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Creating a Conversational Hebrew Vocabulary List

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Creating a Conversational Hebrew Vocabulary List

by

Juan D. Pinto

Thesis

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Dedication

Dedicated to

Acknowledgements

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Creating a Conversational Hebrew Vocabulary List

by

Juan Daniel Pinto
The University of Texas at Austin, 2018
SUPERVISORS: Esther Raizen, Elaine Horwitz

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Table of Contents

List of Tables

1 Introduction

This thesis provides an in-depth look at the creation of the Conversational Hebrew Vocabulary List (hereafter CHVL)—a list of the most common words in spoken Modern Hebrew. Its two-fold aim is (1) to explore the theory behind the creation of the CHVL, along with implications for similar projects, and (2) to describe the methods and provide the tools to make the process as reproducible as possible.

The complete list itself, consisting of 5,000 items, is included as an electronic supplement and can be downloaded free of charge.[1] A partial list of the first 1,000 items can be found in *Appendix 1*.

A review of the literature will first highlight the gap that exists for less commonly taught languages (LCTLs). Because the overwhelming majority of the previous research in vocabulary frequency lists has focused on English (and a handful of other European languages), some important nuances are yet to be addressed. More often than not, the few non-English word lists that do exist, along with much of the research in vocabulary acquisition, have taken at face value some of the findings of this limited-scope research—often without questioning whether the same methodologies and conclusions should be applied to different languages.

The present paper is, therefore, an effort to partially fill that gap in order to help educators interested in creating and/or using word lists for their own classrooms, for wider dissemination, or simply for general research purposes. In doing so, it will provide an overview of some of the key decisions that must be taken into account for such a project.

The various uses of word frequency lists can be loosely classified into research applications and practical applications. Examples of research applications include traditional linguistic studies that look for common morphological patterns, corpus-linguistic studies seeking to understand language through "real world" texts, and psycholinguistic studies that explore connections between a speaker's mental lexicon and word frequency. Practical applications of word lists include curriculum and

[1] Supplements can be downloaded directly from the thesis archive of the University of Texas at Austin. A separate repository at GitHub also contains the complete CHVL at *https://github.com/juandpinto/opus-lemmas*.

textbook planning for language teachers, vocabulary selection for graded readers and dictionaries, and even independent language study. Of course, some of the most influential studies straddle both sides of this divide and attempt to answer questions such as: How can vocabulary knowledge be appropriately tested and measured? What is the role of extensive reading (as opposed to intensive reading) in incidental vocabulary acquisition? What level of vocabulary do learners need in order to read extensively for pleasure? What level of vocabulary do learners need in order to succeed in an academic setting? What role does specialized vocabulary play in reaching understanding? These questions and their answers rely heavily on the creation and use of trustworthy word frequency lists. Yet due to the resources and effort required to create these lists, they are rarely found for less commonly taught languages.

The primary research question guiding this project is this: *What are the most-frequently used words in conversational Modern Hebrew?* The resulting study also addresses the following secondary research questions, which were necessary to address in order to answer the aforementioned question: *What effect does a corpus of unvocalized texts have on the identification of word families in the computerized creation of a vocabulary frequency list? What factors affect the way that boundaries are demarcated for various levels of word families in Modern Hebrew?* And finally: *What implications might these findings have for word list creation and use as it pertains to other less commonly taught languages?*

The literature review will serve as a basis for many of the important decisions taken during the creation of the CHVL. These decisions—surrounding both corpus and list creation—along with their reasoning, will be explained further in an analysis of the literature. For the sake of clarity, these decisions are listed here at the outset. They are as follows:

Corpus design - *Size:* - *Text types:* The corpus consists of a single text type: conversation. This is to best fit with the list's intended audience. In order to accomplish this, movie and television subtitles compose the core of the corpus. **List design:** - *Use:* The primary intended audience for the CHVL is composed of beginning-to-low-intermediate learners of Hebrew as a foreign language. It is designed for both receptive and productive language use. - *Word family levels:* The word family level that is best suited for the CHVL's intended audience is the lemma. - *Criteria:* The

CHVL was created using exclusively objective criteria, meaning that it is the product of calculations, and it was not manually tweaked in any way. The empirical criteria used were frequency and range.

Following the review of literature and explanation of theory, the process of the CHVL's creation will be explained in detail, along with findings from the project. Possible implications for other less commonly taught languages will then be discussed. Finally, the CHVL and any code used will be provided in the appendix.

2 Background: Review of the literature

The theoretical foundation for the creation and use of word frequency lists rests on the observation, made popular by the linguist George Kingsley Zipf in the 1930s and 40s, that if one were to create a frequency list of words in a large enough text, the first word would occur roughly twice as often as the second word, three times as often as the third word, and so on (1935, 1949).

This exponential distribution is significant because it means that a small number of words make up the bulk of a text, whereas the majority of the words occur very few times(Sorell, 2012). Paul Nation, one of the most influential scholars in the field of vocabulary acquisition, has pointed out that Zipf's Law—as it is has come to be known—can serve as motivation to language learners and teachers, since learning the most common vocabulary in a language covers so much of the communication that naturally occurs (2013, p. 34).

This observation guides the entire endeavor of word list creation and use. Though the CHVL is not sorted using raw frequency alone[2], the effect of Zipf's law can be easily seen in the listed frequencies that accompany each item on the list.

One level above this theoretical basis lie the theoretical considerations of the process that serve as the structure upon which the CHVL is built. These include corpus size and text type, general vs. specialized lists, word family levels, and objective criteria. Each of these issues will be treated separately throughout this literature review.

2.1 Corpus Design

Before designing a word list, a careful, clear plan must be made for the design of the corpus from which the list is extracted. The corpus must be representative of the language context that the word list wishes to analyze. Of course, it is impossible to capture all of the communications that take place in a particular language. For this simple reason, researchers must make do with an approximation of the whole: a bounded corpus of language.

[2] The sorting method is explained in the sections *Objective Criteria*, *Dispersion*, and *Sort and Export*.

Though the focus of this literature review is the creation of word frequency lists, the truth is that relatively few corpora have been created for this specific purpose. Most corpora have aimed at being general collections that cover the language (usually English) as a whole in an attempt to serve different theoretical and applied uses. Yet despite this broad objective, the creation of corpora has historically revolved around two big questions: (1) how large should the corpus be, and (2) what kinds of texts should it include. These questions are important not only for corpus creation, but also for corpus selection. Both of these points will be addressed here, with the recurring emphasis being corpus use for word list creation.

2.1.1 Corpus Size

Conventional wisdom in corpus creation states that more is better. If a word list is to accurately reflect the frequencies of words in the language as a whole, then a corpus must contain enough text to approximate the overall use of discourse. This line of thinking is equivalent to the maxim in quantitative research that a sample should be as representative of the target population as possible. And in order to maximize the statistical probability of this representation, the sample must be of an appropriate size for the study.

True, larger sample sizes often increase this probability, but they also tend to be more resource-intensive for the researcher. The same is true of corpus size. When creating a vocabulary list, then, what is an "ideal" corpus size?

Corpora composed of millions of tokens are easy to access today. This is especially true of corpora of written material—corpora of spoken language are still comparatively small. And thanks to advances in computing power, it is finally becoming plausible for more researchers without access to extensive resources to use these mega-corpora for the purpose of word list creation.

The first project to create a one-million-token corpus was a joint effort by Henry Kučera and W. Nelson Francis of Brown University to compile a corpus of American English texts printed in 1961 (Kučera & Francis, 1967), known today simply as the *Brown Corpus*. They strived to create a corpus with equal amounts of texts from different sources by randomly selecting 500 passages of 2,000 words each from different published materials found at the Brown University Library and the Providence Athenaeum. This mixed design would be used as a model by many of the corpora created during the next few decades: . These began to be compiled at increasingly faster rates. Many of these corpora were created—in part—to serve as parallel corpora of different varieties of English.

As an example of how quickly corpora have grown in recent decades, consider the history of COBUILD. What began in 1980 as a collaboration between Collins Publishing and a group of researchers led by John Sinclair—the Collins Birmingham University International Language Database (COBUILD)—led to the creation of the *Collins Corpus* of 7-million-tokens by 1982. It continued expanding until transforming into the *Bank of English* in the 1990s, which reached 320 million words in 1997. In 2005, as part of the Collins World Web, which also comprises French, German, and Spanish corpora, it reached 2.5 billion words (*Collins Cobuild English grammar*, 2005). The Collins Corpus now contains over 4.5 billion words ("The history of Collins COBUILD," n.d.).

Today, with the use of web-crawling applications that scour the internet and collect text at unprecedented speed, we can now use the *enTenTen12* corpus of 12 billion English tokens, which was collected in 12 days (Jakubíček, Kilgarriff, Kovář, Rychlý, & Suchomel, 2013)!

Clearly, then, the sky's the limit when it comes to ever-growing corpora of language. But when it comes to word list creation, is there a corpus size that can be considered sufficient?

Studies have approached this specific problem of corpus size for word list creation by creating multiple frequency lists—each from a different size of corpus—and then comparing the efficacy of these lists themselves. But what makes a word list effective? Different researchers have tackled this question differently.

One way to judge the effectiveness of a word list is to find how closely it correlates with reaction times in a lexical decision task—a widely-used procedure in psychological and psycholinguistic research. In a lexical decision task, participants are presented with a series of words and non-words, one after the other, and they are asked to judge which is which as quickly as possible. The reaction times are then analyzed for each word. The basic idea behind this experiment is that the average time it takes participants to react to a word reflects something about the way the word is accessed in participants' mental lexicons. Given enough data, it is possible to make certain inferences about the arrangement of this internal lexicon, which has led to various psycholinguistic theories over the years. But what does this have to do with words on a frequency list? There is well-attested evidence to suggest that there exists an inverse correlation between word frequency and reaction time on a lexical decision task (Whitney, 1998; Balota and Chumbley, 1984). In other words, more common words are accessed and recognized more quickly than less common words. Therefore—the thinking goes—an effective word frequency list should correspond to and reflect this reality.

This was precisely the approach taken by Brysbaert & New (2009), who compared respond times collected as part of the massive Elexicon Project (Balota, et al., 2007) to words on a series of frequency lists made from increasingly larger corpora. The corpora used were all subcorpora extracted from the British National Corpus (BNC). With each subsequent increase in token count, the word list correlated more and more closely with the response times from lexical decision tasks. This observation validates the line of thinking described at the beginning of this section regarding the need for large corpora. Brysbaert and New hoped to find an "ideal" corpus size after which the increase in effectiveness would no longer be significant enough to justify the additional cost of resources. After conducting several regression analyses on the two sets of data, they found that the variance in the response times that could be accounted for by corpus size reached a plateau at about 16 million words. In other words, for corpora with less than 16 million words, the size of the corpus had a significant effect on the correlation between word frequencies and average response times for those words on lexical decision tasks. For corpora with more than 16 million words, the effect of increasing corpus size became considerably more subtle. In the end, they concluded that in order to construct an effective word list for *high-frequency* words, a corpus of about 1 million tokens is needed. However, in order to reach the same effectiveness for *low-frequency* words, a corpus size of at least 16 million words is preferable.

A different, more straightforward methodology is to directly compare word lists made from corpora of different sizes. Rather than judging the "effectiveness" of a list, this approach measures similarities shared between different lists. Hypothetically, doing this at increasing corpus sizes should allow one to find a size after which the variance between lists only minimally decreases. As with the previous approach, the goal here is to find a point at which the benefits of increasing size no longer outweigh the additional needed resources.

Essentially, then, all corpora of sufficient size should result in nearly the same word frequency list—a theory based on a strict interpretation of Zipf's law applied to all natural language. If the appropriate criteria can be found—Sorell (2013) suggests—then this would, at last, provide a solution to Nation's (2001, 2013) observation that, problematically, word lists tend to disagree rather drastically on both the words included and their respective ranking.

Inspired by the computational linguistic measure of *rank distance* (Popescu and Dinu, 2008)—a method for comparing stylistic differences between texts—Sorell (2013) developed a variant of this methodology. First, he used different corpora of the same size to create multiple word lists, one for each corpus, ranked entirely by frequency. He then identified the percentage of words that are *not* shared between each set of two lists. Finally, he averaged these percentages to find the level of variability created at that specific corpus size. The levels of variability he found were remarkably close to each other—despite using a wide variety of entirely different corpora (with no overlap on texts within each one). He then increased the size of each corpus and repeated the process.

In order to calculate this level of variability, Sorell used a modified version of a complex formula that he borrowed from the natural sciences, and called his resulting calculation the *Dice distance*. Though this Sørensen–Dice coefficient that he altered (also known by other names) is widely used in botany and other fields to measure similarity in areas and samples of different sizes, the frequency lists measured by Sorell were all purposefully of the same size. What this means is that—apparently without realizing it—his *Dice distance* was ultimately just a simple percentage: *number of different words between frequency lists / size of frequency list (total words)*. Regardless of the round-about way he used to calculate it, his resulting measure for each corpus size—the level of variability—can be accurately described as the average proportion of difference for word lists at that particular corpus size.

Sorell found that a stable list (about 2% variation) of the most frequent 1,000 words, or a reasonably stable list (less than 5% variation) of the most frequent 3,000, words can be created using a corpus of 50 million tokens. In other words, 1,000-type word lists created from different 50-million-token corpora will likely only differ by 20 words. At the 3,000-type level using the same sizes of corpora, the lists will likely vary by less than 150 words. This is a remarkable level of similarity. Expanding the list to 9,000 types will still only have about 4–7% variation, or 360–630 words. Even corpora of 20 million tokens can be considered sufficient in many cases, since they will result in 3,000-type word list with roughly 5% variation, and 9,000-type word list with less than 10% variation.

Taking a similar approach, though with significant variations, Brezina and Gablasova (2015) compared four corpora of various sizes: The Lancaster-Oslo-Bergen Corpus (LOB), The BE06 Corpus of British English (BE06), The British National Corpus (BNC), and EnTenTen16. These corpora had respective token sizes of 1 million, 1 million, 100 million, and 12 billion. The word list created from each corpus was, in this case, a combination of frequency and dispersion—a measure that will be discussed in more detail later in this paper. The resulting word lists were then compared, and the percentage of shared vocabulary words calculated. Additionally, the researchers also calculated the correlation between the ranking for each word that was shared between word lists. Contrary to Sorell, Brezina and Gablasova considered this final comparison an important part of understanding the effect of corpus size.

The aim of this study was not to find a corpus size after which the difference was negligible, but rather to find if there was a significant difference between word lists made from corpora of different sizes. The study found a 78%–84% overlap between each of the 3,000–lemma word lists. 71% of the words were shared among all four of the lists. Based on this number, Brezina and Gablasova concluded that regardless of corpus size—at least for anything larger than one million tokens—“similar results” are obtained.

This conclusion differs significantly from Sorell’s, who concluded that a corpus of at least 20 million tokens (though 50 million is preferable) is needed for a stable word list with low variability. These disagreements are primarily the result of a difference in what should be considered “stable.” At 71% vocabulary overlap—which is sufficient for Brezina and Gablasova—870 words were only found in one of the four lists. This is drastically higher than Sorell's threshold, which at the 3,000-word level varies in roughly 150 words. Note that Nation and Hwang (1995) found a level of overlap similar to Brezina and Gablasova when comparing the GSL, the LOB, and the Brown corpora—a percentage of overlap that they deemed to be not particularly high. As Nation later put it, "Brezina and Gablasova are a bit too tolerant in accepting that 71% or even 78%-84% overlap is good enough. If roughly one out of every four or five words is different from one list to another, that is a lot of difference" (2016, p. 100).

Another difference to mention between these two studies is the unit of counting used. Sorell made lists based on *types*, whereas Brezina and Gablasova preferred the use of *lemmas*. I will explain this important distinction in a later section of this review ("Identifying Words"). For now, it is sufficient to say that the effect of these different measures in comparing word lists created from corpora of different sizes has (to my knowledge) not been studies. This is one area that could benefit from further research.

Lastly, the corpora used by Brezina and Gablasova were all-inclusive: each built on its own philosophy on the way that different types of texts should be balanced in a corpus, but all seeking to be representative of English as a whole. This is also true of the corpora used by Brysbaert and New in their study using response times from a lexical decision task. Contrast this with Sorell's word lists, which were systematically created from corpora that consisted of only one specific text type. Surely, this is a factor to consider in corpus design.

Therefore, having a sufficiently large corpus is important, as demonstrated in this section. But is it enough? How much do the types of texts included in a corpus factor into its effectiveness for word list creation?

2.1.2 Text Types

There's been a lot of debate about the "best" way to balance a corpus' text types. This is a major aspect of corpus design, and one worth delving into. At the end of the day, much of it comes down to the purpose of the corpus. When used for the creation of word lists, one must also consider the intended purpose of the word list itself. Is it for general use or for one of many possible specialized uses? More on this in the next section.

