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# Creating a Frequency Dictionary
# of Spoken Hebrew

A Reproducible Use of Technology to Overcome Scarcity of Data

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# Creating a Frequency Dictionary of Spoken Hebrew

## A Reproducible Use of Technology to Overcome Scarcity of Data

by

Juan Daniel Pinto

**Thesis**

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To the giants on whose shoulders we stand.

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by

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The University of Texas at Austin, 2018

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Studies using word frequency dictionaries—on topics such as vocabulary acquisition, vocabulary load, extensive reading, and vocabulary testing—have historically centered around corpora and morphological issues specific to European languages, especially English. One of the reasons for this is the lack of resources that often plagues departments of less commonly taught languages. Corpora of spoken language are particularly difficult to obtain—the funding and time necessary often make such a project impossible.

This thesis is an effort to provide some of the methodology and tools necessary for educators interested in creating frequency dictionaries for research purposes, for their own classrooms, or even for wider dissemination. In doing so, it will provide an overview of some of the key decisions that must be taken into account for such a project.

Throughout this thesis, the creation process behind the *Frequency Dictionary of Spoken Hebrew* (FDOSH)—a list of the most common words in conversational Modern Hebrew—will be explained. The tools used to create the FDOSH, including corpus resources and customized scripts, are provided as part of a repository of supplementary materials. The goal is to make the entire dictionary-creation process as

reproducible as possible while allowing for flexibility and transparency in the tools used. It does this by using well-documented open-source scripts written in an easily readable programming language, Python.

Beyond providing these tools, the present project explores the theory and many of the considerations that play an important role in the creation of a frequency dictionary. These include issues such as corpus size, corpus text type, whether the list is intended for general or specialized use, word family levels, and objective criteria. Issues regarding Hebrew's synthetic morphology and ambiguous non-vocalized writing system are also addressed.

The project aims to serve as a catalyst for future research that may build upon the ideas discussed here. The development and open dissemination of tools such as these can only lead to greater cooperation among educators and researchers, to the benefit of all involved.

# Table of Contents

# 1  Introduction

This thesis provides an in-depth look at the creation of the *Frequency Dictionary of Spoken Hebrew* (FDOSH)—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 FDOSH, 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 dictionary itself, consisting of 5,000 items, is included as an electronic supplement and can be downloaded free of charge.[1] A partial list that includes the first 1,000 items can be found in *Appendix A*.

A review of the literature will first highlight the difficulties that exist for less commonly taught languages (LCTLs). Because the overwhelming majority of previous research on 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 frequency dictionaries 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 frequency dictionaries 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 frequency lists include curriculum and

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[1]All supplementary materials, including the *Frequency Dictionary of Spoken Hebrew* and the scripts used to create it, are licensed as open source materials. They are available at *https://doi.org/10.5281/zenodo.1239886* (Pinto, 2018).

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 (McLean & Kramer, 2015; Nation, 2016; Nation & Webb, 2010)? What is the role of extensive reading (as opposed to intensive reading) in incidental vocabulary acquisition (Restrepo Ramos, 2015)? What level of vocabulary do learners need in order to read extensively for pleasure (Hirsh & Nation, 1992; Nation, 2006; Schmitt, Jiang, & Grabe, 2011)? What level of vocabulary do learners need in order to succeed in an academic setting (Coxhead, 2000, 2016; Xue & Nation, 1984)? What role does specialized vocabulary play in reaching understanding (Nation & Kyongho, 1995)? These questions and their answers rely heavily on the creation and use of trustworthy frequency dictionaries. 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 common words in spoken Modern Hebrew?

The resulting study also addresses the following secondary research questions:

What is an effective alternative for a corpus of spoken language when one is lacking in the desired language, as is often the case for less commonly taught languages?

How can the process of creating a frequency dictionary be simplified so that it is easy to reproduce while maintaining a high level of customizability?

What implications might these findings have for frequency list creation and use as it pertains to other less commonly taught languages?

