station|gas station', 'death
          wish|death certificate', 'police station|weather station', 'subway
          station|research station', 'water availability|water heater', '
          cruise line|party line', 'death wish|death squads', 'space station|
          power station', 'adult life|life expectancy', 'weather station|
          power station', 'water fountain|water hole', 'adult life|love life'
          , 'bus station|space station', 'death wish|death toll', 'life
          savings|life span', 'space station|train station', 'space station|
          research station', 'water pressure|blood pressure', 'water lilies|
          water vapor', 'blood flow|air flow', 'subway station|power station'
          , 'death camp|death squads']
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380
      GloWbE Component Model guessed Not similar when Mechanical Turk
          answered Similar for the following noun compound pairs:

      ['death sentence|time limit', 'air service|air fare', 'time zone|time
          period', 'breakfast table|subway station', 'cruise line|water
          lilies', 'water pressure|air flow', 'bus station|air space', 'water
           line|death certificate', 'dance company|sex life', 'assembly line|
          power station', 'assembly line|life skills', 'life events|life
          style', 'telephone line|chat room', 'assembly line|task force', '
          water line|space station', 'police station|power station', 'water
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line|water hole', 'air flow|heart disease', 'life span|life style', 'heart monitor|heart pounding', 'police station|death squads', 'police station|research station', 'air flow|life sciences', 'water glass|water hole', 'life force|death certificate', 'heart monitor|time interval', 'air force|heart rate', 'water line|water glass', 'air space|air flow', 'finance company|adult life', 'blood pressure|heart pounding', 'blood type|blood pressure', 'weather station|water temperature', 'gas station|water fountain', 'blood vessel|heart monitor', 'brute force|heart attack', 'subway station|chat room', 'life force|air space', 'water pressure|air temperature', 'party line|animal life', 'blood type|heart disease', 'sex life|heart monitor', 'love life|life skills', 'blood flow|heart disease', 'blood flow|life span', 'blood pressure|heart monitor', 'cruise line|finance company', 'weather station|air space', 'love life|life force', 'heart pounding|life force', 'love life|life style', 'police station|reading room', 'blood type|blood flow', 'water fountain|air mattress', 'life savings|life skills', 'water line|water heater', 'death wish|life support', 'weather station|air service', 'air force|air travel', 'heart pounding|death wish', 'research station|reading room', 'blood bank|heart disease', 'blood bank|heart monitor', 'blood test|life events', 'water availability|blood flow', 'adult life|life events', 'heart rate|time period', 'life force|life savings', 'train station|water hole', 'water fountain|life jacket', 'water line|water temperature', 'life span|life support', 'tree line|animal life', 'life force|death penalty', 'police station|computer room', 'air travel|air fare', 'heart monitor|life support', 'air space|air travel', 'trend line|life expectancy', 'death wish|death penalty', 'life force|heart rate', 'time zone|time machine', 'water glass|water pressure', 'hotel room|air mattress', 'train station|air service', 'space station|time zone', 'blood vessel|blood flow', 'subway station|water hole', 'life savings|time period', 'life events|life skills', 'weather station|life sciences', 'water vapor|blood flow', 'cruise line|dance company', 'water heater|air temperature', 'life force|heart pounding', 'blood type|blood test', 'research station|chat room', 'heart attack|life force', 'blood type|heart attack', 'water pressure|heart attack', 'women students|water rights', 'life force|life expectancy', 'blood vessel|heart disease', 'air service|time interval', 'task force|research station', 'trend line|time interval', 'water vapor|water pressure', 'task force|law students', 'power station|water hole', 'heart attack|life sciences', 'party line|dance company', 'chat room|sex life', 'subway station|dorm room', 'water line|air space', 'grad students|adult life', 'heart monitor|time limit', 'life skills|life style', 'air flow|air travel', 'cruise line|air fare', 'law students|reading room', 'air space|air fare', 'life force|space station', 'blood flow|heart monitor', 'water vapor|air space', 'death penalty|life support', 'heart disease|life span', 'gas station|finance company', 'life force|life events', 'cruise line|hotel room', 'life force|heart attack', 'blood pressure|heart attack', 'time interval|time limit', 'air temperature|air service', 'card table|computer room', 'air temperature|time interval', 'death toll|life savings', 'power