In order to design a corpus with different amounts of text types (i.e. narrative, conversational, academic), clear definitions for these text types are necessary. But is there a better way than the use of subjective genres to classify texts?

Or is there a better methodology than simply mixing a bunch of different texts together, with the hope that the resulting word list covers the language as a whole? This is the most common way of creating frequency lists, but it tends to result in a mix of words that have little relevance to any one purpose. Esoteric, academic words in a beginners' vocabulary list? Science fiction terms in a vocabulary list for business managers? It's obvious that a list is only as good as the corpus from which it's made, which is why a clear delineation of different text types and their qualities is critical.

When speaking of corpus balance, I refer to the proportion of different text types that make up a corpus. Published corpora have taken different approaches in this regard, and published word lists have made use of a variety of strategies for balancing the corpora from which they are made. Coxhead's *Academic Word List* (2000) was created from a carefully-designed corpus that used equally-sized sub-corpora of texts from different disciplines. This suited the purpose of her word list well, since it was intended to serve students from a variety of disciplines.

The importance of identifying a taxonomy of text types based on objective criteria: are there distinguishable linguistic differences between an informal correspondence and a narrative work of fiction? What about between a romance and a fantasy novel?

Biber's early work (1988) conducted an analysis of a wide variety of texts using large corpora to tag syntactic markers and other linguistic attributes that could potentially be used to define different types of texts. In this study, he found a series of five categories (each consisting of two opposite ends of a spectrum) in which texts varied: involved vs. informational, narrative, situated vs. elaborated, persuasive, and abstract. He then conducted a very large study, which he published as a book, (1995) that found eight distinct, recurring patterns of different combinations of these categories. These groupings serve as a linguistically-based taxonomy that divides texts along objective lines, rather than subjective, culturally-defined genres.

Similar but independent studies were conducted for Somali, Korean, Nukulaelae Tuvuluan, Taiwanese, and Spanish (Biber, 1995; Jang, 1998). For each language, a unique set of text types were identified. However, the texts were found to align along similar distinguishing linguistic dimensions as the English texts.

Sorell (2013) sought to simplify Biber's eight text types into categories suitable for corpora study. He did this by noticing the closely similar ways that some of the text types lined up along Biber's five linguistic categories, also incorporating some extra-linguistic features, such as shared contexts (e.g. predominantly spoken types). He also dropped Biber's two smallest text types, deeming them impractical for corpus study and difficult to isolate. In doing this, he came up with four simplified text types: interactive (conversation), general reported exposition (general writing), imaginative narrative (narrative writing), and academic. Regarding this last type, Biber's study found a sosignificant difference between academic writing in the natural sciences ("scientific exposition") and the humanities ("learned exposition")—he found that natural science uses more concrete language, whereas the humanities tend to use more abstract language. However, Sorell sought to unify these for the sake of simplicity, simply leaving their distinction to "a future study" (p. 68). Sorell acknowledged that his wasn't the first attempt at simplification of Biber's text types, a surprisingly similar effort having been made in the *Longman Grammar of Spoken and Written English* (Biber, Johansson, Leech, Conrad, & Finegan, 1999: 16) and the *Longman Student Grammar of Spoken and Written English* (Biber, Conrad, & Leech, 2002: 23).

Sorell found that each of his four simplified text types yielded a vocabulary frequency list that was as unique as the linguistic criteria that Biber had used. He also measured how different they were from each other, and found all four to be equidistant from the next in this order: conversation, narrative, general writing, and academic writing (See section on corpus size for an explanation of this measurement). Sorell, therefore, claims that his own study of vocabulary frequency using his simplified text types as a base has "validated Biber's studies by adding a vocabulary dimension to the description of each of the key text types" (201).

Despite the importance of spoken language—or the conversation text type—for language learners and linguistic studies, the number of conversation corpora that exist, as well as their size, is very limited. This is clearly because of the difficulty of gathering large amounts of spoken data that then needs to be transcribed by hand in order to be analyzed. It is true that speech recognition software has come a long way in recent years, but its rate of error remains too high for research purposes. It has been estimated that it takes 40 hours to professionally transcribe one hour of audio recording, making the task too costly. For this reason, some researchers have begun looking at alternative sources for a conversation corpus, including the internet and movie subtitles.

New, et al. (2007) created a 50-million-token corpus of French subtitles. They divided this into four subcorpora, one for each of the type of media from which the subtitles were extracted: French films, English movies, English television series, and non-English-language European films. The reason for using French subtitles from English media is the sheer dominance of English in the film industry. In order to counter-balance the much larger sizes of the two subcorpora extracted from English media, the researchers measured word frequencies for each subcorpora separately, then averaged them to arrive at the final frequency used for their ranked word list.

In order to test the validity of their new approach, New, et al. used two different methods. First, they compared their subtitle word list with word lists created from more traditional corpora. Second, they used lexical decision times—similar to Brysbaert and New (2009) above—to test the rankings of words on their list.

The first test found a .73 correlation with a classical French spoken corpus, the "Corpus de Référence du Français Parlé" (CRFP; Equipe DELIC, 2004). However, when looking at the specific words and semantic categories that differ the most, it's clear that most major differences are caused by the monologue-nature of the CRFP. This corpus was created from a large number of interviews (each asking the same questions to the interviewee), whereas movie subtitles tend to be composed primarily of people interacting in conversations. This results in more colloquial expressions having higher frequencies in the subtitle corpus. The nature of movies themselves also played a role, resulting in an overrepresentation of words related to action movies and police matters—words like *tuer* [to kill], *prison* [jail], and *armes* [weapons] (p. 665).

For the second test of the subtitle word list, the researchers used the lexical decision times from two previous experiments. They found that the subtitle list's ability to predict lexical decision times was at least equally as accurate as the CRFP frequencies or those from a traditional corpus of written French. In many cases, it actually fared much better, surprising even the researchers themselves. However, this latter test was based on the rather small sample sizes of the two previous experiments (234 and 240 words), limiting the reliability of this test.

Picking up on these findings, and expanding the lexical decision task to a much larger sample size, Brysbaert and New (2009) compiled a corpus of English subtitles (SUBTLEX$_{\mathrm{US}}$) and evaluated it as part of their study. This corpus is composed of subtitles from a wide variety of American films since 1900, though a majority are from 1990, as well as a large number of American television series. They found that the subtitle frequencies were especially good at predicting the lexical decision times of short words, often surpassing the accuracy of rankings based on the many written corpora they tested. It had more difficulty explaining the response times of longer words, which are more rarely found in film than in literature. Overall, their own conclusion confirmed that of the New, et al. (2007) study, that word frequencies derived from subtitle corpora seem to have a clear advantage over other types of corpora.

Though these two studies arrive at the same conclusion regarding the use of subtitles, more research is needed in this area. If, indeed, subtitles can be considered as appropriate sources for corpora of the conversation text type, their availability will open many possibilities previously made nearly impossible by the difficulty of the collection medium.

2.2 List Design

Perhaps even more complex than appropriately designing the corpus from which to extract vocabulary for a word list, researchers have found a wide range of variables that play a role in the design of the list itself. Questions addressed in the literature deal with the difference between a general service list and a specialized list, differences in the way that a “word” is defined and measured, different ranking criteria used, and the influence of subjective criteria on list creation, among other issues.

2.2.1 General Use vs. Specialized Use

Nation (2016) emphasized the importance of identifying the purpose of a word list before beginning the creation process. He believes that the main purpose of most general-use lists is to select vocabulary that language learners should learn during their first years of study. Though this may be the stated goal of some general-use lists, it is clear that they in fact serve a wide variety of purposes. He rightfully suggests, however, that the goal of serving language learners is far too broad to be very helpful. Language learners come to the task at different ages, with different language needs, and with different reasons for learning the language. A word list that is useful for adult learners intent on attending university will likely not be helpful for young leaners whose language focuses on animals, colors, and other age-appropriate material. And yet general-use lists are far more common than specialized-use lists. This is largely due to attempt at finding the language’s core vocabulary.

The majority of word lists in use attempt to describe the vocabulary of the language as a whole. They are designed to be broad and all-encompassing so that they can serve any number of uses and scenarios. Essentially, they are lists that are created for general use. This broad nature of general use lists is reflected in the name of the most widely-used word list, West’s *General Service List* (1953). Others include Nation’s BNC/COCA lists, Browne’s *New General Service List* (2014), Brezina and Gablasova’s *New General Service List* (2015), and Dang and Webb’s *Essential Word List* (Nation, 2016).

Another way of understanding general-use lists is that their objective is to find what is often termed the *core* vocabulary. Though not always explicitly stated, the philosophy behind this approach is that the language being used—usually English—has at its center a self-contained lexicon of essential, primary, basic, fundamental vocabulary that then runs through the entire language. There are layers of frequency and increasing complexity beyond this, with regions of specialized language demarcated for specific purposes such as fields of study or external dialects. Still, this core vocabulary is at the center of it all, and the purpose of a word list is to identify what words fall within its boundaries. Sorell (2013) evaluated a number of definitions of core vocabulary found in the literature. He suggests that general use lists, such as West's GSL, serve as intuitively-selected lists of core written communication, whereas survival vocabulary lists—often found in travel guides or similar materials—are core vocabulary lists of oral communication.

Relatively fewer researchers have created word lists aimed at a more specific purpose or target audience. Specialized-use lists can be designed to only include words that belong to a specific domain, such as a discipline or trade. They can also encompass vocabulary found in a broad range of disciplines, but which are common in a specific context, such as academic texts. In this case, they usually serve as supplements to aid language learners who are already familiar with the core vocabulary of the language.

Perhaps the most well-known example of a specialized-use list is Coxhead's Academic Word List (2000), which replaced the University Word List (Xue & Nation, 1984) as the go-to vocabulary list for aspiring students intent on attending an English-speaking university or those entering the academic world. This is considered a *general* academic word list, since it is for academic use in general, and not for a specific discipline.

More specialized lists include those designed for business English courses, or medical English courses. This is sometimes designated *technical vocabulary.* Nation (2016) explains that technical vocabulary is most often taught after students have mastered general-use vocabulary, and after they have some familiarity with academic vocabulary. Chung and Nation (2003) looked into the nature of a technical vocabulary. By studying specialized words in the fields of anatomy and applied linguistics, they found that a large number of technical words are also found in the language's core vocabulary, or have a general academic use as well. However, when used in a technical text, these words take on a specialized definition that is particular to that domain. This means that much vocabulary is shared across layers of vocabulary, though they may vary semantically, based on context.

2.2.2 Identifying Words (Word Family Levels)

One of the most essential questions that needs to be answered when designing a word list is how one is defining a *word*. Though this may seem like a straight-forward decision, it requires thorough planning and a solid understanding of the theory behind the decision. Should *jump* and *jumped* be counted as two different words or just one? What about irregular inflections such as *go* and *went*? In an article aimed at raising awareness of what he calls the "*Word* dilemma," Gardner (2007) points out that the validity of much vocabulary research hinges "on the various ways that researchers have operationalized the construct of *Word* for counting and analysis purposes" (2007, p. 242).

The literature has generally come to accept some key terms that are helpful when speaking of the way words are counted. Beginning with the most basic measurement and progressing to the most complex, we can choose to count tokens, types, lemmas, or word families.

Measuring *tokens* means simply measuring the total number of words. The sentence "I like small dogs, big dogs, and every other kind of dog" contains twelve tokens—twelve words in total. Counting *types* refers to the number of separate and distinct words. That is, *dog* and *dog* are the same type, but *dogs* is a different type—even a single difference makes them different types. The sentence above is composed of eleven types. A level above this, the *lemma* includes the stem of the word and its inflected forms, but not any derived forms of the word (derived forms are usually considered a different part of speech). So *do*, *does*, and *did* are all the same lemma, but *doable* is not. This is because *doable* has the derivational affix *-able*, which turns it into an adjective. Francis and Kučera define lemma as "a set of lexical forms having the same stem and belonging to the same major word class, differing only in inflection and/or spelling" (1982, p. 1).

Finally, the term *word family* is used to describe an even more inclusive level than the lemma. However, its precise definition has often varied among researchers. Bauer and Nation (1993) sought to rectify this problem through an in-depth classification of English affixes. Borrowing from Thorndike's (1941) study of English suffixes, their grouping was based on a series of eight criteria: frequency, productivity, predictability, regularity of the written form of the base, regularity of the spoken form of the base, regularity of the spelling of the affix, regularity of the spoken form of the affix, and regularity of function. (pp. 255–56) They identified seven “levels” of word families, with each successive one including a larger number of affixes, and therefore a larger number of types per word family. One very useful aspect of their particular system is that it places all the previous levels (type, lemma, etc.) within the same framework. Under their schema, a level 1 word family is the same as a type, a level 2 word family is a lemma (including all regular inflected affixes), and level 7 (the highest level) consists of classical roots and affixes beyond what most speakers any longer consider separate affixes.

Nation himself suggests that for the purposes of language learning, these specific family word levels can be used simply “as a starting point as an initial framework of reference” (2016, p. 36). That is, they are one interpretation of how to systematically count words for a frequency list. These levels are based on criteria that reflect the needs of language learners, rather than on any psycholinguistic theory of how speakers’ mental lexicon is arranged. Still, the idea of word families aligns closely with theoretical models that dictate morphological decomposition as a constant. These theories propose that words are often deconstructed into independent morphemes in receptive tasks and recognized that way, for example by deconstructing *jumping* into *jump* and *-ing*. At the other end of the spectrum stand theories that would place *jump* and *jumping* as separate lexical entries (Brysbaert and New, 2009, 982–83).

Either way, there is strong evidence to suggest that inflected/derived forms and their base forms do affect each other in some way, suggesting that word families are a measure of a real representation in speakers’ mental lexicon. In one such study, Nagy et al. (1989) explored the effect of both inflectional and derivational family frequency during a lexical decision task. They found that both types of morphological relationships lowered word recognition times, leading to the conclusion that inflections and derivational relationships are both represented in the mental lexicon, either through the grouping of related words under the same entry, or through linked entries. However, all the participants were native English speakers, so to what extent do L2 learners’ lexicons reflect the same level of linking?

More recent studies have found that L2 learners’ morphological knowledge and word-building ability are not nearly as developed. Ward and Chuenjundaeng (2009) conducted a study that tested the receptive ability of Thai engineering and doctoral students learning English. They were tested for their knowledge of a series of base words, together with various derived forms of the same words. They found a surprising lack of familiarity with the derived words, even when participants knew the base forms from which they were derived. Similarly, but from a productive and not receptive standpoint, Schmitt and Zimmerman (2002) found that learners could produce only a limited number of derived forms when presented with a word family headword. These results challenge the common assumption that "once the base word or even a derived word is known, the recognition of other members of the family requires little or no extra effort" (Bauer and Nation, 1993, p. 253).

There is evidence (Mochizuki and Aizawa, 2000; Schmitt and Meara, 1997) to suggest a positive correlation between vocabulary size and morphological knowledge. If this is the case, then using higher-level word families in Bauer and Nation's framework for word list creation (as is the case in), may not be appropriate for learners with limited knowledge of vocabulary—the very learners that many of these lists target.

Similarly, a study by Jeon (2011) found that L2 learners' morphological knowledge leads to greater reading comprehension. Since many word lists are designed to increase reading comprehension in learners, it follows that they will likely be used by students without strong word-building abilities.

Clearly, then, when it comes to creating a word list, the unit of counting needs to fit the purpose and target audience of that list. Brezina and Gablasova (2015) contend that Bauer and Nation's (1993) higher word family levels ignore the lack of transparency that exists between many of the entries that would be placed under the same word family. Especially when creating a word list for beginners, Brezina and Gablasova point out that the morphological knowledge of language learners is often not developed enough. Because their New General Service List was created for beginners, and since it is intended to aid vocabulary acquisition for both receptive and productive purposes, Brezina and Gablasova chose the lemma as their unit of measure.

Seeking to quantify the effect of choosing to measure word families as opposed to word types, Sorell (2013) compared the text coverage of frequency lists made from the same four corpora. Each corpus corresponded to one of Sorell's text types (see above). Sorell's definition of "word families" was a slightly modified version of Bauer and Nation's (1993) sixth level of affix inclusion. He found, as would be expected, that the most frequent word families have a much larger text coverage than the most frequent types. This is especially true when measuring type coverage—the most frequent word families accounted for roughly 4–6 times as many types in each corpus. However, when measuring overall token coverage, the top word families only covered about 3–10% more than the same number of most frequent types. Sorell also found that the most frequent 1,000 word families consisted of 6,557 word types in the general writing corpus. The number was similar in the other text types, though somewhat lower.

2.2.3 Objective vs. Subjective Design

(Nation 2016:133) >There are two major approaches to making corpus-based word lists. One is to stick strictly to criteria based on range, frequency and dispersion (Brezina & Gablasova, 2015; Dang & Webb, Chapter 15 this volume; Leech, Rayson & Wilson, 2001). The other is to use a similar statistical approach but to adjust the results using other criteria such as ensuring that lexical sets such as numbers, days of the week, months.