The literature review will serve as background for many of the important decisions that went into the creation of the FDOSH. These will be explained more in-depth in the *methods* chapter, where the entire process will be laid out in detail. For the sake of clarity, these key decisions are listed here at the outset. They are as follows:

**Corpus size** The corpus from which the FDOSH was created needed to contain a minimum of 20 million tokens, though 50 million was preferred. In the end, it used a corpus of nearly 200 million tokens.

**Corpus text types** In order to best fit with the FDOSH's intended audience (Hebrew learners), the corpus consists of a single text type: conversation. But because of a lack of large corpora of spoken Hebrew, a corpus of film subtitles was used instead. The reasoning for and validity of such an approach will be elaborated on.

**Use** The primary intended audience for the FDOSH 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 FDOSH's intended audience is the lemma, consisting of a word and all of its inflected forms, but counting derived forms as separate words.

**Criteria** The FDOSH was created using exclusively objective criteria, meaning that it is the product of calculations, and it was not manually tweaked in any way. The words are sorted by dispersion (specifically, Gries' $U_{DP}$), and also include the measures of frequency and range.

Following the review of the literature and explanation of theory, the process of the FDOSH's creation will be explained in detail, along with some findings from the project. As already mentioned, the goal of this is to make the process easy to follow and reproduce for other languages. Finally, the FDOSH and all scripts used will be provided in the appendices.

# 2   Background: Review of the literature

The theoretical foundation of frequency dictionaries—sometimes referred to as frequency lists, word lists, vocabulary lists, and variations thereof—rests on the observation, made popular by the linguist George Kingsley Zipf in the 1930s and 40s, that the first word in any large-enough text occurs roughly twice as often as the second word, three times as often as the third word, and so on (Zipf, 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 such a large percentage of natural communication (Nation, 2013, p. 34).

This observation guides the entire endeavor of frequency dictionary creation and use. Though the *Frequency Dictionary of Spoken Hebrew* 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.

Beyond understanding this theoretical basis and its implications, other considerations play an important role in the creation of a frequency dictionary. These include corpus size, corpus text type, whether the list is intended for general or specialized use, word family levels, and objective criteria. This literature review will treat each of these themes in turn. Because the most comprehensive studies deal with more than one of these issues, some of them will be brought up at various times to illustrate the point under discussion.

## 2.1   Corpus design

Before designing a frequency dictionary, a careful plan must be made for the design of the corpus from which the list is extracted. The corpus must be representative of

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[2]The sorting method and key measures used by the FDOSH is explained in detail in the *objective design* section of this chapter.

the language context that the dictionary wishes to depict. Of course, capturing that context in its entirety is an impossible feat. For this simple reason, researchers must make do with an approximation of the whole: a bounded corpus of language.

Though the focus of this literature review is the creation of word frequency dictionaries, 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 and use of corpora have historically revolved around two big questions: (1) how large should the corpus be, and (2) what kinds of texts should it include. Both of these issues will be addressed here, with the recurring emphasis being corpus design for frequency list creation.

### 2.1.1   Corpus size

Conventional wisdom in corpus creation states that more is better. If a frequency 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 frequency dictionary, then, what is an "ideal" corpus size?

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, which began to be compiled at increasingly

faster rates.

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, the sky's the limit.The *enTenTen12* corpus is composed of 12 billion English tokens, all of which were collected in 12 days (Jakubíček, Kilgarriff, Kovář, Rychlý, & Suchomel, 2013)! At what point, then is a corpus sufficiently large for frequency-list creation?

Researchers have approached this specific problem by creating multiple frequency lists—from varying sizes of corpora—and then comparing the efficacy of these lists themselves. The way that efficacy is operationalized, however, varies among studies.