station|life sciences', 'power station|chat room', 'research
station|computer room', 'blood test|heart monitor', 'trend line|air
 temperature', 'adult life|heart pounding', 'blood type|heart rate'
, 'trend line|power station', 'trend line|heart monitor', 'space
station|air space', 'life force|gas station', 'adult life|time
period', 'water line|air flow', 'air force|blood flow', 'hotel room
|sex life', 'invasion force|death sentence', 'water fountain|water
rights', 'water pressure|heart pounding', 'life sciences|life style
', 'water line|life support', 'shelf life|life span', 'party line|
time zone', 'life support|life jacket', 'heart rate|life force', '
women students|adult life', 'space station|dorm room', 'research
station|life sciences', 'life expectancy|life skills', 'air force|
air space', 'heart monitor|life sciences', 'death wish|death camp',
 'cruise line|subway station', 'trend line|research station', '
space station|air service', 'death certificate|life support', '
breakfast table|living room', 'heart rate|life support', 'death
sentence|death camp', 'death sentence|life jacket', 'power station|
life force', 'water hole|blood vessel', 'water line|water vapor', '
water hole|water lilies', 'space station|air travel', 'water lilies
|water rights', 'blood vessel|blood bank', 'grad students|research
station', 'water line|blood pressure', 'art students|dance company'
, 'police station|death sentence', 'blood vessel|blood test', '
death toll|life span', 'heart disease|heart rate', 'police station|
space station', 'death sentence|life style', 'heart pounding|death
penalty', 'cruise line|train station', 'bus station|air service', '
water availability|time limit', 'task force|death squads', 'heart
disease|life expectancy', 'life skills|life support', 'death
sentence|life support', 'blood pressure|air temperature', 'trend
line|life span', 'love life|life expectancy', 'life events|life
expectancy', 'life force|blood test', 'blood flow|heart rate', '
life expectancy|life support', 'life span|time interval', 'life
force|life support', 'wiggle room|time period', 'telephone line|
finance company', 'death penalty|time limit', 'telephone line|
computer room', 'life expectancy|life style', 'air flow|air fare',
'research station|life support', 'grad students|dorm room', '
invasion force|death squads', 'death sentence|death toll', 'time
zone|time interval', 'heart monitor|heart disease', 'death sentence
|death squads', 'water heater|water pressure', 'water lilies|water
temperature', 'death penalty|life skills', 'blood pressure|blood
bank', 'air temperature|air flow', 'death sentence|death
certificate', 'blood type|life sciences', 'finance company|death
camp', 'water pressure|heart monitor', 'air flow|heart rate', '
death certificate|life style', 'space station|death camp', 'blood
vessel|life force', 'task force|dance company', 'finance company|
life savings', 'blood pressure|life sciences', 'air space|time
interval', 'adult life|death certificate', 'card table|chat room',
'air force|air flow', 'water heater|water rights', 'living room|air
 temperature', 'death sentence|life expectancy', 'blood test|time
limit', 'air flow|time interval', 'television station|finance
company', 'blood test|heart attack', 'bus station|hotel room', '
life events|life support', 'adult life|life skills', 'law students|
dorm room', 'life span|life skills', 'blood test|heart disease', '

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        blood flow|life force', 'weather station|air temperature', 'death
        camp|life events', 'air flow|air mattress', 'life events|life span'
        , 'blood pressure|air service', 'bargaining table|computer room', '
        bargaining table|chat room', 'story line|life events', 'party line|
        dorm room', 'blood flow|heart attack', 'assembly line|invasion
        force', 'computer room|blood bank', 'water temperature|time period'
        , 'trend line|life savings', 'heart pounding|heart rate', 'trend
        line|time period', 'death penalty|life events', 'television station
        |computer room', 'water line|water pressure', 'heart attack|death
        toll', 'story line|power station', 'love life|time period', 'blood
        bank|blood test', 'death squads|life events', 'power station|
        computer room', 'card table|reading room', 'task force|air service'
        , 'air fare|time interval', 'invasion force|death penalty', 'water
        availability|water hole', 'blood pressure|heart disease', 'blood
        vessel|heart attack', 'life force|water availability', 'water vapor
        |life sciences', 'death wish|life expectancy', 'life expectancy|
        life force']
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385

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     COCA Component Model guessed Similar when Mechanical Turk answered
        Unknown for the following noun compound pairs:

390  ['death toll|death certificate', 'death penalty|death toll', 'task
        force|invasion force', 'story line|telephone line', 'brute force|
        life force', 'hotel room|chat room', 'story line|goal line', 'death
         penalty|death squads']
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395  COCA Component Model guessed Similar when Mechanical Turk answered Not
        similar for the following noun compound pairs:

     ['telephone line|trend line', 'dorm room|chat room', 'dorm room|wiggle
        room', 'life expectancy|life sciences', 'trend line|goal line', '
        punch line|trend line', 'death certificate|death squads', 'punch
        line|tree line', 'water line|trend line', 'punch line|goal line', '
        cruise line|tree line', 'cruise line|goal line', 'death penalty|
        death certificate', 'cruise line|punch line', 'telephone line|goal
        line', 'assembly line|goal line', 'story line|punch line', 'dance
        company|finance company', 'reading room|wiggle room', 'life
        expectancy|life savings', 'party line|punch line', 'computer room|
        wiggle room', 'assembly line|trend line', 'living room|wiggle room'
        , 'bus station|weather station', 'invasion force|life force', '
        assembly line|cruise line', 'breakfast table|bargaining table', '
        bargaining table|card table', 'assembly line|telephone line', '
        water fountain|water lilies', 'cruise line|water line', 'punch line
        |water line', 'adult life|shelf life', 'computer room|dorm room', '
        train station|weather station', 'assembly line|punch line', 'party
        line|goal line', 'cruise line|trend line', 'water line|goal line',
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69

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      'telephone line|punch line', 'pool table|card table', 'animal life|
      sex life', 'hotel room|wiggle room', 'sex life|shelf life', 'cruise
       line|telephone line', 'animal life|shelf life']
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COCA Component Model guessed Unknown when Mechanical Turk answered Not
      similar for the following noun compound pairs:

['television station|train station', 'water availability|water
      temperature', 'sex life|life expectancy', 'police station|gas
      station', 'water availability|water vapor', 'life sciences|life
      skills', 'water availability|water lilies', 'party line|story line'
      , 'bus station|research station', 'task force|life force', 'life
      sciences|life savings', 'bus station|television station', 'train
      station|research station', 'air force|life force', 'story line|
      water line', 'water vapor|water temperature', 'bus station|police
      station', 'police station|television station', 'bus station|power
      station', 'water heater|water lilies', 'party line|tree line', '
      computer room|living room', 'water fountain|water availability', '
      weather station|gas station', 'life events|life sciences']
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COCA Component Model guessed Not similar when Mechanical Turk answered
      Very Similar for the following noun compound pairs:

['blood pressure|heart rate', 'blood flow|heart pounding', 'water
      rights|water pressure', 'heart attack|heart pounding', 'blood
      vessel|blood type', 'blood pressure|blood flow', 'heart attack|
      heart monitor', 'time interval|time period', 'blood bank|blood flow
      ', 'life force|life span', 'party line|chat room', 'animal life|
      life force', 'death sentence|life span', 'life expectancy|time
      limit', 'blood vessel|blood pressure', 'air force|air service', '
      life expectancy|time period', 'love life|life events', 'heart
      disease|death sentence', 'heart attack|heart rate', 'heart attack|
      heart disease', 'death penalty|death camp', 'air service|air travel
      ', 'blood pressure|air flow', 'air force|air temperature', 'blood
      pressure|blood test', 'time period|time limit', 'death toll|life
      support', 'life span|time period', 'heart disease|heart pounding',
      'death wish|life span']
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COCA Component Model guessed Similar when Mechanical Turk answered Very
       Similar for the following noun compound pairs:

['women students|law students', 'grad students|law students', 'art
      students|law students', 'police station|subway station', 'death
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```
        penalty|death sentence', 'breakfast table|oak table', 'breakfast
        table|card table', 'reading room|living room', 'grad students|women
         students', 'water temperature|air temperature', 'bus station|train
         station', 'gas station|subway station', 'grad students|art
        students', 'hotel room|dorm room', 'finance company|parent company'
        , 'train station|subway station', 'bus station|subway station']
    -------------------------------------------------------
420
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    COCA Component Model guessed Unknown when Mechanical Turk answered Very
        Similar for the following noun compound pairs:

425 ['water heater|water temperature', 'air force|task force', 'shelf life|
        life expectancy', 'power station|research station', 'life
        expectancy|life span', 'death wish|death sentence', 'sex life|love
        life']
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430 COCA Component Model guessed Not similar when Mechanical Turk answered
        Unknown for the following noun compound pairs:

    ['bargaining table|death wish', 'blood vessel|heart rate', 'blood
        pressure|death toll', 'water line|water fountain', 'cruise line|
        space station', 'invasion force|water rights', 'blood test|blood
        flow', 'blood flow|life sciences', 'animal life|life support', '
        tree line|water lilies', 'adult life|time interval', 'research
        station|time period', 'air temperature|life span', 'life force|air
        service', 'water heater|water hole', 'death squads|life span', '
        cruise line|water rights', 'air service|life force', 'party line|
        air flow', 'water hole|water rights', 'blood vessel|life support',
        'air force|police station', 'goal line|water hole', 'heart attack|
        death certificate', 'life force|death toll', 'trend line|water
        temperature', 'death sentence|life force', 'heart attack|life
        expectancy', 'water hole|water pressure', 'water line|life force',
        'life force|life sciences', 'dorm room|air space', 'life force|time
         interval', 'water availability|life span', 'life savings|life
        style', 'blood type|heart pounding', 'shelf life|time limit', 'life
         force|life skills', 'goal line|life savings', 'water temperature|
        life force', 'party line|reading room', 'water fountain|water
        pressure', 'gas station|death camp', 'air force|life support', '
        subway station|hotel room', 'power station|reading room', 'party
        line|blood bank', 'blood bank|life savings', 'space station|life
        support', 'life force|blood pressure', 'air temperature|air space',
         'adult life|life span', 'air space|air service', 'life force|time
        period', 'goal line|life events', 'breakfast table|water glass', '
        life events|life force', 'dorm room|death camp', 'train station|
        blood vessel', 'heart disease|life support', 'pool table|television
         station', 'television station|animal life', 'invasion force|police
         station', 'heart disease|time period', 'sex life|life skills', '
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        heart pounding|life expectancy', 'weather station|living room', '
        shelf life|death certificate', 'subway station|computer room', '
        time zone|time limit', 'gas station|air fare', 'brute force|heart
        rate', 'blood test|death certificate', 'cruise line|life events', '
        life force|life jacket', 'water rights|blood bank']
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COCA Component Model guessed Unknown when Mechanical Turk answered
    Similar for the following noun compound pairs:

['gas station|power station', 'life force|task force', 'police station|
    power station', 'police station|research station', 'water
    availability|water rights', 'hotel room|living room', 'space
    station|gas station', 'love life|shelf life', 'water availability|
    water pressure', 'police station|train station', 'bus station|gas
    station', 'television station|power station', 'art students|women
    students', 'train station|gas station', 'death wish|death
    certificate', 'police station|weather station', 'subway station|
    research station', 'water availability|water heater', 'space
    station|television station', 'space station|power station', 'adult
    life|life expectancy', 'weather station|power station', 'television
     station|gas station', 'life expectancy|life skills', 'adult life|
    love life', 'bus station|space station', 'space station|train
    station', 'space station|research station', 'police station|space
    station', 'water pressure|blood pressure', 'life events|life
    expectancy', 'air force|brute force', 'weather station|research
    station', 'blood flow|air flow', 'subway station|power station', '
    death camp|death squads']
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COCA Component Model guessed Not similar when Mechanical Turk answered
    Similar for the following noun compound pairs:

['death sentence|time limit', 'air service|air fare', 'time zone|time
    period', 'breakfast table|subway station', 'cruise line|water
    lilies', 'water pressure|air flow', 'bus station|air space', 'water
     line|death certificate', 'dance company|sex life', 'assembly line|
    power station', 'assembly line|life skills', 'life events|life
    style', 'telephone line|chat room', 'assembly line|task force', '
    water line|space station', 'water line|water hole', 'air flow|heart
     disease', 'life span|life style', 'heart monitor|heart pounding',
    'police station|death squads', 'air flow|life sciences', 'water
    glass|water hole', 'life force|death certificate', 'heart monitor|
    time interval', 'air force|heart rate', 'water line|water glass', '
    air space|air flow', 'finance company|adult life', 'blood pressure|
    heart pounding', 'blood type|blood pressure', 'weather station|
    water temperature', 'gas station|water fountain', 'blood vessel|
    heart monitor', 'brute force|heart attack', 'subway station|chat
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room', 'life force|air space', 'water pressure|air temperature', 'party line|animal life', 'blood type|heart disease', 'sex life|heart monitor', 'love life|life skills', 'blood flow|heart disease', 'blood flow|life span', 'blood pressure|heart monitor', 'cruise line|finance company', 'weather station|air space', 'love life|life force', 'heart pounding|life force', 'love life|life style', 'water glass|water heater', 'police station|reading room', 'blood type|blood flow', 'water fountain|air mattress', 'life savings|life skills', 'water line|water heater', 'death wish|life support', 'weather station|air service', 'air force|air travel', 'heart pounding|death wish', 'research station|reading room', 'blood bank|heart disease', 'blood bank|heart monitor', 'blood test|life events', 'water availability|blood flow', 'adult life|life events', 'heart rate|time period', 'life force|life savings', 'train station|water hole', 'water fountain|life jacket', 'water line|water temperature', 'life span|life support', 'tree line|animal life', 'life force|death penalty', 'police station|computer room', 'air travel|air fare', 'water glass|water lilies', 'heart monitor|life support', 'air space|air travel', 'trend line|life expectancy', 'life force|heart rate', 'time zone|time machine', 'water glass|water pressure', 'hotel room|air mattress', 'train station|air service', 'space station|time zone', 'blood vessel|blood flow', 'subway station|water hole', 'life savings|time period', 'life events|life skills', 'weather station|life sciences', 'water vapor|blood flow', 'cruise line|dance company', 'water heater|air temperature', 'life force|heart pounding', 'blood type|blood test', 'research station|chat room', 'heart attack|life force', 'blood type|heart attack', 'water pressure|heart attack', 'women students|water rights', 'life force|life expectancy', 'blood vessel|heart disease', 'air service|time interval', 'task force|research station', 'trend line|time interval', 'water vapor|water pressure', 'task force|law students', 'power station|water hole', 'heart attack|life sciences', 'party line|dance company', 'chat room|sex life', 'subway station|dorm room', 'water line|air space', 'grad students|adult life', 'heart monitor|time limit', 'life skills|life style', 'air flow|air travel', 'cruise line|air fare', 'law students|reading room', 'air space|air fare', 'life force|space station', 'blood flow|heart monitor', 'water vapor|air space', 'death penalty|life support', 'heart disease|life span', 'gas station|finance company', 'life force|life events', 'cruise line|hotel room', 'life force|heart attack', 'blood pressure|heart attack', 'time interval|time limit', 'air temperature|air service', 'card table|computer room', 'air temperature|time interval', 'death toll|life savings', 'power station|life sciences', 'power station|chat room', 'research station|computer room', 'blood test|heart monitor', 'trend line|air temperature', 'adult life|heart pounding', 'blood type|heart rate', 'trend line|power station', 'trend line|heart monitor', 'space station|air space', 'life force|gas station', 'adult life|time period', 'water line|air flow', 'air force|blood flow', 'hotel room|sex life', 'invasion force|death sentence', 'water fountain|water rights', 'water pressure|heart pounding', 'life sciences|life style', 'water line|life support', 'shelf life|life span', 'party