Brezina and Gablasova (2015), p. 3: > Seen from the perspective of current corpus linguistic research (cf. McEnery and Hardie 2011), one of the main problems of West's GSL lies in the fact that its compilation involved a number of competing principles that brought a large element of subjectivity into the final product. When reviewing the compilation principles of the GSL, we can see that in addition to the quantitative measure of word frequency, West also used a number of 'qualitative' criteria for the selection of individual lexical items. These include (i) the ease of learning, (ii) necessity, (iii) cover, and (iv) stylistic and emotional neutrality (West 1953: ix–x). Let us now briefly discuss these principles.

2.2.4 Objective Criteria (Frequency, Range, Dispersion)

Nation (2016), p. 103: > Dividing a corpus into sub-corpora allows the creation of range and dispersion figures. In some ways range figures are more important than frequency figures, because a range figure shows how widely used a word is, and this indicates its "general service". Brysbaert and New (2009) found that a range measure was a good predictor of lexical decision times. Carroll, Davies and Richman (1971) found in their study that frequency and their measure of dispersion correlated at .8538 (page xxix), showing that the more widely used a word is, the more likely it is to be frequent. Some words however are frequent in just one or two texts or sub-corpora and may not even occur in others. The use of a range or dispersion figure or both can indicate such words.

Brysbert and New (2009), pp. 984–5: > Another variable that has been proposed as an alternative to WF frequency is the contextual diversity (CD) of a word (Adelman, Brown, & Quesada, 2006). This variable refers to the number of passages (documents) in a corpus containing the word. So, rather than calculating how often a word appeared in the BNC, Adelman et al. measured how many of the 3,144 text samples in the corpus contained the word. They found that the CD measure explained 1%–3% more of the variance in the Elexicon data.

Brezina and Gablasova (105), p. 8: > ARF is a measure that takes into account both the absolute frequency of a lexical item and its distribution in the corpus (Savicky´and Hlava´c ˇ ova´2002; Hlava´c ˇ ova´2006). Thus if a word occurs with a relatively high absolute frequency only in a small number of texts, the ARF will be small (cf. Cerma´k and Kr ˇ en 2005; Kilgarriff 2009). All four wordlists were then sorted according to the ARF that ensured that only words that are frequent in a large variety of texts appeared in the top positions in the wordlists.

Sorell (2013), p. 89: Dispersion.

2.3 Modern Non-English Word Lists

Gardner, D. (2007), p. 242: > Hazenberg and Hulstijn 1996—Dutch language;

3 Methods: Creating the Conversational Hebrew Vocabulary List (CHVL)

As we have seen, the brunt of the work in high-quality vocabulary frequency list creation has focused on *English* frequency lists. Outside of the English-speaking world, and especially when dealing with less commonly taught languages, it's difficult to find well-researched word lists, if they exist at all. Why have not more educators—those who may benefit from these lists the most—decided to undertake such a task?

This need not be a project that one starts from scratch every time. Many tools already exist to make the process smoother. Still, with the rapid pace at which technology changes, these tools tend to quickly become obsolete. They are also usually restrictive to the specific preferences of their creators.

Rather than using these tools, I chose to create a series of simple scripts to create the Conversational Hebrew Vocabulary List.

The two most widely-used languages for the type of data analysis involved in a word list creation are Python and R. I chose to use Python for this project. Python was designed specifically to be a very readable programming language. That is, it is easy to read and understand the purpose and flow of the code. This was one of my primary reasons for choosing to use it, since it increases the ease with which this project can be reproduced by other researchers and educators to create their own word lists. R, on the other hand, requires a deeper familiarity with the syntax and conventions of the language in order to understand.

The second characteristic that makes Python ideal for an open-source project of this nature is its mild learning curve. Though considerable effort must be made to learn any programming language, Python is widely considered good for beginners because of its simplicity. With only a rudimentary knowledge of Python, even educators or enthusiasts without a coding background will be able to modify the scripts used here to suit their own needs. To this end, I will also carefully explain what, exactly, the code does.

Though all of the code is included in this thesis (*Appendix 2*), it can also be found in an online repository at https://github.com/juandpinto/opus-lemmas. The repository can easily be cloned, or individual files can be downloaded, for modification and use. The repository uses the version control system *Git*. This means that anyone can easily look through the history of each file to see specific changes that have been made over time.

Suggestions for improvements can also be submitted through the GitHub interface, allowing for a system of cooperation and incremental innovation among researchers. The exported Conversational Hebrew Vocabulary List, in its entirety, can also be found in the repository.

This thesis, then, beyond explaining the theory behind the creation of the CHVL, aims to make the process as reproducible as possible. This section contributes to that aim by carefully documenting each step of the process.

3.1 The corpus

Before coding or analyzing anything, it's important to find an appropriate corpus to use and to become familiar with its structure. A useful place to begin is OPUS[3], which is part of the Nordic Language Processing Laboratory (NLPL), and hosted by the CSC IT center in Finland. OPUS is a database of many open, parallel corpora. These include corpora of movie and television subtitles, TED talks, web-crawled data, newspapers, and of course, books. The corpora are all free and open to the public.

The CHVL was created using one of OPUS's corpora, the OpenSubtitles2018[4] corpus. The corpus can be downloaded in a variety of formats, and can be downloaded either as *parallel* corpora, or as a monolingual corpus. A parallel corpus consists of two languages interwoven together. For example, a line from the English subtitles of a movie will be paired with the same line from the French subtitles of the same movie. In theory, this means that each line of the corpus should have the same meaning in two different languages. The creation of parallel corpora has made possible many interesting and useful tools for linguistics, translators, and language learners. These

[3] http://opus.nlpl.eu

[4] http://opus.nlpl.eu/OpenSubtitles2018.php

include the open-source CASMACAT[5] project and the ReversoContext[6] tool.

For the purpose of creating a word list, a monolingual corpus is best. Note that parallel corpora will often be composed of less tokens than monolingual ones. This is because parallel corpora will only include movies for which the subtitles exist in both selected languages.

Though it's possible to download plain text files, the most useful format available for download is XML. Indeed, the most common file format used for large corpora is XML. The XML structure allows for nested key-value pairs, which are especially useful for parsed corpora that contain extensive metadata. XML is comparable to JSON, which we will use later to extract specific movie metadata directly from a database.

Another factor to consider is whether to download an untokenized, tokenized, or parsed corpus. An untokenized corpus contains simply the raw lines of text as found in the original subtitle files (divided into lines as they would appear while watching the movie, and labeled with the appropriate time for them to be shown):

```
<s id="49">
  <time id="T39S" value="00:03:22,280" />
מה אתה אומר, שרלוק?
  <time id="T39E" value="00:03:24,120" />
</s>
```

A tokenized corpus has further been split into individual words and punctuation, such that each word is tagged on its own:

```
<s id="49">
  <time id="T39S" value="00:03:22,280" />
  <w id="49.1">מה</w>
  <w id="49.2">אתה</w>
  <w id="49.3">אומר</w>
```

[5] http://www.casmacat.eu

[6] http://context.reverso.net/translation/

```
  <w id="49.4">,</w>
  <w id="49.5">שרלוק</w>
  <w id="49.6">?</w>
  <time id="T39E" value="00:03:24,120" />
</s>
```

A parsed corpus contains much more information for each token. The data included depends on the features of the language and on the parsing script used, but it can include things such as part of speech, syntactic role, lemma, and even specific features like gender, person, and number. Here is an example:

```
<s id="49">
  <time value="00:03:22,280" id="T39S" />
  <w xpos="ADV" head="49.3" feats="PronType=Int" upos="ADV"
   ↪  lemma="מה"
      id="49.1" deprel="obj">מה</w>
  <w xpos="PRON" head="49.3" feats="Gender=Masc|Number=Sing|Person=2|
      PronType=Prs" upos="PRON" lemma="הוא" id="49.2"
↪  deprel="nsubj">אתה</w>
  <w xpos="VERB" head="0"
   ↪  feats="Gender=Masc|HebBinyan=PAAL|Number=Sing|
      Person=1,2,3|VerbForm=Part|Voice=Act" upos="VERB"
↪  misc="SpaceAfter=No"
      lemma="אמר" id="49.3" deprel="root">אומר</w>
  <w xpos="PUNCT" head="49.3" upos="PUNCT" lemma="," id="49.4"
      deprel="punct">,</w>
  <w xpos="NOUN" head="49.3" feats="Gender=Masc|Number=Sing"
   ↪  upos="NOUN"
      misc="SpaceAfter=No" lemma="שרלוק" id="49.5"
↪  deprel="obj">שרלוק</w>
  <w xpos="PUNCT" head="49.3" upos="PUNCT" misc="SpaceAfter=No"
   ↪  lemma="?"
      id="49.6" deprel="punct">?</w>
```

```
  <time value="00:03:24,120" id="T39E" />
</s>
```

All of the data used to create the CHVL came from a monolingual parsed corpus of Hebrew. The parsing was all done automatically using .

3.2 Cleansing the corpus

Unlike many corpora, the OpenSubtitles2018 corpus as presented in its downloadable form has already undergone significant preprocessing by the OPUS team.(Lison & Tiedemann, 2016) This is good news, since data cleansing is often the most laborious part of the process. However, there is one issue that must be addressed before the corpus can be used to create a word list: deduplication.

The files inside the downloaded folder are organized as follows:

```
Zipped folder in GZ format
    Folder for year X
        Folder for movie A
            Zipped XML in GZ format
            Zipped XML in GZ format
            Zipped XML in GZ format
        Folder for movie B
            Zipped XML in GZ format
            Zipped XML in GZ format
    Folder for year Y
        Folder for movie C
            Zipped XML in GZ format
        Folder for movie D
            Zipped XML in GZ format
            Zipped XML in GZ format
            Zipped XML in GZ format
        Folder for movie E
```

```
            Zipped XML in GZ format
            Zipped XML in GZ format
    Folder for year Z
          Folder for movie F
               Zipped XML in GZ format
               Zipped XML in GZ format
```

This organization is straight-forward, except for the fact that there are multiple XML files for each movie. The subtitle files that OPUS has collected, parsed, organized, and made available for mass download were all obtained from the Open Subtitles[7] project (hence the name of the corpus). Because this is a database where users can upload the subtitle files they extract from their own movie collection, there are often multiple uploads for the same movie. For our purposes, this results in movies that can have anywhere from a single subtitle file to dozens of them. Unfortunately, though the tokens in the files themselves are usually the same (with only minor variations in the XML metadata), this is not always true. Some few variations seem to be different and independent translations.

Part of cleansing the corpus, then, entails getting rid of these duplicates. As a means of simplifying the entire process, I chose simply to use the first file in each movie folder. I've included the short Python script for this in its entirety in *Appendix 2.3*. However, I will here explain what it does in detail so that it can be easily modified to fit different circumstances.

The script first makes a copy of the entire folder structure in the original downloaded (and unzipped!) corpus into a new directory. It then finds the first XML file in each movie folder and copies it into the appropriate place in the new folder structure. This means that it doesn't delete or otherwise change the files in the original corpus in any way.

The first block of code imports necessary modules that are used later in the script (`shutil` and `os`). Lines 7 and 8 define where the original corpus is (`source`), and where the new one will be placed (`destination`).

[7]

```python
import shutil
import os

source = '../OpenSubtitles2018_parsed'
destination = './OpenSubtitles2018_parsed_single'
```

Next, a single line of code copies all directories and subdirectories into their new location.

```python
shutil.copytree(source, destination, ignore=shutil.ignore_patterns('*.*'))
```

Lastly, we create a variable that holds all the XML files located in each movie folder, trim the list to just one, and copy that one into its new location. This process is carried out for one movie folder at a time. The originals are left untouched.

```python
for dirName, subdirList, fileList in os.walk(source):
    for fname in fileList:
        if fname == '.DS_Store':
            fileList.remove(fname)
    if len(fileList) > 0:
        del fileList[1:]
        src = dirName + '/' + fileList[0]
        dst = destination + dirName[27:] + '/'
        shutil.copy2(src, dst)
```

With a newly organized version of the corpus, it's now possible to begin the process of reading and processing data. At this stage, I took some time to gather metadata for all the movies in the corpus in order to identify movies that were originally filmed with Hebrew as their primary language (as opposed to translated subtitles). Because I ultimately decided against this approach for the creation of the CHVL, I will skip that step here. However, a description of the entire process will be discussed later under *Using original-language movies exclusively*.

3.3 Reading data

Before calculating any measures such as frequency, individual lemmas must be extracted from the XML files in the downloaded corpus. There are two ways to go about this. Because XML consists of nested tags and key-value pairs, a dedicated XML parsing tool can be used to extract specific information. In this case we would be creating a list of all *values* in the 'lemma' *key* within each <w> *tag*. The value that corresponds to the 'lemma' tag below for the word אומר is אמר.

```
<w xpos="VERB" head="0"
↪  feats="Gender=Masc|HebBinyan=PAAL|Number=Sing|
   Person=1,2,3|VerbForm=Part|Voice=Act" upos="VERB"
↪  misc="SpaceAfter=No"
   lemma="אמר" id="49.3" deprel="root">אומר</w>
```

A different approach is to use *regular expressions* to search for a specific string of characters and extract every instance of that string. This is a more brute-force approach, since it ignores the structure of the XML file and treats it all simply as raw text. To find a lemma, a very simple regular expression is sufficient: lemma="[א-ת]+". This will search for any instance of the characters lemma=", followed by a combination of any number of Hebrew letters (at least one), followed by the character ".

Despite the existence of various Python modules for parsing XML files, I found a simple search using regular expressions to be more efficient for various reasons. First, not all elements in the parsed corpus contain *lemma* attributes. Second, punctuation and non-Hebrew words are often lemmaticized. This means that even after extracting all the *lemma* values in a file, I would still need to use regular expressions to search through the results and delete any that contain non-Hebrew characters. I chose instead to skip the XML parsing step altogether.

I will now explain the code in the script used to create the CHVL. As with the other code, the entire script in its entirety can be found in *Appendix 2.1*.

After importing necessary packages and initializing variables, two functions near the beginning of the script serve to open a file and extract a list of lemmas from it.

```python
# Open XML file and read it.
def open_and_read(file_loc):
    with gzip.open(file_loc, 'rt', encoding='utf-8') as f:
        read_data = f.read()
    return read_data
```

```python
# Search for lemmas and add counts to "lemma_by_file_dict{}".
def find_and_count(doc):
    file = str(f)[40:-3]
    match_pattern = re.findall(r'lemma="[א-ת]+"', doc)
    for word in match_pattern:
        if word[7:-1] in lemma_by_file_dict:
            count = lemma_by_file_dict[word[7:-1]].get(file, 0)
            lemma_by_file_dict[word[7:-1]][file] = count + 1
        else:
            lemma_by_file_dict[word[7:-1]] = {}
            lemma_by_file_dict[word[7:-1]][file] = 1
```

We then run both of these functions for each XML file in the corpus directory (defined earlier in `corpus_path`).

```python
for dirName, subdirList, fileList in os.walk(corpus_path):
    if len(fileList) > 0:
        f = dirName + '/' + fileList[0]
        find_and_count(open_and_read(f))
```

The `find_and_count()` function finds each instance of the string described above using a regular expression, then adds the Hebrew part of the string—the lemma itself—to a dictionary. The dictionary is named `lemma_by_file_dict`, and its structure looks like this:

```
'lemma': {'path of file': 'frequency of lemma in file'}
```

A dictionary is at its core a list of key:value pairs. Much like an actual dictionary consists of words and their definitions, this dictionary's keys are made up of all the individual lemmas found by our search. For each lemma, the value is another dictionary—making it a nested dictionary, or a dictionary within a dictionary. The keys for each inner dictionary are the paths of all the XML files (movies) that the lemma appears in, and the value of each is an integer that represents how many times that lemma appears in that file (frequency).

After the script reads each file, it returns a complete dictionary. Here is a sample:

```
'ב': {
        '/he/0/5753574/6853341.xml': 168,
        '/he/0/3607000/5764778.xml': 94},
'פרק': {
        '/he/0/5753574/6853341.xml': 3},
'קודם': {
        '/he/0/5753574/6853341.xml': 6,
        '/he/0/3607000/5764778.xml': 2,
        '/he/0/1278351/3777598.xml': 1}
```

Throughout the rest of the script, this nested dictionary serves as the basis for all of the calculations needed.

3.4 Calculations

For each lemma, the CHVL includes three measures: frequency, range, and U_{DP} (dispersion). It uses dispersion as its sorting value. Let's look at how each of these is calculated. Range will be addressed in the export section, since the script calculates it on the spot as the list is created.