Some studies have explored how closely the rankings of items on a word frequency dictionary correlate with reaction times in a lexical decision task—a widely-used procedure in psychological and psycholinguistic research (Forster & Chambers, 1973; Oldfield & Wingfield, 1965). 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. Their reaction times are then analyzed for each word. It is generally agreed that the average time it takes participants to react to a word provides insights into the arrangement of the mental lexicon(Gilquin & Gries, 2009; Jurafsky, 2003). For our purposes, multiple studies have found that there exists an inverse correlation between word frequency and reaction time on a lexical decision task (Balota & Chumbley, 1984; Whitney, 1998). In other words, more common words are accessed and recognized more quickly than less common words. Therefore, an effective word frequency list should correspond to and reflect

this reality.

This was precisely the approach taken by Brysbaert and 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 frequency list correlated more and more closely with the response times from lexical decision tasks. 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 tokens. 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 frequency dictionary for *high-frequency* words, a corpus of about 1–3 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 (Brysbaert & New, 2009, p. 988).

A different, more straightforward methodology is to directly compare frequency lists made from differently sized corpora. 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 needed additional resources.

Essentially, then, all corpora of sufficient size should result in nearly the same frequency dictionary—a theory based on a strict interpretation of Zipf's law. If the appropriate criteria can be found— Sorell (2013) suggests—then this would, at last, provide a solution to the observation made by Nation (2013, p. 24) that, problematically, frequency 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 & 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 frequency 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 (2013, p. 80)—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 is widely used in botany and other fields[3] to measure similarity in areas and samples of different sizes (Dice, 1945; Sørensen, 1948), 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 fraction:

$$\frac{\textbf{number of different words between frequency lists}}{\textbf{total size of frequency list}}$$

In essence, this measure can be accurately described as the average proportion of difference for frequency 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 (2013, p. 203). In other words, 1,000-word frequency lists created from different 50-million-token corpora will likely only differ by 20 words. At the 3,000-word level using the same corpus size, the lists will likely vary by less than 150 words. This is a remarkable level of similarity. Expanding the list to 9,000 words will still only yield about 4–7% variation, or 360–

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[3]It has even been used in corpus linguistics studies before, primarily as a way to measure collocation (Rychlý, 2008).

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630 words. Even corpora of 20 million tokens can be considered sufficient in many cases, since they will result in 3,000-word frequency lists with roughly 5% variation and 9,000-word frequency lists with less than 10% variation.

Taking a similar comparative approach, Brezina and Gablasova (2015) evaluated frequency lists created from 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 have respective token sizes of 1 million, 1 million, 100 million, and 12 billion. The frequency dictionary created from each corpus was, in this case, ranked by a combination of frequency and dispersion—a measure that will be discussed in more detail in the *dispersion* section of this chapter. In addition to finding the percentage of shared items between frequency lists, the researchers calculated the correlations between the rankings for each shared word. Contrary to Sorell (2013), 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 frequency lists made from corpora of different sizes. The study found a 78%–84% overlap between each of the 3,000–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 (2015, p. 18).

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 frequency list with low variability (Sorell, 2013, p. 203). 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 Kyongho (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" (Nation, 2016, p. 100).

One issue that has yet to be studied (to my knowledge) is the difference in units of counting between these two studies. Sorell made lists based on *types*, whereas Brezina and Gablasova preferred the use of *lemmas*. The exact difference between these two units is explained later under *identifying words (word family levels)* in this chapter. The effect of these different measures for comparing frequency lists created from differently sized corpora is an area that could benefit from further research.

Regardless of differences between approaches, the studies in this section have demonstrated the importance of having a sufficiently large corpus in order to create a trustworthy frequency dictionary. The next section deals with the second aspect of corpus design: the types of texts that are included.

### 2.1.2 Text types

Deciding on the texts that make up a corpus, and their corresponding text types, is a critical aspect of corpus design. Designing a corpus for the goal of creating a frequency dictionary needs to take the dictionary's intended purpose into account. Many corpora take a conglomerate approach, meaning that they simply amass as many texts as possible, regardless of their type. This often results in frequency lists that serve no distinct purpose.