line|time zone', 'life support|life jacket', 'heart rate|life force
', 'women students|adult life', 'water fountain|water hole', 'space
 station|dorm room', 'research station|life sciences', 'air force|
air space', 'heart monitor|life sciences', 'death wish|death camp',
 'cruise line|subway station', 'trend line|research station', 'life
 savings|life span', 'space station|air service', 'death
certificate|life support', 'breakfast table|living room', 'heart
rate|life support', 'death sentence|death camp', 'death sentence|
life jacket', 'power station|life force', 'water hole|blood vessel'
, 'water line|water vapor', 'water hole|water lilies', 'space
station|air travel', 'water lilies|water rights', 'blood vessel|
blood bank', 'grad students|research station', 'water line|blood
pressure', 'art students|dance company', 'police station|death
sentence', 'blood vessel|blood test', 'death toll|life span', '
heart disease|heart rate', 'death sentence|life style', 'heart
pounding|death penalty', 'cruise line|train station', 'bus station|
air service', 'water availability|time limit', 'task force|death
squads', 'heart disease|life expectancy', 'life skills|life support
', 'death sentence|life support', 'blood pressure|air temperature',
 'trend line|life span', 'love life|life expectancy', 'life force|
blood test', 'blood flow|heart rate', 'life expectancy|life support
', 'life span|time interval', 'life force|life support', 'wiggle
room|time period', 'telephone line|finance company', 'death penalty
|time limit', 'telephone line|computer room', 'life expectancy|life
 style', 'air flow|air fare', 'research station|life support', '
grad students|dorm room', 'invasion force|death squads', 'death
sentence|death toll', 'time zone|time interval', 'heart monitor|
heart disease', 'death sentence|death squads', 'water heater|water
pressure', 'water lilies|water temperature', 'death penalty|life
skills', 'blood pressure|blood bank', 'air temperature|air flow', '
death sentence|death certificate', 'blood type|life sciences', '
finance company|death camp', 'water pressure|heart monitor', 'air
flow|heart rate', 'death certificate|life style', 'space station|
death camp', 'blood vessel|life force', 'task force|dance company',
 'finance company|life savings', 'blood pressure|life sciences', '
air space|time interval', 'adult life|death certificate', 'card
table|chat room', 'air force|air flow', 'water heater|water rights'
, 'living room|air temperature', 'death sentence|life expectancy',
'blood test|time limit', 'air flow|time interval', 'television
station|finance company', 'blood test|heart attack', 'bus station|
hotel room', 'life events|life support', 'adult life|life skills',
'law students|dorm room', 'life span|life skills', 'blood test|
heart disease', 'blood flow|life force', 'weather station|air
temperature', 'death camp|life events', 'air flow|air mattress', '
life events|life span', 'blood pressure|air service', 'bargaining
table|computer room', 'bargaining table|chat room', 'story line|
life events', 'party line|dorm room', 'blood flow|heart attack', '
assembly line|invasion force', 'computer room|blood bank', 'water
temperature|time period', 'trend line|life savings', 'heart
pounding|heart rate', 'trend line|time period', 'death penalty|life
 events', 'television station|computer room', 'water line|water
pressure', 'heart attack|death toll', 'story line|power station', '

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    love life|time period', 'blood bank|blood test', 'death squads|life
     events', 'power station|computer room', 'card table|reading room',
     'task force|air service', 'air fare|time interval', 'invasion
     force|death penalty', 'water availability|water hole', 'blood
     pressure|heart disease', 'blood vessel|heart attack', 'life force|
     water availability', 'water vapor|life sciences', 'death wish|life
     expectancy', 'life expectancy|life force']
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GloWbE Vanilla Model guessed Similar when Mechanical Turk answered Not
    similar for the following noun compound pairs:


['dorm room|chat room', 'dorm room|wiggle room', 'reading room|wiggle
    room', 'computer room|dorm room']
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GloWbE Vanilla Model guessed Unknown when Mechanical Turk answered Not
    similar for the following noun compound pairs:

['telephone line|trend line', 'water availability|water temperature', '
    trend line|goal line', 'punch line|trend line', 'punch line|tree
    line', 'water line|trend line', 'punch line|goal line', 'cruise
    line|tree line', 'cruise line|punch line', 'assembly line|goal line
    ', 'story line|punch line', 'dance company|finance company', 'party
     line|punch line', 'computer room|wiggle room', 'party line|story
    line', 'assembly line|cruise line', 'breakfast table|bargaining
    table', 'bargaining table|card table', 'assembly line|telephone
    line', 'water fountain|water lilies', 'cruise line|water line', '
    punch line|water line', 'adult life|shelf life', 'assembly line|
    punch line', 'water vapor|water temperature', 'telephone line|punch
     line', 'pool table|card table', 'animal life|sex life', 'hotel
    room|wiggle room', 'cruise line|telephone line', 'animal life|shelf
     life']
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GloWbE Vanilla Model guessed Not similar when Mechanical Turk answered
    Very Similar for the following noun compound pairs:

['blood pressure|heart rate', 'blood flow|heart pounding', 'water
    rights|water pressure', 'heart attack|heart pounding', 'blood
    vessel|blood type', 'blood pressure|blood flow', 'heart attack|
    heart monitor', 'time interval|time period', 'blood bank|blood flow
    ', 'air force|task force', 'police station|subway station', 'life
    force|life span', 'party line|chat room', 'animal life|life force',
     'death penalty|death sentence', 'death sentence|life span', 'life
    expectancy|time limit', 'blood vessel|blood pressure', 'air force|
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    air service', 'life expectancy|time period', 'shelf life|life
    expectancy', 'love life|life events', 'heart disease|death sentence
    ', 'heart attack|heart rate', 'heart attack|heart disease', 'death
    penalty|death camp', 'air service|air travel', 'blood pressure|air
    flow', 'power station|research station', 'air force|air temperature
    ', 'blood pressure|blood test', 'time period|time limit', 'life
    expectancy|life span', 'death wish|death sentence', 'death toll|
    life support', 'life span|time period', 'heart disease|heart
    pounding', 'death wish|life span']
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GloWbE Vanilla Model guessed Similar when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

```
['grad students|art students', 'hotel room|dorm room', 'bus station|
    subway station']
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GloWbE Vanilla Model guessed Unknown when Mechanical Turk answered Very
    Similar for the following noun compound pairs:

```
['women students|law students', 'grad students|law students', 'water
    heater|water temperature', 'art students|law students', 'breakfast
    table|oak table', 'breakfast table|card table', 'reading room|
    living room', 'grad students|women students', 'water temperature|
    air temperature', 'bus station|train station', 'gas station|subway
    station', 'sex life|love life', 'finance company|parent company', '
    train station|subway station']
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GloWbE Vanilla Model guessed Not similar when Mechanical Turk answered
    Unknown for the following noun compound pairs:

```
['bargaining table|death wish', 'blood vessel|heart rate', 'blood
    pressure|death toll', 'water line|water fountain', 'cruise line|
    space station', 'invasion force|water rights', 'death toll|death
    certificate', 'blood test|blood flow', 'blood flow|life sciences',
    'animal life|life support', 'tree line|water lilies', 'adult life|
    time interval', 'research station|time period', 'train station|
    power station', 'air temperature|life span', 'life force|air
    service', 'death penalty|death toll', 'water heater|water hole', '
    death squads|life span', 'cruise line|water rights', 'air service|
    life force', 'party line|air flow', 'water hole|water rights', '
    task force|invasion force', 'story line|tree line', 'blood vessel|
    life support', 'air force|police station', 'goal line|water hole',
    'heart attack|death certificate', 'life force|death toll', 'trend
```

```
    line|water temperature', 'death sentence|life force', 'heart attack
    |life expectancy', 'water hole|water pressure', 'water line|life
    force', 'life force|life sciences', 'animal life|love life', 'dorm
    room|air space', 'life force|time interval', 'water availability|
    life span', 'life savings|life style', 'blood type|heart pounding',
     'shelf life|time limit', 'life force|life skills', 'goal line|life
     savings', 'water temperature|life force', 'party line|reading room
    ', 'gas station|research station', 'water fountain|water pressure',
     'party line|water line', 'gas station|death camp', 'air force|life
     support', 'subway station|hotel room', 'power station|reading room
    ', 'party line|blood bank', 'blood bank|life savings', 'space
    station|life support', 'life force|blood pressure', 'air
    temperature|air space', 'adult life|life span', 'air space|air
    service', 'life force|time period', 'goal line|life events', '
    breakfast table|water glass', 'life events|life force', 'dorm room|
    death camp', 'train station|blood vessel', 'heart disease|life
    support', 'pool table|television station', 'television station|
    animal life', 'invasion force|police station', 'heart disease|time
    period', 'sex life|life skills', 'heart pounding|life expectancy',
    'weather station|living room', 'shelf life|death certificate', '
    subway station|computer room', 'time zone|time limit', 'gas station
    |air fare', 'brute force|heart rate', 'blood test|death certificate
    ', 'cruise line|life events', 'television station|research station'
    , 'life force|life jacket', 'water rights|blood bank', 'death
    penalty|death squads']
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    GloWbE Vanilla Model guessed Unknown when Mechanical Turk answered
        Similar for the following noun compound pairs:

    ['bargaining table|oak table', 'card table|oak table', 'space station|
        gas station', 'pool table|bargaining table', 'art students|women
        students', 'women students|minority students', 'weather station|
        subway station', 'computer room|chat room', 'space station|subway
        station', 'adult life|animal life', 'space station|television
        station', 'reading room|chat room', 'television station|weather
        station', 'assembly line|water line', 'breakfast table|pool table',
         'reading room|computer room', 'adult life|love life', 'dorm room|
        living room', 'space station|research station', 'story line|trend
        line', 'telephone line|water line', 'space station|weather station'
        , 'assembly line|party line', 'cruise line|story line', 'television
         station|subway station', 'air force|invasion force', 'pool table|
        oak table', 'water heater|water vapor', 'adult life|sex life', '
        party line|trend line', 'art students|minority students', 'weather
        station|research station', 'blood flow|air flow', 'telephone line|
        tree line', 'law students|minority students', 'water line|tree line
        ']
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GloWbE Vanilla Model guessed Not similar when Mechanical Turk answered
    Similar for the following noun compound pairs:

['death sentence|time limit', 'air service|air fare', 'time zone|time
    period', 'breakfast table|subway station', 'gas station|power
    station', 'cruise line|water lilies', 'water pressure|air flow', '
    bus station|air space', 'water line|death certificate', 'dance
    company|sex life', 'assembly line|power station', 'life force|task
    force', 'tree line|goal line', 'assembly line|life skills', 'life
    events|life style', 'telephone line|chat room', 'assembly line|task
     force', 'water line|space station', 'police station|power station'
    , 'water line|water hole', 'air flow|heart disease', 'life span|
    life style', 'heart monitor|heart pounding', 'police station|death
    squads', 'police station|research station', 'air flow|life sciences
    ', 'water glass|water hole', 'life force|death certificate', 'heart
     monitor|time interval', 'dance company|parent company', 'air force
    |heart rate', 'water line|water glass', 'air space|air flow', '
    water availability|water rights', 'finance company|adult life', '
    blood pressure|heart pounding', 'blood type|blood pressure', '
    weather station|water temperature', 'gas station|water fountain', '
    blood vessel|heart monitor', 'brute force|heart attack', 'subway
    station|chat room', 'hotel room|living room', 'life force|air space
    ', 'water pressure|air temperature', 'party line|animal life', '
    blood type|heart disease', 'sex life|heart monitor', 'love life|
    life skills', 'blood flow|heart disease', 'blood flow|life span', '
    blood pressure|heart monitor', 'cruise line|finance company', '
    weather station|air space', 'love life|life force', 'heart pounding
    |life force', 'love life|life style', 'water glass|water heater', '
    police station|reading room', 'blood type|blood flow', 'water
    fountain|air mattress', 'life savings|life skills', 'water line|
    water heater', 'love life|shelf life', 'death wish|life support', '
    weather station|air service', 'air force|air travel', 'heart
    pounding|death wish', 'water availability|water pressure', '
    research station|reading room', 'blood bank|heart disease', 'police
     station|train station', 'blood bank|heart monitor', 'blood test|
    life events', 'water availability|blood flow', 'adult life|life
    events', 'heart rate|time period', 'life force|life savings', '
    train station|water hole', 'water fountain|life jacket', 'water
    line|water temperature', 'bus station|gas station', 'life span|life
     support', 'tree line|animal life', 'life force|death penalty', '
    police station|computer room', 'air travel|air fare', 'water glass|
    water lilies', 'heart monitor|life support', 'air space|air travel'
    , 'trend line|life expectancy', 'death wish|death penalty', 'life
    force|heart rate', 'death toll|death squads', 'time zone|time
    machine', 'water glass|water pressure', 'hotel room|air mattress',
    'television station|power station', 'train station|air service', '
    space station|time zone', 'blood vessel|blood flow', 'subway
    station|water hole', 'life savings|time period', 'life events|life
    skills', 'train station|gas station', 'weather station|life
    sciences', 'water vapor|blood flow', 'cruise line|dance company', '
    water heater|air temperature', 'life force|heart pounding', 'death
```