3.4.1 Frequency

Since we've already calculated the frequency of each lemma for each individual file, calculating total frequency per lemma is straight forward. The script simply creates a new dictionary, `lemma_totals_dict`, and adds to it every lemma in the corpus as its keys, with the corresponding value being a sum of the frequencies in all files for that lemma. In other words, {'lemma1':'frequency1', 'lemma2':'frequency2', . . . }

```
for lemma in lemma_by_file_dict:
    lemma_totals_dict[lemma] = sum(lemma_by_file_dict[lemma].values())
```

This returns Using the short example given above, this would result in the following dictionary:

```
262:'ב',
3:'פרק',
9:'קודם'
```

3.4.2 $\mathrm{U_{DP}}$ (dispersion)

Dispersion is more complicated. In theory, it should provide a single quantifiable measure that incorporates both frequency and range, and which can then be used to sort the word list. There is no agreed-upon, single way to calculate dispersion, and different researchers will use the words in slightly different contexts. The model of dispersion I have chosen to follow for this project is Gries' dispersion coefficient, or $\mathrm{U_{DP}}$, () calculated from Gries' DP. ()

In order to calculate Gries' DP for $\mathrm{lemma_x}$, we must first make two calculations for each file in the corpus ($\mathrm{file_i}$): the lemma's *expected frequency* if it were perfectly distributed, and its *observed frequency*—or its actual frequency.

$$\textbf{expected frequency} = \frac{tokens\ in\ file_i}{tokens\ in\ corpus}$$

$$\textbf{observed frequency} \;=\; \frac{frequency\ of\ lemma_x\ in\ file_i}{frequency\ of\ lemma_x\ in\ corpus}$$

We must then subtract the lemma's observed frequency from its expected frequency, which will return a value between -1 and 1. We can normalize this result by finding the absolute value. Now the closer the result is to 0, the closer that lemma's frequency is in that particular file to what we would expect if it were perfectly distributed throughout the corpus. A higher number (closer to 1), would indicate a heavier load in that file that we would expect.

By performing this calculation for every file in the corpus, adding them all together, and dividing the result by two (since we're using the absolute value and are therefore adding values originally in both directions), we now have Gries' DP. Where `n` is the number of files:

$$\textbf{DP} \;=\; 0.5\sum_{i=1}^{n} \mid \text{expected frequency} \;-\; \text{observed frequency} \mid$$

A DP of 0 represents a perfectly even dispersion, and a DP close to 1 means a more uneven distribution, where fewer files contain a larger load of the lemma's overall frequency. A DP of 1 is not actually possible.

Gries' usage coefficient, or $\mathrm{U_{DP}}$, is an attempt to make this number more useful. DP is first subtracted from 1 and the result is multiplied by the lemma's total frequency. The full equation for $\mathrm{U_{DP}}$ is as follows:

$$\left(1 - 0.5\sum_{i=1}^{n}\left|\frac{file_i\ tokens}{total\ tokens} - \frac{frequency_x\ in\ file_i}{total\ frequency_x}\right|\right) \times total\ frequency_x$$

In order to calculate this, the script must first find the number of tokens in each file. Like before, this is done by creating a dictionary, `token_count_dict`, which contains the key:value pairs of file:tokens. Since we already have a dictionary with the number of times that each lemma appears in each file, `lemma_by_file_dict`, we don't need to open and read the files again. Instead, we can add the values in this dictionary and rearrange them into what we want.

```
for lemma in lemma_by_file_dict:
    for file in lemma_by_file_dict[lemma]:
        token_count_dict[file] = token_count_dict.get(
            file, 0) + lemma_by_file_dict[lemma][file]
```

We also need to know the total number of tokens in the entire corpus. This is a simple matter of adding all the values in the `token_count_dict` dictionary. The final count is saved into an integer variable, `total_tokens_int`.

```
for file in token_count_dict:
    total_tokens_int = total_tokens_int + token_count_dict.get(file, 0)
```

Finally, the script uses all these measures to calculate DP and then U_{DP} for each lemma, and places them into their respective dictionaries, `lemma_DPs_dict` and `lemma_UDPs_dict`.

```
# Calculate DPs
for lemma in lemma_by_file_dict.keys():
    for file in lemma_by_file_dict[lemma].keys():
        lemma_DPs_dict[lemma] = lemma_DPs_dict[lemma] + abs(
            (token_count_dict[file] /
             total_tokens_int) -
            (lemma_by_file_dict[lemma][file] /
             lemma_totals_dict[lemma]))
lemma_DPs_dict = {lemma: DP/2 for (lemma, DP) in lemma_DPs_dict.items()}

# Calculate UDPs
lemma_UDPs_dict = {lemma: 1-DP for (lemma, DP) in lemma_DPs_dict.items()}
```

With these values all calculated for each lemma, the only thing left is to sort and create the final list.

3.5 Sort and export

In order to ensure that the words on the list do not have an abnormally high frequency in some subcorpora (movies) and are nearly absent in others, some have suggested setting a minimum range or dispersion. All words that fall below this threshold are discarded, and the remaining words can then be sorted by frequency.

Though this is a more systematic approach than that used to create many early frequency lists, it still depends on a subjective decision and the whim of the researcher.

Rather than setting an arbitrary bar, the CHVL is sorted entirely by Gries' usage coefficient of dispersion ($\mathrm{U_{DP}}$). This *modus operandi* ensures that the order of words itself—not just which words make it onto the list and which don't—is decided by a combination of both relevant measures: frequency and dispersion. This approach also has the added benefit of being entirely objective.

Since we've already calculated the $\mathrm{U_{DP}}$ for each lemma, sorting the list is simple.

```
UDP_sorted_list = [(k, lemma_UDPs_dict[k]) for k in sorted(
    lemma_UDPs_dict, key=lemma_UDPs_dict.__getitem__,
    reverse=True)]
```

A final table is then created (using a list of tuples, `table_list`), with each line consisting of a lemma, its overall frequency, its range, and its $\mathrm{U_{DP}}$. This table is already sorted by $\mathrm{U_{DP}}$ as it's being created.

Because the script has not calculated range by this point, it must do so on the spot as it's entering each lemma into the table. It does this with a simple dictionary comprehension that quickly counts the number of files included in the `lemma_by_file_dict`. Here is the resulting code:

```python
for k, v in UDP_sorted_list[:list_size_int]:
    table_list.append((k, lemma_totals_dict[k], sum(
        1 for count in lemma_by_file_dict[k].values() if count > 0),
        v))
```

Lastly, now that everything is organized into a table, the script opens (or creates, if it doesn't yet exist) a CSV file, writes a header line into it (`LEMMA, FREQUENCY, RANGE, UDP`), and exports the entire table into the file. It then closes it to clear the computer's memory cache.

```python
result = open('./export/WordList.csv', 'w')
result.write('LEMMA, FREQUENCY, RANGE, UDP\n')
for i in range(list_size_int):
    result.write(str(table_list[i][0]) + ', ' +
                 str(table_list[i][1]) + ', ' +
                 str(table_list[i][2]) + ', ' +
                 str(table_list[i][3]) + '\n')
result.close()
```

The list is now complete. The next section will explore the list itself more in-depth.

4 The CHVL: A vocabulary list of conversational Modern Hebrew

The Conversational Hebrew Vocabulary List in its entirety can be found as an electronic supplement to this thesis (in CSV format) or at the following GitHub repository: *https://github.com/juandpinto/opus-lemmas*. It contains the most common 5,000 lemmas of conversation Modern Hebrew, as found in the OpenSubtitles2018 corpus. A sample of the first 1,000 lemmas is included in *Appendix 1*.

For discussion purposes, a small sample of the first 20 items is here presented.

Table 1: Sample of the first 20 items on the CHVL.

RANK	LEMMA	FREQUENCY	RANGE	U_{DP}
1	הוא	23446109	43455	0.9480170255915042
2	ל	5638813	43448	0.9420130372643667
3	ה	9850733	43458	0.929266134661147
4	ב	4812778	43450	0.9292364864789281
5	את	6846782	43426	0.9285176069174289
6	לא	5272808	43433	0.9145688112131216
7	ש	3880654	43439	0.9088900047303463
8	של	3892328	43445	0.9067041511201389
9	על	1766990	43430	0.9042865019832009
10	זה	5118759	43441	0.9015544612816044
11	מה	2362419	43403	0.8922532708182579
12	היה	2579370	43420	0.8909904417204713
13	מ	1061614	43411	0.88900672760779
14	כול	1325676	43414	0.8860074112131449
15	ו	1906717	43429	0.8852706380348441
16	יש	1069358	43376	0.8770543442171884
17	עם	839575	43331	0.8668140051895192
18	אם	861163	43321	0.8654587702150129
19	ידע	1202416	43323	0.8586088803742931
20	אבל	921757	42963	0.8519038846130076

Besides each lemma and its respective rank on the list, the CHVL includes three pieces of information: frequency, range, and U_{DP}. Frequency in this case is not raw frequency—the total number of times the lemma appears in the corpus—but rather how many times the lemma appears for every million tokens in the corpus. Using frequency per million makes the number more meaningful since—in theory—it reflects the per-million count of all spoken Hebrew, not just the OpenSubtitles2018 corpus. The range is the number of sub-corpora—or in this case, movies—the lemma appears in.

The most important piece of information the list provides, however, is the U_{DP}, which refers to Griers' usage coefficient for dispersion. This is discussed more in-depth in the methods section above. U_{DP} is also used as the sorting measure for the CHVL.

The percentage of the corpus that is covered by the first n items on the list is referred to as coverage. This is a simple matter of finding the total number of tokens in the corpus, and dividing from it the sum of all the *raw* frequencies from the first n items.

For example, the sum of the frequencies of the first 20 lemmas in *Table 1* (84,656,819) divided by the total size of the corpus (193,755,220) is 0.436926649. In theory, this means that by knowing just the first 20 lemmas on the CHVL one would be able to understand 43.7% of the words in the entire OpenSubtitles2018 corpus! That is a clear example of the power of Zipf's Law (see *Introduction* for more on Zipf's Law).

Table 2 presents a listing of some important coverages provided by different amounts of lemmas on the CHVL.

Table 2: Breakdown of coverage percentages.

n Lemmas	Frequency Sum	÷ Corpus Size	= Coverage
374	135,767,644	193,755,220	70%
939	155,016,588	193,755,220	80%
4,246	174,380,519	193,755,220	90%
13,758	184,067,666	193,755,220	95%

The entire CHVL consists of 5,000 lemmas. This number was chosen in order for it to include the required items for 90% coverage, while also making it an even factor of

1,000. In its entirety, the CHVL covers 90.8% of the corpus from which it is created.

4.1 Challenges and future direction

Throughout the course of this project, I have encountered several issues that are worth discussing. Some of these are questions that require further study in order to address adequately. Others are technical issues related to the complex task of pre-processing and parsing the corpus—something not directly dealt with in this thesis. Others yet are simple suggestions that I simply did not have time to implement given this project's time constraints. And finally, there are limitations that are the inevitable result of the tools at hand.

I have divided all of these issues into two categories: methodological challenges of a bigger nature, and functional challenges of a more limited scope.

4.1.1 Methodological challenges

One of the more obvious issues of this project is the use of a corpus of movie subtitles as substitute for a corpus of true conversational language. This issue in a way forms the backbone of the CHVL, and it is at the heart of what this project is all about. Though I discuss several points related to this in the *Background* section of this thesis, I will here discuss some of its implications for future work.

4.1.1.1 Ideal vs. practical corpora The use of a subtitle corpus has both positive and negative aspects. As mentioned earlier, the early research that has been done on the topic indicates that movie subtitles share many features with spontaneous, spoken language. This includes a high level of correlation between the two , as well as a strong ability to predict the outcomes of a lexical decision task .

One especially positive aspect of subtitle corpora is their accessibility. Thanks to the efforts of organizations such as *http://opensubtitles.com* and OPUS[8], very large

[8] http://opus.nlpl.eu

corpora are available to the public for free. And they already come pre-processed, as an additional incentive for the time-constrained researcher.

This free and open nature makes subtitle corpora excellent tools for research in languages that don't yet have large, high-quality corpora of spoken language. Though advances in technology are rapidly making this type of data-collection more accessible, the costs remain too high for many less-commonly taught languages as of now. This is largely due to the arduous process of transcribing audio recordings.(Izre'el, 2004)

An ideal corpus for this sort of task would consist of many millions of tokens of recorded, transcribed, and parsed, spontaneous spoken language. Several attempts have been made to create a corpus of this nature in Hebrew.

The most prominent of these is the Corpus of Spoken Israeli Hebrew (CoSIH)[9], created at Tel Aviv University between 2000 and 2002.(Izre'el, Hary, & Rahav, 2001) Designed and initiated by a team of distinguished scholars, it unfortunately ran out of funding long before its goals were met. The CoSIH website (*http://cosih.com/*) makes available to the public a total of 13.5 hours of recorded Hebrew, with just over five hours of it having been transcribed.

Though a few publications have used data from CoSIH, these have been primarily methodological studies for the design of the project itself.(Amir, Silber-Varod, & Izre'el, 2004; Izre'el et al., 2005; Mettouchi, Lacheret-Dujour, Silber-Varod, & Izre'el, 2007) At least one dissertation, by Nurit Dekel, uses data exclusively from CoSIH. Her entire corpus consists of 44,000 tokens. (2010, p. 7)

Other corpora of spoken Hebrew include the Haifa Corpus of Spoken Hebrew (Yael, 2014) and the Hebrew CHILDES corpus (Albert, MacWhinney, Nir, & Wintner, 2013; Gretz, Itai, MacWhinney, Nir, & Wintner, 2015). The first consists of 17.5 hours of audio recordings, along with a limited selection of transcribed text. The latter is a collection of recordings of interactions between adults and children, comprising a total of 417,938 transcribed tokens. The CHILDES corpus is unique in that the transcriptions are provided using a Latin-based phonemic transliteration. This was done in order to avoid many of the textual ambiguities of using the Hebrew script,

[9]http://cosih.com/

which are addressed below under *Functional challenges*.

Though ideal in some ways, these corpora remain far too small to be effectively used for the creation of frequency lists. Even combined into a single corpus (which would introduce a series of new issues to solve), the total size would not be bigger than two million tokens. As discussed earlier in this thesis, Sorell provides evidence to suggest that a corpus of 20–50 million tokens is the minimum for a stable word list.(2013)

Are movie and television subtitles an suitable substitute for spontaneous, spoken language? Early studies suggest it is at least adequate, but much more research is needed to answer this question definitively. For now, it remains as one practical option.

4.1.1.2 Using original-language movies exclusively One of the potential downsides of using the OpenSubtitles2018 corpus not yet discussed is that it includes all subtitles of a specific language, even *translated* subtitles from movies filmed in other languages. The question is, does a translated script represent true conversational language as faithfully as an original script?

This is a question that requires more research in order to answer satisfactorily. Though translated subtitles don't need to try to approximate the utterance length and visual cues that a dubbed script does, its quality still largely depends on the skills of a translator. Most importantly, a translation may not accurately reflect the register of the original, no longer serving as a representation of conversational language. Again, these are important points to consider.

One solution is to simply use movies that were originally filmed in the target language of the corpus. In theory, each XML file in a monolingual OpenSubtitles2018 file should contain a tag that identifies the original language of the movie. In practice, I found that the overwhelming majority of the files contained an empty `<lang>` tag instead. Luckily, there is a way to obtain the desired metadata for each movie in the corpus.

This can be done with a script that uses an application programming interface (API) to fetch specific information from an online movie database. The name of each movie folder in the corpus, which is simply a series of numbers, corresponds to that movies

IMDb ID, which is a unique ID registered with the Internet Movie Database[10]. This makes the process relatively easy, as we simply need to query the database using this ID to receive all of the movie's metadata.

Though IMDb does provide their own API, I decided instead to use an API created for the Open Movie Database (OMDb)[11]. This API can be used free-of-charge, but it has a 1,000 movie limit per day. Since the OpenSubtitles2018 Hebrew corpus contains nearly 50,000 movies, I decided instead to pay for a daily limit of 100,000 movies. This only requires a $1.00 donation for each month that one is registered to use the OMDb API.

Once an API key is obtained, a script can be written to obtain the information desired for every movie all at once. In this case, we want to know the original language(s) for each movie.

This script in its entirety is found in Appendix 2.2[12]. It uses an imported Python wrapper for the API, written by Derrick Gilland[13], which can be found at https://github.com/dgilland/omdb.py. This package can be installed through PIP by entering `pip install omdb` into the command line.

For practical purposes, the script requires one to enter a specific year (or, more accurately, corpus folder name). If desired, an asterisk can act as wildcard: `python OMDb-fetch.py 1988` will fetch data for movies from 1988, while `python OMDb-fetch.py 198*` will do it for all movies in the 1980s. In order to fetch data for all movies in the database at once, use `python OMDb-fetch.py *`. I don't recommend this, however, since it may overload the server and cause the script to time out.