Some published corpora—especially those designed for a specific purpose rather than "core vocabulary" or the language as a whole—do take a more strategic approach. For example, Coxhead's (2000) *Academic Word List* was created from a carefully designed corpus that used equally sized subcorpora of texts from different disciplines. This suited the purpose of the frequency list well, since it was intended to serve students from a variety of disciplines.

In order to better understand text types, some studies have sought a taxonomy that would make the selection process more objective. These seek to establish, for example, if there are distinguishable linguistic differences between an informal correspondence and a narrative work of fiction, or between a romance and a fantasy novel.

One influential attempt at this categorization was conducted by Biber (1988), who analyzed a 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. He found a series of five categories (each consisting of two opposite ends of a spectrum) in which texts varied:

1. Involved vs. informational
2. Narrative
3. Situated vs. elaborated
4. Persuasive
5. Abstract

Biber then conducted an in-depth follow-up study that found eight distinct, recurring patterns of different combinations of these categories (1995). These groupings serve as a linguistically-based taxonomy that divides texts along objective lines, rather than subjective, culturally-defined genres.

Similar but independent studies have been conducted for Somali, Korean, Nukulaelae Tuvuluan, Taiwanese, and Spanish (Biber, 1995; Jang, 1998). For each language, a unique set of text types was identified. Significantly, the texts were found to align along similar distinguishing linguistic dimensions as the English texts (Biber, 1995, p. 270).

Sorell (2013) sought to simplify Biber's eight text types into categories suitable for corpus design. He did this by identifying the similar ways that some of the text types lined up along Biber's five linguistic categories while incorporating some extra-linguistic features, such as shared contexts (e.g. predominantly spoken types). He excluded Biber's (1995) two smallest text types—"situated on-line reportage" and "involved persuasion"—deeming them impractical for corpus study and difficult to isolate (Sorell, 2013, p. 68). In doing this, he came up with four simplified text types:

1. Interactive (conversation)
2. General reported exposition (general writing)

3. Imaginative narrative (narrative writing)

4. Academic

Using his comparison method of Dice distance (described above under *corpus size*), Sorell found each simplified text type to be equidistant from the next in this order: conversation, narrative, general writing, and academic writing (2013, pp. 153–154). This allowed him to claim that his own study of vocabulary frequency—using 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" (p. 201).

Similar efforts to simplify Biber's text types have also been carried out in the *Longman Grammar of Spoken and Written English* (Biber, Johansson, Leech, Conrad, & Finegan, 1999, p. 16) and the *Longman Student Grammar of Spoken and Written English* (Biber, Conrad, & Leech, 2002, p. 23)

**2.1.2.1 Conversation text type** Despite the importance of the conversation text type for language learners and linguistic studies, corpora of spoken language remain much smaller than more traditional corpora. This is due to the costs and resources involved with gathering large amounts of spoken data that then need 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 (New, Brysbaert, Veronis, & Pallier, 2007, p. 662). For this reason, some researchers have begun looking at alternative sources of speech corpora, including the internet and movie subtitles (Kilgarriff & Grefenstette, 2003).

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 counterbalance 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 frequency dictionary 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 another French spoken corpus, the *Corpus de Référence du Français Parlé* (CRFP) (Delic, Teston-Bonnard, & Véronis, 2004). A closer look revealed that the majority of significant differences were 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) (New et al., 2007, p. 665).

On the second test, New et al. found that their 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 (New et al., 2007, p. 675). In many cases, it actually fared much better, surprising even the researchers themselves. However, this can only be considered a preliminary finding for two reasons:

1. The sample sizes of the lexical decision task experiments were very small (234 and 240 words).
2. The study's dependence on *translated* subtitles—while understandable given the prevalence of English in the film industry—requires more thorough study before it can be considered a valid alternative. For now, these early findings seem to indicate that it may very well be.[4]

Picking up on the findings of New et al. (2007), and expanding the lexical decision task to a much larger sample size, Brysbaert and New (2009) compiled a corpus

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[4]I deal with a similar limitation of the *Frequency Dictionary of Spoken Hebrew* in the *methodological challenges* section of this thesis.

of English subtitles (SUBTLEX$_{\text{US}}$) 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: word frequencies derived from subtitle corpora are as good as—and sometimes better than—those from true speech corpora.