78

wish|death certificate', 'assembly line|story line', 'blood type|
blood test', 'research station|chat room', 'heart attack|life force
', 'blood type|heart attack', 'police station|weather station', '
subway station|research station', 'water pressure|heart attack', '
water availability|water heater', 'women students|water rights', '
life force|life expectancy', 'blood vessel|heart disease', 'air
service|time interval', 'task force|research station', 'hotel room|
computer room', 'trend line|time interval', 'water vapor|water
pressure', 'task force|law students', 'power station|water hole', '
heart attack|life sciences', 'party line|dance company', 'chat room
|sex life', 'subway station|dorm room', 'water line|air space', '
living room|chat room', 'grad students|adult life', 'heart monitor|
time limit', 'life skills|life style', 'cruise line|party line', '
air flow|air travel', 'cruise line|air fare', 'law students|reading
 room', 'air space|air fare', 'life force|space station', 'blood
flow|heart monitor', 'water vapor|air space', 'death wish|death
squads', 'death penalty|life support', 'heart disease|life span', '
gas station|finance company', 'life force|life events', 'cruise
line|hotel room', 'life force|heart attack', 'blood pressure|heart
attack', 'time interval|time limit', 'air temperature|air service',
 'card table|computer room', 'air temperature|time interval', '
death toll|life savings', 'power station|life sciences', 'space
station|power station', 'power station|chat room', 'research
station|computer room', 'blood test|heart monitor', 'reading room|
hotel room', 'trend line|air temperature', 'adult life|heart
pounding', 'blood type|heart rate', 'trend line|power station', '
trend line|heart monitor', 'space station|air space', 'life force|
gas station', 'adult life|time period', 'water line|air flow', 'air
 force|blood flow', 'hotel room|sex life', 'invasion force|death
sentence', 'adult life|life expectancy', 'weather station|power
station', 'water fountain|water heater', 'water fountain|water
rights', 'water pressure|heart pounding', 'life sciences|life style
', 'water line|life support', 'shelf life|life span', 'television
station|gas station', 'party line|time zone', 'life support|life
jacket', 'heart rate|life force', 'women students|adult life', '
water fountain|water hole', 'space station|dorm room', 'research
station|life sciences', 'life expectancy|life skills', 'air force|
air space', 'heart monitor|life sciences', 'bus station|space
station', 'death wish|death camp', 'cruise line|subway station', '
trend line|research station', 'death wish|death toll', 'life
savings|life span', 'space station|air service', 'death certificate
|life support', 'space station|train station', 'breakfast table|
living room', 'heart rate|life support', 'death sentence|death camp
', 'death sentence|life jacket', 'water fountain|water vapor', '
power station|life force', 'water hole|blood vessel', 'water line|
water vapor', 'water hole|water lilies', 'space station|air travel'
, 'water lilies|water rights', 'blood vessel|blood bank', 'grad
students|research station', 'water line|blood pressure', 'tree line
|trend line', 'art students|dance company', 'police station|death
sentence', 'blood vessel|blood test', 'death toll|life span', '
heart disease|heart rate', 'police station|space station', 'water
pressure|blood pressure', 'death sentence|life style', 'heart