The script begins by creating a list of all movie directory paths for the desired year.

```
for name in glob.glob(
        './OpenSubtitles2018_parsed_single/parsed/he/' + year +
        '/*/'):
```

[10] http://www.imdb.com/
[11] http://www.omdbapi.com/
[12] 14_appendix_2.md
[13] https://github.com/dgilland

```
17     IDs.append(name)
```

Each item in the list is then trimmed to include only the name of the movie folder, which is *almost* equivalent to the IMDb ID.

```
20 IDs = [os.path.basename(os.path.dirname(str(i))) for i in IDs]
```

In order to make the IDs match those in the database, additional zeros must be added to the beginning until they are seven digits long.

```
23 for i in IDs:
24     while len(i) < 7:
25         IDs[IDs.index(i)] = '0' + i
26         i = '0' + i
```

The list is then sorted numerically in order to more easily interpret the results: `IDs.sort()`.

The API key is set in line 32, but be sure to replace `906517b3` with your own key, which can be obtained at http://www.omdbapi.com/.

```
32 omdb.set_default('apikey', '906517b3')
```

The script then prints a table header, fetches the title, year, and language(s) for each movie, and prints the results directly into the computer terminal.

```
35 print('# ' + year + '\n' +
36       'IMDb ID\tTitle\tYear\tLanguage(s)')
```

```
    for i in IDs:
        doc = omdb.imdbid('tt' + i)
        print('tt' + i + '\t' +
              doc['title'] + '\t' +
              doc['year'] + '\t' +
              doc['language'])
```

4.1.2 Functional challenges

A quick scan of the CHVL reveals some notable items. Some of these are mere quirks of the automatic parser, while others are the result of ambiguities.

For example, the very first lemma on the list is a bit unexpected. "הוא" is certainly not the most common lemma in Modern Hebrew. A quick look at some of the files in the corpus, however, reveals that all pronouns are grouped under this lemma. That is, אתה (you), היא (she), and אנחנו (we), just to name a few, are parsed as belonging to the lemma "הוא." Considering how common pronouns are in the majority of spoken dialogue (in many languages), its place at the top of the list ceases to be a surprise.

Another thing to note is that verbs are all listed in their traditional third-masculine-singular past conjugation. The first verb on the list is "היה"—a lemma referring to all forms of the verb להיות, including the infinitive. The same is true of "ידע" (item 19) and "דיבר" (item 60).

Many of the most common lemmas on the CHVL are prepositions. Note that even inseparable prepositions, such as -ה and -ב are considered independent lemmas by the parser, and are listed respectively as the lemmas "ה" and "ב".

Other issues, however, are more difficult to explain.

4.1.2.1 Textual ambiguity of Hebrew orthography The flexible spelling conventions of Hebrew are at the root of many of the problems with the CHVL. For example, דִּבֵּר *he spoke* can be written as either דיבר ("full spelling") or דבר ("defective spelling"). There is also a noun, דָּבָר *thing*, that looks identical to the verb's defective spelling (דבר). Though the difference is usually clear from context, the automatic parser has some difficulty with this orthographic ambiguity.

The lemma “דבר” (item 27) includes instances of both the verb and the noun, which are completely unrelated. A simple search through the corpus reveals multiple examples of the noun דבר tagged with `lemma="דבר"`:

```
<w xpos="NOUN" head="579.3" feats="Gender=Masc|Number=Sing"
 ↪  upos="NOUN" lemma="דבר" id="579.2" deprel="nsubj">דבר</w>

<w xpos="NOUN" head="200.11" feats="Gender=Masc|Number=Plur"
 ↪  upos="NOUN" lemma="דבר" id="200.12" deprel="obj">דברים</w>
```

We also find plenty of examples of the verb with the same lemma tag:

```
<w xpos="VERB" head="0"
 ↪  feats="Gender=Fem|HebSource=ConvUncertainHead|Number=Sing|Person=3|Tense=Past"
 ↪  upos="VERB" lemma="דבר" id="2346.4" deprel="root">דברה</w>

<w xpos="VERB" head="0"
 ↪  feats="Gender=Fem,Masc|Number=Plur|Person=1|Tense=Past"
 ↪  upos="VERB" lemma="דבר" id="1270.2" deprel="root">דברנו</w>

<w xpos="VERB" head="0"
 ↪  feats="Gender=Fem,Masc|Number=Plur|Person=3|Tense=Past"
 ↪  upos="VERB" lemma="דבר" id="368.4" deprel="root">דברו</w>
```

A different lemma, “דיבר” (item 61), is the expected lemma for the verb since it follows the standard third masculine plural conjugation. Interestingly, however, the parser applies this lemma only to attestations of the word with an inserted *yod*, or with a *mem* or *lamed* prefix (present tense or infinitive). All other instances are parsed as the lemma “דבר.” Though unexpected and simply wrong, at least this issue is consistent.

```
<w xpos="VERB" head="840.4"
↪  feats="Gender=Fem,Masc|HebBinyan=HITPAEL|Number=Plur|Person=1|Tense=Past"
↪  upos="VERB" lemma="דיבר" id="840.16" deprel="conj">דיברנו</w>

<w xpos="VERB" head="1451.12"
↪  feats="Gender=Masc|HebBinyan=PIEL|Number=Sing|Person=1,2,3|VerbForm=Part|Voice=Ac
↪  upos="VERB" lemma="דיבר" id="1451.20" deprel="obl">מדבר</w>
```

To complicate matters more, we also find the unexpected lemmas "דיברה" (item 1184), "שדיבר" (item 2588), and "שדיברה" (item 4106).

Which, based on context (), should clearly be parsed as two separate lemmas, "ש" and "דיבר."

These are just a few among many examples of the difficulties encountered by the automatic parser. Though the parsing was carried out by the OPUS team as part of the corpus's pre-processing stage, it is valuable to at least have an idea of how it works its magic. I will here explain the basics of the process and some of the implications entailed.

4.1.2.2 Automatic parsing Automatic parsing refers to the process of having a computer program create a syntactic tree for a corpus of natural language. Natural language, as opposed to artificial or constructed language, is notoriously complex in its structure. Natural language processing (NLP) is an entire field of research, currently at the forefront of computer science. Parsing can serve many purposes, from theoretical linguistic research to machine translation or even the creation of artificial intelligences such as Siri or Alexa. For our purposes, a parsed text is important in order to use lemmas as the word family level for the CHVL. This decision is discussed under *Identifying Words* in this thesis.

Two distinct types of syntactic parsers exist, contituency parsers and dependency parsers. These are based on the two respective linguistic theories of syntax, constituent grammar (sometimes referred to as phrase structure grammar) and dependency grammar.

Constituent grammar is the classic syntax tree structure taught in introductory-level linguistics classes. It is essentially a theory of the logic structure of language as a whole. Dependency grammar is a competing theory that treats words as more directly interconnected to each other. A thorough description of these ideas is outside the scope of this thesis, and is not pertinent to the project. What is important to know is that dependency grammar, and thus dependency parsers, have played an important role in the advancement of NLP and computational linguistics as a whole. The term "automatic parser", therefore, most often refers to an automatic *dependency* parser.

Some parsers proceed in a two-step process of morphological tagging (part of speech) and then dependency parsing (syntactic role and conjugations). In all cases, tokenization must first take place, which refers to splitting the text into individual lemmas.

Most automatic parsers are "trained" using a small corpus that has been manually parsed by a human previously, or at least one that was automatically parsed and then checked and corrected by the researcher. These "gold-standard" pre-parsed corpora are called treebanks, and repositories of them they have been created for many languages. Building on existing databases of knowledge, these many of these parsers use statistical models to determine the most likely syntactic structure and conjugation for each word in each sentence.

Some parsers, however, are instead simply given entirely unparsed corpora and no knowledge of the language's syntactic structure. Working with nothing but the text itself, the program seeks out patterns and begins to create links and relationships that it deems significant.

Unfortunately, though automatic parsers have achieved surprising levels of accuracy in recent years, even the best continue to produce erroneous parsings. Some researchers have claimed as 95% or higher accuracy, including for some Hebrew parsers. When dealing with such a large corpus, such as the Hebrew OpenSubtitles2018 corpus consisting of nearly 200 million tokens, a best-case scenario for a 5% error threshold results in nearly 10 million incorrectly parsed words.

Undoubtedly, this can have a negative impact on the accuracy of lemma frequency counts. Many of the issues found in the CHVL are not due to orthographic ambiguity, but simply to inaccurate parsing. Some, as shown in the previous section, are even caused by erroneous automatic tokenization (consider the lemma “שדיבר”).

The good news is that automatic parsers are continually improving in accuracy. This is a problem that exists across the board, regardless of the corpus being used—unless it is manually parsed and lemmaticized, which is nearly impossible for such large corpora. The tools and techniques outlined in this thesis do not directly deal with the process of parsing.

5 Implications for other less commonly taught languages

5.1 Easy reproducibility and growth

Appendix 1: Conversational Hebrew Vocabulary List (CHVL)

	LEMMA	FREQUENCY	RANGE	UDP
1	הוא	23446109	43455	0.9480170256
2	ל	5638813	43448	0.9420130373
3	ה	9850733	43458	0.9292661347
4	ב	4812778	43450	0.9292364865
5	את	6846782	43426	0.9285176069
6	לא	5272808	43433	0.9145688112
7	ש	3880654	43439	0.9088900047
8	של	3892328	43445	0.9067041511
9	על	1766990	43430	0.904286502
10	זה	5118759	43441	0.9015544613
11	מה	2362419	43403	0.8922532708
12	היה	2579370	43420	0.8909904417
13	מ	1061614	43411	0.8890067276
14	כול	1325676	43414	0.8860074112
15	ו	1906717	43429	0.885270638
16	יש	1069358	43376	0.8770543442
17	עם	839575	43331	0.8668140052
18	אם	861163	43321	0.8654587702
19	ידע	1202416	43323	0.8586088804
20	אבל	921757	42963	0.8519038846
21	אמר	799835	43196	0.8515460134
22	רק	580549	43306	0.8490225759
23	עשה	957476	43311	0.8460669028
24	רצה	905161	43202	0.8453711531
25	יותר	519740	43206	0.8426501511
26	דבר	549346	43192	0.8389916741
27	אז	785143	43202	0.8317146818
28	חשב	585499	43062	0.8311268353
29	ראה	464852	43120	0.8276119303
30	אין	376940	42895	0.826471392

	LEMMA	FREQUENCY	RANGE	UDP
31	איך	367902	42714	0.825284943
32	זמן	397979	43034	0.8227270095
33	אחד	447348	43074	0.8218430306
34	שם	511696	43109	0.820013059
35	משהו	424351	42768	0.8199292075
36	צריך	678461	43101	0.8173698432
37	כך	538120	43151	0.8172938964
38	כמה	327641	42552	0.8144761932
39	אל	548185	43249	0.8123221549
40	עכשיו	464746	42758	0.8106640852
41	טוב	947724	43291	0.8084645436
42	יכול	490428	43141	0.8064150537
43	בא	419823	43050	0.8047477721
44	כמו	388089	42849	0.8041853147
45	גם	321102	42702	0.8041830813
46	כן	1207533	43226	0.8041799654
47	למה	433036	42608	0.8024645921
48	מן	260131	42071	0.8022138497
49	נכון	394738	42700	0.8014874793
50	מי	373446	42688	0.80073736
51	אחר	255588	41924	0.7996141928
52	נראה	310681	42564	0.7980211954
53	כ	270578	42075	0.797586002
54	פעם	286598	42191	0.7952189434
55	איש	562845	42958	0.7942488824
56	או	412974	42796	0.7936468503
57	הגיע	267993	41984	0.7917680395
58	עד	218184	41190	0.7917160839
59	עצמו	205086	41000	0.7894097508
60	דיבר	289788	41648	0.7883758932
61	הרבה	214954	41188	0.7877135038
62	לפני	225776	41249	0.7876190347

	LEMMA	FREQUENCY	RANGE	UDP
63	כבר	250376	41870	0.7861533936
64	אולי	316008	42239	0.7851973472
65	דרך	277379	41924	0.7851063904
66	קרה	298579	42161	0.7839807769
67	עדיין	208160	40811	0.7825677023
68	עוד	260354	42041	0.7824611913
69	ניסה	201709	40669	0.7812562648
70	הבין	178461	40099	0.7787652199
71	אף	224000	40829	0.7783418455
72	עבר	181166	40252	0.7771570269
73	מישהו	238416	40919	0.7759852576
74	אפילו	139866	38453	0.7743368394
75	כאן	623430	41759	0.773984761
76	שמע	171278	39499	0.7729531526
77	נתן	172041	39452	0.7726047557
78	כש	158697	38893	0.7723833043
79	שוב	157377	39393	0.7718752651
80	בדיוק	154089	38931	0.7716276664
81	כדי	306213	41152	0.770282592
82	אחת	154130	39146	0.7695547607
83	מקום	198165	40314	0.7680001789
84	חזר	202999	40579	0.7671689493
85	יצא	162483	39369	0.7662316518
86	התחיל	99971	35015	0.7652934349
87	בטוח	141725	38426	0.7652236472
88	במקום	55050	27901	0.7643551072
89	יום	266260	41382	0.7642633607
90	הספיק	75388	31940	0.7641498356
91	שב	95518	34110	0.7641391656
92	באמת	279723	41591	0.7624500121
93	אחרי	138136	37831	0.7622924022
94	וה	54161	26863	0.7622073428

	LEMMA	FREQUENCY	RANGE	UDP
95	שני	168829	39248	0.7621461876
96	חיים	256770	41514	0.7618890655
97	תמיד	138710	37943	0.7616653194
98	לקח	109842	35652	0.7609634126
99	קשה	100832	34923	0.7608985492
100	הכיל	183652	34316	0.7606625397
101	לפחות	46736	25727	0.760652816
102	כמעט	54522	27109	0.7599555508
103	קודם	71584	31900	0.7598150177
104	רגע	220597	40784	0.7597664595
105	המשיך	74650	30977	0.7595020775
106	חייב	271131	40994	0.7593203249
107	הביא	117845	36660	0.759057256
108	לשם	43631	24044	0.7586111453
109	קיווה	65759	29695	0.7585663791
110	מדי	117371	34092	0.7581777015
111	אחרון	115785	36237	0.7580135334
112	קרוב	64765	29164	0.7578402237
113	שמר	81313	31883	0.7575578845
114	עלה	63374	28020	0.7575210474
115	קרא	140013	37324	0.7572790956
116	מלא	48054	25189	0.7572739997
117	איזה	179147	39606	0.7570976824
118	שינה	64559	29600	0.7570520698
119	השאיר	52040	26619	0.7569118991
120	יחיד	73740	31360	0.7568256124
121	קצת	175325	38554	0.7568215267
122	חיכה	57163	27476	0.756807387
123	איתך	50853	25409	0.7565141919
124	עמד	103159	34456	0.7563573904
125	אי	146976	38291	0.7559666454
126	חשוב	70535	29954	0.7559403175

	LEMMA	FREQUENCY	RANGE	UDP
127	חוץ	90712	32860	0.7559332039
128	הכיר	131321	36335	0.7556745826
129	שאל	106181	34201	0.7553535119
130	נעשה	70421	30093	0.7553442662
131	מאוחר	52191	25779	0.7550953779
132	מוכן	115301	35648	0.7549545997
133	נשמע	69814	30269	0.7548470289
134	נכנס	90429	33029	0.7548084432
135	חלק	87778	32785	0.754725404
136	מבין	50540	25479	0.7545120899
137	נ	46983	24902	0.7544822115
138	אמור	89700	33337	0.753689558
139	קל	44150	24171	0.7534149166
140	ילד	59244	27026	0.7527902619
141	בכלל	60990	27698	0.7527396448
142	אלה	233644	38074	0.7527022741
143	כלל	53987	25929	0.7525384927
144	שום	146411	36788	0.7521875367
145	גרם	110859	35168	0.7520426531
146	הפסיק	64442	28808	0.7520203665
147	הפעם	40967	23297	0.7519715819
148	מתי	56953	26975	0.7516978167
149	הת	46255	24614	0.7515972282
150	סיים	49967	25437	0.7515551798
151	שכח	45437	23959	0.7511920907
152	איתי	46761	24239	0.7509541014
153	בין	79758	31121	0.7509185448
154	עבד	119322	35370	0.75091488
155	נשאר	98287	33880	0.7505987967
156	האמין	133888	37080	0.7502095967
157	בחר	54812	26160	0.7502076842
158	אכפת	72821	29977	0.7500879199