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      pounding|death penalty', 'cruise line|train station', 'bus station|
      air service', 'water availability|time limit', 'water lilies|water
      vapor', 'task force|death squads', 'heart disease|life expectancy',
       'life skills|life support', 'death sentence|life support', 'blood
      pressure|air temperature', 'brute force|task force', 'trend line|
      life span', 'love life|life expectancy', 'life events|life
      expectancy', 'air force|brute force', 'life force|blood test', '
      blood flow|heart rate', 'life expectancy|life support', 'life span|
      time interval', 'life force|life support', 'wiggle room|time period
      ', 'telephone line|finance company', 'death penalty|time limit', '
      telephone line|computer room', 'life expectancy|life style', 'air
      flow|air fare', 'research station|life support', 'grad students|
      dorm room', 'invasion force|death squads', 'death sentence|death
      toll', 'time zone|time interval', 'heart monitor|heart disease', '
      death sentence|death squads', 'water heater|water pressure', 'water
       lilies|water temperature', 'death penalty|life skills', 'blood
      pressure|blood bank', 'air temperature|air flow', 'death sentence|
      death certificate', 'blood type|life sciences', 'finance company|
      death camp', 'water pressure|heart monitor', 'air flow|heart rate',
       'death certificate|life style', 'space station|death camp', 'blood
       vessel|life force', 'task force|dance company', 'life force|
      invasion force', 'finance company|life savings', 'blood pressure|
      life sciences', 'air space|time interval', 'adult life|death
      certificate', 'card table|chat room', 'air force|air flow', 'water
      heater|water rights', 'living room|air temperature', 'death
      sentence|life expectancy', 'blood test|time limit', 'air flow|time
      interval', 'television station|finance company', 'blood test|heart
      attack', 'bus station|hotel room', 'life events|life support', '
      adult life|life skills', 'law students|dorm room', 'life span|life
      skills', 'blood test|heart disease', 'blood flow|life force', '
      weather station|air temperature', 'subway station|power station', '
      death camp|death squads', 'death camp|life events', 'air flow|air
      mattress', 'life events|life span', 'blood pressure|air service', '
      bargaining table|computer room', 'bargaining table|chat room', '
      story line|life events', 'party line|dorm room', 'blood flow|heart
      attack', 'assembly line|invasion force', 'computer room|blood bank'
      , 'water temperature|time period', 'trend line|life savings', '
      heart pounding|heart rate', 'trend line|time period', 'death
      penalty|life events', 'television station|computer room', 'water
      line|water pressure', 'party line|telephone line', 'heart attack|
      death toll', 'story line|power station', 'love life|time period', '
      blood bank|blood test', 'death squads|life events', 'power station|
      computer room', 'card table|reading room', 'task force|air service'
      , 'air fare|time interval', 'invasion force|death penalty', 'water
      availability|water hole', 'blood pressure|heart disease', 'blood
      vessel|heart attack', 'life force|water availability', 'water vapor
      |life sciences', 'death wish|life expectancy', 'life expectancy|
      life force']
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Listing 6: *Model Mistakes*

11. REFERENCES

REFERENCES

[COCA] Davies, M. (2008-). *The Corpus of Contemporary American English: 450 million words, 1990-present.* Available online at **http://corpus.byu.edu/coca/**.

[GloWbE] Davies, M. (2013-). *Corpus of Global Web-Based English: 1.9 billion words from speakers in 20 countries.* Available online at **http://corpus.byu.edu/glowbe/**.

[Fellbaum1998] Fellbaum, C. (1998, ed.) WordNet: An Electronic Lexical Database. Cambridge, MA: MIT Press.

[Fyshe2013] Fyshe, A., Talukdar, P., Murphy, B., and Mitchell, T. (2013). Documents and Dependencies: an Exploration of Vector Space Models for Semantic Composition. *CONLL*, pp. 84-93.

[Harris1954] Harris, Z. S. (1954). Distributional structure. *Word, 10*(23), pp. 146-162.

[Huang2012] Huang, E. H., Socher, R., Manning, C. D., and Ng, A. (2012). Improving word representations via global context and multiple word prototypes. *Proceedings of the 50th Annual Meeting of the Association for Computational Linguistics: Long Papers - Volume 1*, pp. 873-882.

[Nakov2013] Nakov, P. I., and Hearst, M. A. (2013). Semantic interpretation of noun compounds using verbal and other paraphrases. *ACM Transactions on Speech and Language Processing, 10*(3), pp. 1-51.

[Sahlgren2006] Sahlgren, M. (2006). *The Word-Space Model: Using distributional analysis to represent syntagmatic and paradigmatic relations between words in high-dimensional vector spaces* (Doctoral dissertation). Stockholm University, Department of Lingustics, Computational Linguistics, Stockholm, Sweden.

[Schnoebelen2010] Schnoebelen, T., and Kuperman, V. (2010). Using Amazon Mechanical Turk for linguistic research. *Psihologija, 43*(4), pp. 441-464.

[Turney2010] Turney, P. D. and Pantel, P. (2010). From Frequency to Meaning: Vector Space Models of Semantics. *Journal of Artificial Intelligence Research, 37*, pp. 141-188.

[Turney2012] Turney, P. D. (2012). Domain and Function: A Dual-Space Model of Semantic Relations and Compositions. *Journal of Artificial Intelligence Research, 44*, pp. 533-585.

[VanDeCruys2013] Van de Cruys, T., Poibeau, T., and Korhonen, A. (2013). A Tensor-based Factorization Model of Semantic Compositionality. *Proceedings of NAACL-HLT, (June)*, pp. 1142-1151.