	LEMMA	FREQUENCY	RANGE	UDP
159	קיבל	243889	40776	0.7500171151
160	ישב	45291	23369	0.7499018222
161	רע	79634	30810	0.7497801544
162	הוציא	51586	25538	0.7494769452
163	עזר	166920	38806	0.7494677516
164	בעיה	133192	36380	0.749376319
165	הראה	41990	22842	0.7493114348
166	גדול	182308	39208	0.7490466276
167	כוונה	42481	23367	0.7489349235
168	אעשה	39467	22636	0.7484708894
169	צדק	57882	27334	0.7484672402
170	שנה	219155	39679	0.747974035
171	אלא	41737	22893	0.747954367
172	ביקש	71177	28968	0.7478055486
173	חסר	48992	24559	0.7475294553
174	סוף	87864	31625	0.7475109849
175	תודה	269458	40779	0.7473604624
176	עובד	80911	30543	0.7471789502
177	גרוע	49393	25267	0.7469436121
178	הניח	100464	33988	0.7468575081
179	השתמש	76694	30709	0.7457989917
180	מושג	43162	23299	0.7452825579
181	היום	161107	37991	0.7452401042
182	בלי	82463	31103	0.7451788216
183	בבקש	45787	23109	0.7450939608
184	הפך	79849	30971	0.7450116709
185	חץ	55858	25677	0.7449420523
186	הבטיח	49463	24500	0.744862888
187	ברור	55491	25902	0.7448479539
188	מזל	59141	26640	0.7448047006
189	תן	126600	35753	0.7444971437
190	אופן	63422	26925	0.7441921309

	LEMMA	FREQUENCY	RANGE	UDP
191	לאן	61827	27273	0.7441448176
192	מאוד	242051	40437	0.7441282577
193	הסתכל	42945	22239	0.7436579639
194	עניין	115658	34716	0.7435984846
195	איבד	48731	24396	0.7435728837
196	מעולם	77133	28830	0.7435419138
197	במשך	47299	23392	0.7435258738
198	קטן	148715	37651	0.7433888266
199	רעיון	60631	26575	0.7430392985
200	הלך	638998	43040	0.7429720343
201	שתי	39982	21679	0.7427308035
202	סדר	834217	42733	0.7426789343
203	החזיק	54710	25545	0.7425742773
204	עין	68827	28544	0.7423705866
205	שונה	45562	23096	0.7423548847
206	מצב	84165	31396	0.7422339254
207	שה	34689	20798	0.7422119424
208	הצטער	190553	38552	0.7421879954
209	חדש	142727	37387	0.7420182822
210	השיג	48373	23811	0.7419727547
211	הקשיב	44182	22621	0.741928355
212	הגיד	152422	35355	0.7417440599
213	שעה	121973	34939	0.7417170913
214	מקרה	98210	32986	0.7413964143
215	שנייה	58550	26144	0.7413615068
216	עזב	85029	31038	0.7412648676
217	לבד	49030	24642	0.7410606074
218	ישן	62874	27460	0.7408563335
219	ודה	36919	21077	0.7407312507
220	פנים	83000	31491	0.7407147299
221	הזדמנות	42643	22444	0.7404669742
222	רציני	39596	21409	0.7402443896

	LEMMA	FREQUENCY	RANGE	UDP
223	שבוע	92062	30773	0.7400989553
224	עזרה	42332	23031	0.7400542463
225	חי	55083	25663	0.7399883645
226	חיפש	82840	31018	0.7395963524
227	בהחלט	45868	22666	0.7394598613
228	שאלה	67213	27781	0.7393956671
229	אמיתי	76011	29258	0.7393012975
230	נגמר	42863	22750	0.7389565606
231	זכר	77021	29885	0.7388757029
232	בטח	124636	35618	0.7386129576
233	שניים	37443	20788	0.7385213779
234	יד	162906	37277	0.738349124
235	מייד	43011	21960	0.7382879283
236	אכל	105627	34354	0.7381245586
237	איפה	199458	38203	0.7381112111
238	מצא	206740	39632	0.738090718
239	שלח	56416	25495	0.7379336542
240	כנראה	54321	24952	0.737712106
241	פתח	43581	22423	0.7377085338
242	הנה	176643	38711	0.7376343479
243	מעל	45180	22991	0.737591866
244	לעולם	71132	28630	0.737578682
245	ככה	50618	23796	0.7373942767
246	חודש	58403	24849	0.7372285979
247	חזק	57852	25977	0.7372138662
248	נחמד	70052	27659	0.7371124211
249	כלום	93067	31268	0.7368065449
250	לפעמים	38191	21002	0.7367866745
251	כמובן	79627	29256	0.7363298635
252	דקה	76463	28622	0.7362924936
253	קורה	44598	23024	0.7362295076
254	פרק	47729	27236	0.7362027981

	LEMMA	FREQUENCY	RANGE	UDP
255	מילה	44487	22043	0.7358839517
256	בעוד	38921	21239	0.7358829875
257	מספיק	32456	20251	0.7357807778
258	שאר	36934	20718	0.7353728441
259	נוסף	58792	25572	0.7352874904
260	שמח	77624	30078	0.7352431471
261	יפה	83352	29667	0.7351487295
262	הציע	39769	21157	0.7351081906
263	הודה	65515	26896	0.7350893805
264	סיכוי	41951	22067	0.7349590884
265	צורה	44400	22438	0.7346784759
266	הצליח	59142	25896	0.7344972776
267	חבר	186844	38452	0.734147728
268	פחות	33427	19982	0.7341361879
269	לגמרי	48709	23158	0.7339458687
270	סוג	57056	24733	0.7337693895
271	חזרה	58804	25849	0.7337249196
272	אהב	267134	40244	0.7336376602
273	ירד	37336	20241	0.7335996357
274	שכן	36998	21089	0.7334231512
275	לב	112118	34293	0.7333369915
276	פגע	47572	23466	0.7333269908
277	כדאי	73858	28723	0.733054925
278	שלוש	51076	22791	0.7330223662
279	בתוך	43425	21982	0.7328734462
280	ליד	33666	20052	0.7327245222
281	בדק	55246	24773	0.7326923297
282	עבודה	179543	37349	0.7323951341
283	מחר	63071	25269	0.7323940254
284	נמצא	120923	34685	0.7323215003
285	בית	327260	40888	0.7321608087
286	הרגיש	148724	36977	0.7318832591

	LEMMA	FREQUENCY	RANGE	UDP
287	בלתי	44157	21790	0.7318474784
288	אפשר	111812	33563	0.7316673429
289	עצר	60763	26180	0.731573767
290	למד	56993	24951	0.7315141467
291	ראש	111934	33647	0.7315138677
292	קשר	146801	36266	0.7315131651
293	דעה	38500	20700	0.731489195
294	הביתה	83284	29329	0.731299241
295	מהר	65270	27051	0.7312323278
296	קח	46087	21743	0.7312303244
297	פשוט	276544	40438	0.7309931605
298	סיפר	134031	35660	0.7308407835
299	אמת	81307	29720	0.7305176277
300	תראה	100316	31667	0.7301189215
301	החוצה	48959	22603	0.729862538
302	די	92028	31259	0.7297169818
303	שלושה	41876	20973	0.7296060878
304	רב	104109	32606	0.72955377
305	סלח	43823	21207	0.7295246895
306	הצלחה	32762	19333	0.7294969843
307	סתם	43930	21609	0.7294567963
308	רגיל	33532	19572	0.729249545
309	סיבה	113796	34419	0.7291835982
310	הכי	92936	31255	0.7291680678
311	למעשה	51291	23015	0.7290616868
312	התכוון	135096	35138	0.7288138228
313	נקודה	44903	21657	0.7285867446
314	בבקשה	159524	36882	0.7285685947
315	בוקר	99172	30693	0.7281264133
316	לכן	49933	22825	0.7281093816
317	אלי	37067	19944	0.7280241905
318	קנה	53850	23964	0.7280068208

	LEMMA	FREQUENCY	RANGE	UDP
319	תפס	36698	20032	0.7278323204
320	מוזר	60733	25833	0.7277972419
321	גש	35553	19488	0.7277121856
322	בשביל	141977	35703	0.7276218143
323	עסק	91416	29969	0.7268211845
324	יחד	45480	21633	0.7266399146
325	אוכל	78950	29281	0.7265271334
326	אתן	42718	21524	0.7263799243
327	כאילו	81780	30119	0.7262683135
328	מיוחד	38008	20056	0.7261426774
329	חושבת	48123	22479	0.7259277175
330	בגלל	121582	33952	0.7253824561
331	תרא	63828	25651	0.725201538
332	שילם	51446	22382	0.7251261161
333	התראה	51727	22837	0.7249730967
334	בוא	183452	38124	0.7249015648
335	צעיר	46982	21498	0.7248317714
336	ביותר	88518	28965	0.7245400689
337	למעלה	44407	20843	0.7244146559
338	התקשר	71098	25533	0.7242354425
339	טעות	33998	19445	0.7241870178
340	בחור	68431	25592	0.7240913472
341	ציפה	28977	18426	0.7240666724
342	זאת	458405	41920	0.7238993223
343	נהג	44367	20845	0.7238395601
344	מצטער	34301	19572	0.7237249771
345	ארוך	29358	18330	0.7236610723
346	טיפל	35412	19710	0.7236317511
347	גבוה	33710	18756	0.7235971022
348	החזיר	36007	20104	0.7235659301
349	העליי	77454	24793	0.723488197
350	לאחר	55784	23190	0.7231869589

	LEMMA	FREQUENCY	RANGE	UDP
351	הסכים	32794	18770	0.7228958514
352	שיחה	38827	19897	0.7228810085
353	פחד	51801	22795	0.7227687501
354	כי	277322	38980	0.7226128673
355	ניתן	33218	18888	0.7221544319
356	מוקדם	28974	18294	0.7219771836
357	מת	209263	39030	0.7219628992
358	יכולת	32277	19032	0.7219402362
359	צד	34626	19226	0.7218224721
360	נורא	38503	19735	0.7218197452
361	חכה	68492	25911	0.7216722253
362	תדאג	31904	19026	0.7213861779
363	למען	38847	19906	0.721304746
364	כפי	40865	19918	0.7200534595
365	אתמול	45515	21452	0.7199803257
366	ערב	57377	23196	0.7199797507
367	מספר	72795	25912	0.7198548978
368	בעל	76549	27783	0.7197942705
369	חמש	38896	19160	0.7193984301
370	מאשר	28195	17633	0.7179471355
371	תחת	31938	17993	0.7178875479
372	כרגע	39722	19976	0.7178318886
373	שווה	30611	18112	0.7175492795
374	לילה	169318	35873	0.7173176145
375	שקט	34966	18622	0.7171228943
376	הסביר	28968	17836	0.7170220435
377	העביר	30214	17975	0.7167067263
378	זו	389942	38399	0.7164040078
379	י	42114	20366	0.7157420446
380	מסוגל	35529	18869	0.7156238736
381	הוריד	32852	18273	0.7153206863
382	חושב	92894	28956	0.7152910962

	LEMMA	FREQUENCY	RANGE	UDP
383	שאמר	25388	17308	0.7152421478
384	צריכה	46925	21649	0.7152074257
385	הבחור	55510	22331	0.7150010543
386	ללא	61731	24590	0.7148350498
387	נעלם	39306	19993	0.7147805669
388	עובדה	28205	17294	0.7147342763
389	סיפור	69616	26111	0.7147277465
390	חדר	109017	31987	0.7141118947
391	כבוד	51623	21817	0.7139722358
392	נגע	45566	21069	0.7135320108
393	בחייך	48561	20788	0.7134925247
394	סליחה	72672	25859	0.7134712582
395	לגבי	63139	23852	0.7133698597
396	מטה	46518	20269	0.7133580286
397	רוח	55806	23413	0.7131913761
398	בקרוב	29234	18039	0.7130681253
399	האליי	38658	18630	0.7128121409
400	דלת	60595	24076	0.7127045891
401	הכין	32161	18648	0.7126869215
402	דאג	32783	18349	0.7124880102
403	אית	26211	17189	0.7124481146
404	שיחק	58699	23577	0.7120624872
405	אפשרי	30242	17658	0.7120244767
406	אדם	200100	38089	0.7118554468
407	אצל	31511	17589	0.7113908312
408	לפ	31149	17418	0.7112366987
409	ממש	190693	37369	0.7108608252
410	נהדר	77117	26285	0.7107238238
411	נגד	38107	18684	0.7105908384
412	רחוק	28613	17301	0.7105602372
413	ביחד	40371	19338	0.710509941
414	כאב	42011	19849	0.7098332821

	LEMMA	FREQUENCY	RANGE	UDP
415	כיוון	33585	17992	0.7097300266
416	רוב	30663	17127	0.7082659531
417	ארוחה	35455	18292	0.7078307699
418	אלף	26957	17337	0.7076901203
419	אישי	27779	16623	0.7075250817
420	מעבר	28859	16944	0.7074280407
421	עלול	30722	17521	0.707404867
422	תורגם	35600	19872	0.7073848364
423	הופיע	28375	16743	0.707236713
424	בנה	30064	17246	0.707115285
425	נסע	51262	20354	0.7064758117
426	עולם	106212	31680	0.7063031666
427	זהו	88493	28003	0.7057294006
428	שלום	134482	34158	0.705414933
429	משך	26666	16544	0.7054148652
430	ערך	27833	16806	0.7052770346
431	מאחורי	25711	16436	0.7046718771
432	שנא	31478	17318	0.7046126398
433	בגד	31315	17232	0.7043811871
434	יצר	38263	18486	0.7037014243
435	א	47853	20598	0.7036041426
436	חברה	112610	31444	0.7035715971
437	תוכנית	77143	26625	0.7034012997
438	ניצח	43784	19665	0.7033827166
439	כתב	68326	23615	0.7032628794
440	תמונה	52029	20845	0.703052461
441	הזכיר	22880	15934	0.7028798911
442	מוות	67543	24487	0.702866482
443	בערך	26705	16236	0.7028281894
444	גר	37657	17985	0.7025931732
445	אמצע	23722	15917	0.7025409909
446	מתחת	27256	16600	0.7025043494

	LEMMA	FREQUENCY	RANGE	UDP
447	לחץ	33426	17264	0.7024540764
448	לעזאזל	68624	24177	0.7023060468
449	טלפון	66712	22700	0.7022575358
450	הגן	34085	17830	0.7021851713
451	התאים	24649	16114	0.702067948
452	הכניס	24328	15835	0.7020622143
453	התמודד	27809	16712	0.7018327426
454	נפגש	26092	16054	0.7015122968
455	עבור	85841	24695	0.7007542386
456	בן	270834	40029	0.7002527794
457	מצחיק	31729	16994	0.7001774739
458	מעט	28455	16294	0.7000108207
459	זוכר	30267	16942	0.6996247424
460	קיים	28007	16353	0.6995253097
461	הציל	44028	19759	0.6992853964
462	הזמין	27482	16304	0.6992744887
463	למרות	26167	16043	0.6992328041
464	אקח	23209	15773	0.6991071693
465	איתן	29262	16540	0.69897796
466	לפי	29227	16438	0.698903123
467	סימן	31504	16983	0.6985069202
468	לבש	29275	16629	0.6984565372
469	ספק	25278	15635	0.6979374643
470	בת	93599	28383	0.6975583872
471	במיוחד	22176	15147	0.6971721905
472	מחדש	27450	16186	0.6971600739
473	התחלה	21710	15161	0.6967019141
474	רחוב	39941	17507	0.6963750102
475	משפחה	104525	29823	0.6963376646
476	הערב	45069	18671	0.6961500605
477	אלוהים	210842	35618	0.6959731886
478	קצר	22297	15089	0.6959566078

	LEMMA	FREQUENCY	RANGE	UDP
479	עזאזל	100331	28613	0.695819585
480	הצטרך	22495	15287	0.6955729046
481	טיפש	28604	16103	0.695523551
482	אסור	29549	16451	0.6955129843
483	החלטה	28762	15978	0.6955030906
484	זז	28681	16105	0.6953489373
485	הודעה	32800	16692	0.6952133673
486	יופי	38738	18075	0.6948367181
487	גבר	119470	31398	0.6946615752
488	נקרא	22878	15250	0.6942184777
489	סביבה	24446	15259	0.6941596047
490	אור	30970	16257	0.6939727559
491	חוק	38433	17001	0.6938093837
492	אח	62249	22129	0.6937258948
493	גנב	36703	17273	0.6935358098
494	משרד	53856	19641	0.6933660069
495	החליט	22521	14991	0.6932626846
496	מערכת	45814	18981	0.6930330541
497	נפל	24793	15183	0.6929591896
498	מושלם	25446	15526	0.692932052
499	שתיים	29266	15645	0.6927257115
500	הוטרף	26467	15580	0.6923941155
501	ן	23039	15104	0.6917846177
502	העדיף	21524	14882	0.6914479499
503	ספר	126021	32397	0.6911662598
504	מהלך	27210	15503	0.6908194406
505	קטע	31794	16392	0.6900902886
506	טעם	24740	15311	0.6900390323
507	ניסיון	22094	14770	0.6900377888
508	בתור	26690	15608	0.6900352933
509	מוצא	22210	14629	0.6897565967
510	נהנה	24566	15334	0.6895847836

	LEMMA	FREQUENCY	RANGE	UDP
511	מין	31053	15961	0.6895422947
512	שירות	28723	15767	0.6894819475
513	צעד	26512	15122	0.6892665452
514	נפלא	33808	16076	0.6891480192
515	גוף	32953	16491	0.6889814462
516	קול	43516	17953	0.6888180192
517	אדיר	42280	17816	0.6887415417
518	חדשות	25677	15380	0.6887395018
519	תפקיד	30626	15537	0.6885656229
520	צהריים	25563	14887	0.6884474358
521	אראה	21223	14588	0.6883200942
522	תשובה	23630	14878	0.688264663
523	חלה	60204	21244	0.6882338866
524	סבל	23693	14809	0.6881210183
525	זקוק	28408	15699	0.6879757716
526	גמור	25377	14927	0.6879061051
527	מים	46803	18838	0.6878891266
528	עיר	84067	26088	0.6878717009
529	רצינות	24555	15123	0.6876706831
530	והיי	388785	36676	0.6876699482
531	שן	22289	15141	0.6876507207
532	החליף	22008	14641	0.6874974022
533	בצד	22200	14506	0.687494966
534	גידי	29006	15672	0.6874567503
535	ברוך	24841	14984	0.6873558061
536	נעל	30612	15835	0.6872947396
537	הוביל	24282	14940	0.6872409139
538	צורך	21780	14581	0.6870485965
539	צוות	60182	21080	0.6870229797
540	ברח	26786	15514	0.6866285704
541	כוח	65992	23354	0.6865035252
542	נשק	44828	18112	0.6864818854

	LEMMA	FREQUENCY	RANGE	UDP
543	שולחן	26796	14963	0.686306115
544	ככל	21610	14377	0.6860225856
545	הורה	34611	16310	0.6859805942
546	מטרה	33106	15951	0.6859462123
547	פנימה	23950	14506	0.6854226527
548	גילה	22066	14658	0.685287813
549	הרשה	21051	14105	0.6852823893
550	חם	25170	14682	0.6850446951
551	מיטה	28113	15212	0.6849563886
552	ארבע	25315	14298	0.6845052354
553	אהבה	48349	18292	0.6842906115
554	ילד	286526	39003	0.6842788489
555	ישר	21503	13788	0.684210625
556	זוג	29494	15370	0.6841469783
557	ותק	48434	18007	0.6839113203
558	תוך	22093	14170	0.6838908592
559	נוח	22057	14384	0.6837318084
560	חשבתי	19504	14490	0.6835461456
561	מדינה	39099	15768	0.6835264385
562	סמך	24286	14787	0.6834645923
563	מול	22733	14323	0.6831493689
564	אב	36237	16121	0.6830663561
565	זכות	25428	14256	0.6829699097
566	כלומר	42567	16988	0.6826894041
567	יקר	21816	14095	0.6826519838
568	שחרר	27115	15146	0.6826342435
569	מידע	37642	16139	0.6826077034
570	ענה	21309	14788	0.6821787425
571	חשבון	25497	14268	0.6813941773
572	מאה	24481	14247	0.6812393257
573	הפריע	19994	13961	0.6808298315
574	אוויר	29391	14943	0.6806467383

	LEMMA	FREQUENCY	RANGE	UDP
575	פגישה	31627	15003	0.6806137431
576	הצטרף	21644	14144	0.6804024728
577	שלומך	25313	13675	0.6803961452
578	מוח	33414	15815	0.6802982858
579	אלו	79895	21603	0.6801781522
580	הדבר	21069	14108	0.6800283772
581	כדור	58850	20345	0.6798777039
582	הרגל	23986	14088	0.6798187118
583	מיני	24270	14421	0.6796423144
584	תקשיב	24742	14245	0.679063459
585	נעים	22824	13761	0.6788524482
586	מבט	20802	13651	0.6787799978
587	צפה	20797	14047	0.6787504505
588	מתוק	30675	15261	0.6786662669
589	חבל	21785	13954	0.6786475839
590	נשא	23551	13857	0.6782422631
591	הרג	129020	29925	0.6782185649
592	לתוך	23236	14037	0.6781059414
593	שייך	22585	14040	0.6780237312
594	הרס	21537	14270	0.6779511674
595	לבן	26079	14048	0.6776427474
596	שעשה	18128	13540	0.6775737869
597	המ	27799	14494	0.6775318892
598	הסתובב	19667	13377	0.677064829
599	בחורה	28881	14657	0.6767060865
600	פעולה	24189	13885	0.6766103988
601	נרגע	26088	14117	0.6766056949
602	סגר	20917	13586	0.6763634772
603	גדל	20911	13562	0.6763225834
604	היקח	19466	13467	0.6760658873
605	תפסיק	23856	13940	0.6759811966
606	אגיד	20937	13702	0.6758237864

	LEMMA	FREQUENCY	RANGE	UDP
607	מסוכן	21915	13987	0.6758127032
608	זרק	21314	13618	0.6755505569
609	תהי	21587	13941	0.6755314781
610	עשר	23977	13697	0.6755251882
611	חכם	20336	13425	0.6752554862
612	גברת	64140	20248	0.6751813371
613	דולר	60965	18338	0.6751702352
614	שינוי	21790	13717	0.67490225
615	ביצע	23118	13684	0.6747570407
616	שלם	18514	13358	0.6747451015
617	עלייך	25562	14499	0.6747042683
618	זונה	40225	15443	0.6746088468
619	מנהל	31646	14360	0.6745423267
620	חתיכה	22389	13661	0.6744828553
621	חומר	27716	14014	0.6744228935
622	רכב	35362	15119	0.6742473557
623	אחראי	21545	13581	0.6736649998
624	חתך	22388	13556	0.6735182669
625	ניהל	19826	12930	0.6730627155
626	משטרה	62585	18340	0.6727316177
627	צוחק	27135	13873	0.6726623337
628	עוזב	19926	13289	0.6724123
629	עונה	21128	16314	0.6723301941
630	רופא	45488	16659	0.672024932
631	מכר	23577	13216	0.6719295775
632	השתנה	20353	13421	0.6718465454
633	מפה	29533	14189	0.6709086698
634	עץ	34139	14898	0.670832602
635	כלא	43491	15589	0.6708308059
636	מהיר	20903	13155	0.6705956003
637	כרטיס	29702	13967	0.6705263381
638	אצטרך	18209	13342	0.6704775286

	LEMMA	FREQUENCY	RANGE	UDP
639	פשע	35547	14565	0.6703819783
640	קבוצה	40544	15813	0.6703108733
641	המון	22918	13256	0.6702285421
642	כלשהו	21146	13207	0.6701005457
643	סכנה	21596	13566	0.669462576
644	מתוך	19147	12809	0.6693526876
645	שנוכל	18269	13339	0.66928734
646	קו	25216	13233	0.6692700889
647	הלוואה	19687	13220	0.6690227782
648	מסר	21693	13107	0.6689513536
649	יחסים	26687	13752	0.6687970945
650	מכונית	78708	21273	0.6686906036
651	וב	17646	12447	0.6686623457
652	ארץ	40008	15669	0.6686397384
653	הגיוני	19235	13055	0.6685594793
654	דם	62041	20297	0.6685565848
655	הדה	21093	13101	0.668513652
656	כיף	25538	14072	0.6682454932
657	עשוי	22701	13352	0.6682395193
658	העריך	17831	12680	0.6679289203
659	שליטה	21269	13108	0.6678991286
660	זכה	24942	13316	0.667862798
661	רמה	20702	12815	0.6676860515
662	אוי	44899	16449	0.6674228528
663	אפשרות	19160	12787	0.6673955164
664	שמחה	20060	13077	0.6673158968
665	פתוח	18684	12827	0.6671985811
666	שיר	42679	15685	0.6670326267
667	חופשי	19901	12818	0.6670280318
668	כסף	135843	28087	0.6670047228
669	רשימה	26386	13403	0.6668214889
670	פרטי	20520	12665	0.6666343952

	LEMMA	FREQUENCY	RANGE	UDP
671	אש	37360	15071	0.6665901443
672	חמוד	25354	13620	0.666167358
673	צא	23703	13087	0.6659784686
674	שש	22812	12825	0.6658906289
675	עתיד	25814	13385	0.6655604852
676	הלו	28281	13386	0.6655441795
677	נושא	20248	12484	0.6654212333
678	שחור	29409	13552	0.6653889217
679	משחק	81151	24065	0.6653530879
680	תיק	36739	14271	0.6653430249
681	גיל	22207	12759	0.6652898669
682	פעל	19709	12705	0.6651821943
683	איתה	18666	12929	0.6649849948
684	קפה	27340	13261	0.6646339454
685	עקב	20069	12874	0.6640737607
686	היכן	48255	16013	0.6640217227
687	החלק	18140	12666	0.6639917196
688	אזור	24762	13129	0.663918207
689	שטח	24612	13205	0.6638577069
690	חייך	18082	12577	0.6637210853
691	לחלוטין	19290	12506	0.6634580465
692	וואו	43989	15605	0.6634340093
693	עמוק	18686	12460	0.6632497577
694	נלחם	29162	13749	0.6632355502
695	גמר	19924	12307	0.6630216875
696	תגיד	17813	12195	0.6629976726
697	כאשר	56166	15772	0.6623824349
698	אחרת	15921	12093	0.6622270427
699	מסוים	18260	12276	0.6616631782
700	זקן	25313	12838	0.6616223306
701	דובר	22191	12523	0.6606712046
702	נצטרך	17872	12496	0.6604553639

	LEMMA	FREQUENCY	RANGE	UDP
703	תוצאה	20866	12297	0.66018425
704	לישון	19558	12295	0.6597971878
705	כבד	18444	11980	0.6592738659
706	חשש	18628	12296	0.6591882722
707	מעניין	17128	12116	0.6590920683
708	גב	27010	12727	0.6590021389
709	מצוין	22819	12431	0.6589085092
710	שקר	20460	12361	0.6588475702
711	ובכן	188842	27119	0.6588335
712	תקופה	18466	11999	0.6588048374
713	האשים	17959	12138	0.6586872276
714	ביי	32434	12971	0.6586047704
715	בדיקה	30789	13232	0.6582379081
716	תני	19112	12338	0.6581687605
717	התקרב	17162	12090	0.6580893063
718	פרט	17794	11925	0.6577512017
719	אידיוט	21741	12174	0.6575986185
720	מעמד	18726	11840	0.6575800008
721	פגש	16502	11762	0.6572396301
722	שהייה	15521	11779	0.657085437
723	הוכיח	18670	11951	0.6568365934
724	הבחורה	23272	12398	0.6565952224
725	שכנע	17282	11976	0.6564856379
726	רץ	19090	11630	0.6564817288
727	כה	23858	12452	0.6562881351
728	צבע	22920	12078	0.6561303903
729	חלום	28440	12785	0.655806186
730	חנות	25012	12676	0.6558036879
731	דין	43969	14317	0.6555802175
732	מחיר	20145	11950	0.6554877141
733	עדיף	16851	11850	0.6551502507
734	דירה	31147	13077	0.6551130059

	LEMMA	FREQUENCY	RANGE	UDP
735	הפחיד	17331	11866	0.6550067758
736	מתנה	20836	12112	0.654993717
737	מלחמה	43193	14580	0.6549903666
738	הגנה	22583	12072	0.6544375918
739	מרחק	18451	11900	0.6543854146
740	אדום	23426	11969	0.6543603976
741	שלט	18549	12031	0.6540224021
742	רגל	18311	11455	0.6540123152
743	עורך	29916	12270	0.653985097
744	תחנה	25747	12378	0.6538947506
745	סרט	52329	16423	0.6537311197
746	שבר	17298	11673	0.653518665
747	קדימה	198854	34380	0.6534927601
748	זיהה	18212	11751	0.6529948422
749	הוגן	17267	11626	0.6528978377
750	כלב	43138	14561	0.6528336538
751	שומר	18922	11831	0.6528197914
752	לכי	22331	12188	0.6527805514
753	ויתר	17187	11732	0.6526623736
754	לאחרונה	16225	11795	0.6526518282
755	יחידה	23205	12092	0.6526375596
756	תא	26021	12524	0.6524951103
757	אבא	158901	29216	0.6524220653
758	ביטחון	20138	11698	0.6520770684
759	יכל	18556	11541	0.6517396914
760	עלי	15428	11528	0.651617516
761	כלי	20356	11784	0.6514161345
762	בעצם	18483	11350	0.6513389503
763	משפט	39156	13243	0.6513068635
764	הסתיים	16495	11512	0.6512381499
765	חך	18850	11749	0.6512331414
766	עוזר	18391	11674	0.6511786639

	LEMMA	FREQUENCY	RANGE	UDP
767	אתר	23175	12246	0.6510946499
768	נפגע	17792	11568	0.6510894301
769	פ	18936	11502	0.6509383997
770	פה	179198	32392	0.650795368
771	נפטר	17128	11360	0.6507900754
772	חלון	19129	11414	0.6507829235
773	שלב	19177	11500	0.6506977908
774	אחי	63906	17859	0.6505429884
775	תלוי	14728	11185	0.6502090406
776	אמא	167065	26720	0.6500226527
777	בעצמך	14318	11272	0.6500174782
778	ההוא	19265	11584	0.6499870609
779	כעת	43252	14172	0.6499634779
780	שכר	18688	11152	0.6496699478
781	עצמך	14313	11145	0.6493888189
782	רצח	60144	16162	0.6493052613
783	הבחר	16890	11356	0.6491876544
784	בר	18472	11298	0.6491741908
785	מר	146704	26570	0.6490224129
786	תכנן	15857	11352	0.6488646482
787	שיעור	22104	11679	0.6487376366
788	הא	34636	12766	0.6486768104
789	התרחק	17474	11527	0.6486502522
790	מותק	25611	12259	0.648618291
791	שותף	22502	11556	0.6485146259
792	נדבר	15215	11122	0.6484347421
793	שמונה	18191	11034	0.6483853238
794	הלאה	16442	11215	0.6479885944
795	הצעה	20113	11235	0.6478501144
796	תסתכל	17573	11244	0.6476732706
797	ראייה	24456	11606	0.6471709215
798	הדע	14982	11125	0.6471310956

	LEMMA	FREQUENCY	RANGE	UDP
799	מדוע	37332	12801	0.6470783704
800	הידי	16651	11046	0.6468596261
801	עשית	14287	11109	0.6466812122
802	מחשבה	15714	11067	0.6466228783
803	אקדח	39948	12963	0.6465681297
804	מאושר	18661	11038	0.6463500223
805	סביב	15711	10810	0.6460287958
806	גישה	17476	11205	0.645804639
807	מהירות	18824	10975	0.6454430352
808	פנה	15694	10759	0.6450294635
809	שוטר	56235	14924	0.6448564384
810	מידה	15478	10674	0.6443406095
811	מיליון	26116	10942	0.644080189
812	נחש	16005	11043	0.644000921
813	קר	17343	10900	0.6439416391
814	מרכז	19237	10929	0.6436605734
815	נקי	16549	10838	0.6435246041
816	קבע	14837	10636	0.6434463895
817	זהיר	16261	10768	0.6431411339
818	העלה	14300	10511	0.6431050256
819	הסתדר	14436	10726	0.6430832736
820	ארבעה	17056	10579	0.642847399
821	שער	23225	11155	0.6427641541
822	ראוי	16150	10716	0.6426654687
823	נת	14024	10760	0.6425963739
824	אדמה	22675	11340	0.6425716519
825	מוכר	14943	10646	0.6424313062
826	ם	18094	10857	0.6423498462
827	תינוק	49123	14886	0.6421549492
828	העמיד	14541	10781	0.6416158382
829	אגב	14601	10783	0.6415822338
830	רצון	17003	10723	0.6415436783

	LEMMA	FREQUENCY	RANGE	UDP
831	דרש	15086	10705	0.6413020835
832	סגור	14788	10525	0.6412690057
833	הכה	16928	10523	0.6411804032
834	יוצא	13603	10314	0.6411760238
835	בניין	24245	11215	0.6411259746
836	בקושי	13857	10689	0.6409341156
837	עשי	14841	10993	0.6409186484
838	כניסה	15394	10563	0.640841239
839	ביקר	15213	10469	0.6405967235
840	ירה	21259	10718	0.6405054387
841	כוכב	33861	12372	0.64040029
842	דעתך	14270	10610	0.6403974806
843	רגש	17663	10886	0.6402669368
844	רעב	17084	10755	0.6401895042
845	איום	16945	10677	0.6401645514
846	אירוע	17203	10547	0.6401587224
847	השנה	17729	10483	0.6401000299
848	נשבע	15614	10431	0.640096061
849	אינו	97424	22002	0.6400922382
850	כעס	16194	10766	0.6399348394
851	הושלם	14931	10624	0.6397692214
852	המשך	14399	10453	0.6397504879
853	יגע	15599	10380	0.6396627983
854	התעורר	15781	10636	0.6395637873
855	בפני	15101	10488	0.6395623345
856	תקווה	16258	10662	0.6394894516
857	אדוני	119659	23260	0.6394781788
858	ניו	31706	11132	0.6394041344
859	רואה	14931	10948	0.6392676481
860	ים	26783	11409	0.6392602266
861	היטב	15348	10445	0.63907521
862	טיפול	21154	10912	0.6388078307

	LEMMA	FREQUENCY	RANGE	UDP
863	מפתח	20255	10730	0.6386307043
864	אכן	18504	10630	0.6382189052
865	קלט	17929	10591	0.6381770053
866	תראו	16401	10783	0.6381297552
867	מחלקה	21061	10556	0.6381147361
868	כמוני	13449	10338	0.6381142233
869	דוד	34311	12007	0.6380696722
870	מעשה	15444	10331	0.6375348014
871	אסף	14132	10389	0.6375294472
872	מאית	14315	10630	0.637363769
873	שטות	15059	9762	0.6370325165
874	גאה	14788	10180	0.6368535345
875	תת	14572	10301	0.6368165865
876	אלף	22105	10277	0.6362856564
877	הודיע	13848	10053	0.6362325456
878	ידיד	18120	10365	0.636000479
879	היסטוריה	16055	10043	0.6359981157
880	צחק	15117	10313	0.6359893169
881	מאחור	14145	10141	0.6359808507
882	האם	252114	31767	0.6355576557
883	משימה	26215	11277	0.6353326807
884	אורח	15323	10094	0.6350002439
885	וידא	13419	10373	0.6347930762
886	חרא	35830	11147	0.6347731563
887	תיקן	15845	10546	0.6345010271
888	ע	17728	10061	0.6343152887
889	תעש	14043	10224	0.6341616893
890	בירה	18982	10361	0.6336301933
891	בחינה	14402	9702	0.6333294761
892	מס	27950	10714	0.6331734526
893	התגעגע	16436	10209	0.6331526696
894	שלישי	14900	9673	0.6331134505

	LEMMA	FREQUENCY	RANGE	UDP
895	ניקה	14371	10171	0.6330208976
896	מקומי	15015	9921	0.6330172436
897	תחושה	14659	9992	0.6329762137
898	תהה	13079	9984	0.6329708853
899	התנהג	13402	10000	0.6329102726
900	ר	18144	10008	0.6328678992
901	קרב	18170	10203	0.6327703065
902	תאונה	20467	10322	0.6324579178
903	מילא	13112	9922	0.6323616322
904	נתחיל	13094	9890	0.6320485045
905	הפה	15224	9761	0.6319536943
906	עצור	18357	9969	0.6318472859
907	הציג	13058	9316	0.6310836173
908	הריח	15936	10142	0.6310753406
909	טובה	12856	9796	0.630920668
910	השג	14189	9964	0.6307658955
911	ברירה	14294	10242	0.6305407031
912	נו	17461	10079	0.6303642267
913	אתקשר	13871	9724	0.630079445
914	חוסר	13243	9667	0.6300372872
915	השקר	14766	9914	0.6299231011
916	מישהי	15678	10164	0.6296962365
917	שר	27584	10350	0.6294577543
918	הבנה	12504	9531	0.6294190374
919	חטף	16497	9866	0.629398524
920	משמעות	14356	9692	0.6293963852
921	טען	14950	9634	0.6293123723
922	שדה	18519	9777	0.6292853814
923	סם	32318	10829	0.6292684006
924	אבי	25210	10450	0.6290176556
925	צפון	17658	9785	0.6290015587
926	הפסיד	15106	9441	0.6289462904

	LEMMA	FREQUENCY	RANGE	UDP
927	עבורך	16207	9891	0.6289375764
928	התחל	11877	9398	0.6288659047
929	ייתכן	19498	10136	0.6287532454
930	מפני	22710	10575	0.6286980446
931	אלייך	15140	9960	0.6286547419
932	גבול	15935	9761	0.6285210688
933	הרים	12802	9306	0.6283404914
934	תנועה	14982	9386	0.6282947313
935	חקירה	24262	10087	0.628291565
936	ראשי	14696	9411	0.6281780833
937	סיפק	13210	9530	0.6281450779
938	אשר	22578	9766	0.6280505889
939	מקור	15699	9702	0.6280228726
940	מלון	24568	9865	0.6276081781
941	יורק	27791	9829	0.6273454869
942	דומה	12924	9468	0.6271437481
943	רשם	13080	9321	0.626766924
944	התחה	15025	9242	0.6267395572
945	ודאי	20206	9844	0.6266106799
946	כביש	18887	9677	0.6265302389
947	מנה	15573	9390	0.6264745692
948	סיכון	14296	9540	0.6263396616
949	עשרה	15509	9185	0.6262430927
950	לימד	13514	9280	0.626033317
951	הכול	52201	11674	0.6258631736
952	חש	14861	9585	0.6258606337
953	בחירה	13755	9557	0.6256709006
954	לפה	19366	9858	0.6252465957
955	עצוב	14366	9531	0.625212899
956	התנצל	13273	9438	0.6249713179
957	הסתיר	13497	9576	0.6249458234
958	לאט	16978	9232	0.6247997152

	LEMMA	FREQUENCY	RANGE	UDP
959	נהרג	15526	9546	0.6247885972
960	שיקר	14289	9589	0.6246517235
961	התייחס	12043	9036	0.6246440976
962	מכירה	16418	9343	0.6245483334
963	דיווח	14769	9390	0.6244039585
964	הו	108693	17359	0.624233775
965	טלוויזיה	19027	9566	0.6240775861
966	ריצה	14132	9286	0.6240761445
967	דפק	14239	9071	0.6238463174
968	נולד	13391	9172	0.6237391282
969	לשעבר	15093	9252	0.6236662063
970	אמריקני	21671	9337	0.6233666638
971	רחב	12844	9012	0.6231106402
972	תרופה	24470	10022	0.6229912611
973	מאחר	12768	9169	0.6228875959
974	זר	13710	9107	0.6227707514
975	התחתן	19464	9118	0.6225162241
976	פרץ	14472	9273	0.6224521242
977	קלות	11632	8976	0.6223452963
978	חמישה	13755	8933	0.6223190967
979	שישה	13188	8819	0.6221384595
980	שת	11984	9151	0.6220896285
981	גוש	12111	8928	0.6215892099
982	קפץ	12880	9033	0.6215815402
983	הרגשה	12244	9093	0.6214685059
984	משוגע	12826	8867	0.6214370418
985	זבל	17386	9105	0.6213662061
986	לקוח	20913	9252	0.6210193268
987	קרע	13143	9067	0.6207150099
988	ול	11528	8693	0.6206236099
989	חוקי	13720	8773	0.6206086392
990	נמשך	11977	8918	0.6201722638

	LEMMA	FREQUENCY	RANGE	UDP
991	החבב	15419	9143	0.6200478095
992	רשמי	12053	8877	0.620044703
993	גודל	12512	8786	0.6199315469
994	חן	15280	8825	0.6197141211
995	משקה	13544	8853	0.6195560105
996	חופש	13379	8735	0.6194960178
997	אצבע	14209	8982	0.6193206225
998	שורה	12503	8574	0.6193160177
999	הרוויח	12824	8729	0.6192660882
1000	לם	12282	8955	0.61925743

Appendix 2: Scripts

Appendix 2.1: HebrewLemmaCount.py

```
#! /usr/bin/env python3
# -*- coding: utf-8 -*-

import re
import os
import gzip
from collections import defaultdict


##########################################################
# ---------------- INITIALIZE VARIABLES ---------------- #
##########################################################

# Define path for topmost directory to search. Make sure this points to
# the correct location of your corpus.
corpus_path = './OpenSubtitles2018_parsed_single'

# Initialize dictionaries
lemma_by_corpus_dict = {}
lemma_totals_dict = {}
token_count_dict = {}
lemma_DPs_dict = defaultdict(float)
lemma_UDPs_dict = defaultdict(float)

total_tokens_int = 0
table_list = []

```

```python
# Set size of final list
list_size_int = 5000


############################################################
# ------------------- DEFINE FUNCTIONS ------------------- #
############################################################


# Open XML file and read it.
def open_and_read(file_loc):
    with gzip.open(file_loc, 'rt', encoding='utf-8') as f:
        read_data = f.read()
    return read_data


# Search for lemma and add counts to "frequency{}".
def find_and_count(doc):
    corpus = str(f)[38:-4]
    match_pattern = re.findall(r'lemma="[א-ת]+"', doc)
    for word in match_pattern:
        if word[7:-1] in lemma_by_corpus_dict:
            count = lemma_by_corpus_dict[word[7:-1]].get(corpus, 0)
            lemma_by_corpus_dict[word[7:-1]][corpus] = count + 1
        else:
            lemma_by_corpus_dict[word[7:-1]] = {}
            lemma_by_corpus_dict[word[7:-1]][corpus] = 1


############################################################
# -------------------- OPEN AND READ --------------------- #
############################################################

```

```
# Open and read all files. If calculating only for a specific language,
# comment out this code and uncomment the large block that follows.
#
for dirName, subdirList, fileList in os.walk(corpus_path):
    if len(fileList) > 0:
        f = dirName + '/' + fileList[0]
        find_and_count(open_and_read(f))

##############################################################
# ---------------- LANGUAGE-SPECIFIC BLOCK -----------------
#
# This large block of code is for creating a list using only movies #
# with a specific primary language (in this case, Hebrew). Be sure to #
# uncomment the relevant lines of code, and to comment out the block #
# above. #
#
#
# Create list of IDs for movies with Hebrew as primary language. #
# This makes use of a text file that must already exist with this list. #
#
# Hebrew_IDs_list = []
# with open('./Hebrew_originals.txt', 'r', encoding='utf-8') as f:
#     read_data = f.read()
#     Hebrew_IDs_list = re.findall(r'\s\stt[0-9]+\t', read_data)
# Hebrew_IDs_list = [line[4:-1] for line in Hebrew_IDs_list]
#
#
# Delete extra 0s at the beginning of Hebrew movie IDs. #
```

```python
#
# for item in Hebrew_IDs_list:
#     if item[0] == '0':
#         Hebrew_IDs_list[Hebrew_IDs_list.index(item)] = item[1:]
# for item in Hebrew_IDs_list:
#     if item[0] == '0':
#         Hebrew_IDs_list[Hebrew_IDs_list.index(item)] = item[1:]
#
#
# Open and read files for movies with Hebrew as the primary
↪  language. #
#
# for dirName, subdirList, fileList in os.walk(corpus_path):
#     if len(fileList) > 0:
#         f = dirName + '/' + fileList[0]
#         folders = re.split('/', dirName)
#         if folders[len(folders)-1] in Hebrew_IDs_list:
#             find_and_count(open_and_read(f))
#
# ------------- END OF LANGUAGE-SPECIFIC BLOCK -------------
############################################################


############################################################
# --------------------- CALCULATIONS --------------------- #
############################################################

# Calculate token count per corpus
for lemma in lemma_by_corpus_dict:
    for corpus in lemma_by_corpus_dict[lemma]:
        token_count_dict[corpus] = token_count_dict.get(
            corpus, 0) + lemma_by_corpus_dict[lemma][corpus]

```

```python
# Calculate total frequencies per lemma
for lemma in lemma_by_corpus_dict:
    lemma_totals_dict[lemma] = sum(lemma_by_corpus_dict[lemma].values())

# Calculate total token count
for corpus in token_count_dict:
    total_tokens_int = total_tokens_int + token_count_dict.get(corpus, 0)

# Calculate DPs
for lemma in lemma_by_corpus_dict.keys():
    for corpus in lemma_by_corpus_dict[lemma].keys():
        lemma_DPs_dict[lemma] = lemma_DPs_dict[lemma] + abs(
            (token_count_dict[corpus] /
             total_tokens_int) -
            (lemma_by_corpus_dict[lemma][corpus] /
             lemma_totals_dict[lemma]))
lemma_DPs_dict = {lemma: DP/2 for (lemma, DP) in lemma_DPs_dict.items()}

# Calculate UDPs
lemma_UDPs_dict = {lemma: 1-DP for (lemma, DP) in lemma_DPs_dict.items()}


##############################################################
# -------------- SORT LIST AND CREATE TABLE -------------- #
##############################################################

# Sort entries by UDP
UDP_sorted_list = [(k, lemma_UDPs_dict[k]) for k in sorted(
    lemma_UDPs_dict, key=lemma_UDPs_dict.__getitem__,
```

```python
    reverse=True)]

# Create list of tuples with all values (Lemma, Frequency, Range,
↪  UDP)
for k, v in UDP_sorted_list[:list_size_int]:
    table_list.append((k, lemma_totals_dict[k], sum(
        1 for count in lemma_by_corpus_dict[k].values() if count >
         ↪  0),
        v))

##############################################################
# ---------------- SORT-BY-FREQUENCY BLOCK -----------------
#
# Sort entries by raw frequency (total lemma count). To sort the
↪  final #
# list by frequency instead of UDP, comment out the above code
↪  within the #
# "SORT LIST AND CREATE TABLE" section, and also uncomment the
↪  relevant #
# lines of code in this block. #
#
#
# Sort entries by raw frequency #
#
# frequency_sorted_list = [(k, lemma_totals_dict[k]) for k in
↪  sorted(
#     lemma_totals_dict, key=lemma_totals_dict.__getitem__,
#     reverse=True)]
#
#
# Create list of tuples with all values (Lemma, Frequency, Range,
↪  UDP) #
#
```

```python
# for k, v in frequency_sorted_list[:list_size_int]:
#     table_list.append((k, v, sum(
#         1 for count in lemma_by_corpus_dict[k].values() if count > 0),
#         lemma_UDPs_dict[k]))
#
# ------------- END OF SORT-BY-FREQUENCY BLOCK -------------
############################################################

# Calculate list size for 80% coverage and set that as the list size. Note
# that if the initial list_size_int (set near the beginning of the script)
# provides less than the desired coverage, it will default to that instead.
#
# added_freq_int = 0
# count = 0
# for k, v in UDP_sorted_list:
#     if added_freq_int / total_tokens_int < 0.8:
#         added_freq_int = added_freq_int + lemma_totals_dict[k]
#         count = count + 1
#     else:
#         break
# list_size_int = count

# Write final tallies to CSV file
result = open('./export/HebrewWordList2.csv', 'w')
result.write('LEMMA, FREQUENCY, RANGE, UDP\n')
for i in range(list_size_int):
    result.write(str(table_list[i][0]) + ', ' +
                 str(table_list[i][1]) + ', ' +
                 str(table_list[i][2]) + ', ' +
```

```
                  str(table_list[i][3]) + '\n')
result.close()

# Print final tallies. Uncomment this code to see the results
# printed instead of writing them to a file.
#
# for i in range(list_size_int):
#     print('Lemma: ' + table_list[i][0] +
#            '\tFrequency: ' + str(table_list[i][1]) +
#            '\tRange: ' + str(table_list[i][2]) +
#            '\tUDP: ' + str(table_list[i][3]))
```

Appendix 2.2: OMDb-fetch.py

```
#! /usr/bin/env python3
# -*- coding: utf-8 -*-

# import re
from sys import argv
import os
import glob
import omdb

# year = '1996'
script, year, id_start = argv

dirs = []
p = []


for name in glob.glob(
        '../OpenSubtitles2018_parsed/parsed/he/' + year + '/*/'):
    p.append(name)
# p = Path('../OpenSubtitles2018_parsed/parsed/he')
# p = list(p.glob('[198-199]*/*/*.xml'))

p = [os.path.basename(os.path.dirname(str(i))) for i in p]

for i in p:
    if i not in dirs:
        dirs.append(i)

for i in dirs:
    while len(i) < 7:
        dirs[dirs.index(i)] = '0' + i
```

```
        i = '0' + i

dirs.sort()

# for i in dirs:
#     print('tt' + i)

print('# ' + year + '\n' +
      'IMDb ID\tTitle\tYear\tLanguage(s)')


omdb.set_default('apikey', '906517b3')

for i in dirs:
    if id_start != '':
        if i > id_start:
            print('tt' + i + '\t', end="", flush=True)
            doc = omdb.imdbid('tt' + i)
            # if doc['language'] == 'Hebrew':
            print(doc['title'] + '\t' +
                  doc['year'] + '\t' +
                  doc['language'])
    else:
        print('tt' + i + '\t', end="", flush=True)
        doc = omdb.imdbid('tt' + i)
        # if doc['language'] == 'Hebrew':
        print(doc['title'] + '\t' +
              doc['year'] + '\t' +
              doc['language'])
```

Appendix 2.3: single_file_extract.py

```python
#! /usr/bin/env python3
# -*- coding: utf-8 -*-

import shutil
import os

source = '../OpenSubtitles2018_parsed'
destination = './OpenSubtitles2018_parsed_single'

# Copy the directory tree into a new location
shutil.copytree(source, destination,
↪ ignore=shutil.ignore_patterns('*.*'))

# Copy the first file in each folder into the new tree
for dirName, subdirList, fileList in os.walk(source):
    for fname in fileList:
        if fname == '.DS_Store':
            fileList.remove(fname)
    if len(fileList) > 0:
        del fileList[1:]
        src = dirName + '/' + fileList[0]
        dst = destination + dirName[27:] + '/'
        shutil.copy2(src, dst)
```

Appendix 3: Movies used

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