Though both of these 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 facilitates the creation of frequency dictionaries of spoken language—something that is otherwise too cost-prohibitive due to the difficulty of the collection medium.

Precisely because of this ease of access, subtitles provide the perfect corpus for a project that seeks to be both representative of *spoken* language and easily reproducible. This is therefore the approach taken in the present thesis to create the *Frequency Dictionary of Spoken Hebrew*. I will give a detailed description of the corpus chosen in the next chapter.

## 2.2 LIST DESIGN

Perhaps even more complex than appropriately designing the corpus from which to extract word frequencies is designing the frequency dictionary, or list, itself. Many distinct variables are involved in the process. 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, and different ranking criteria used, among other issues.

### 2.2.1 General use or specialized use

The majority of frequency dictionaries aim to describe the vocabulary of the language as a whole. They are designed to be all-encompassing so that they can serve any number of uses and scenarios. This broad nature of general-use lists is reflected in the name of the one that has historically been most widely used: West's *General Service List* (1953). Others include Nation's *BNC2000* list (2006), 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, pp. 153–167).

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 theory behind this approach is that the language contains at its center a self-contained lexicon of essential vocabulary that is fundamental to 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 geographically specific dialects. Still, this core vocabulary remains at the center of it all, and the purpose of a frequency dictionary is to identify what words fall within its boundaries. Sorell (2013) has evaluated a number of existing definitions of core vocabulary in the literature.

Fewer researchers have created frequency dictionaries for 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.

The most well-cited 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 could be considered a *general* academic word list, since it is intended for academic use in general, and not for a specific discipline.

More specialized frequency dictionaries include those designed for business English or medical English courses. This is sometimes designated *technical vocabulary.* Technical vocabulary is most often taught after students have mastered general-use vocabulary, and after they have some familiarity with academic vocabulary (Nation, 2016). Chung and Nation (2003, 2004) have analyzed the typical makeup of 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 often take on a specialized definition that is particular to that domain.

The important takeaway is that the intended purpose of a frequency dictionary needs to be thoroughly considered, since this purpose will affect both the process and outcome of the project. As already mentioned, the *Frequency Dictionary of Spoken Hebrew* is designed for Hebrew learners who wish to focus on *spoken* Hebrew. This narrows the focus from the general core vocabulary of the entire language, but it is not as restricted as a specialized list would be.

## 2.2.2   Identifying words (word family levels)

Another essential aspect of creating a frequency dictionary is deciding on how to measure a word. Though this may seem like a straightforward task, it requires an 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" (p. 242).

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

Consider this example sentence:

I like small dogs and medium dogs, but even her big dog can be likable.

Measuring *tokens* means simply measuring the total number of words. The example sentence contains fifteen tokens—fifteen words in total. Counting *types* refers to the number of separate and distinct words. That is, *dogs* and *dogs* are the same type, but *dog* is a different type—even a single difference makes them different types. The example sentence is composed of fourteen types. Types are often the simplest measure to use for frequency dictionaries, since they are relatively easy to identify and count.

A *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 *likes*, *liked*, and *liking* (the verb) are all the same lemma, but *likable* is not. This is because *likable* has the derivational affix *-able*, which turns it into an adjective. Francis et al. 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" (Francis, Kučera, & Mackie, 1982, p. 1). The example sentence is made up of thirteen lemmas.

Finally, the term *word family* is used to describe an even more inclusive level than the lemma, though 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 (Bauer & Nation, 1993, pp. 255–256). 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 taxonomy, 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 purpose of language learning, these specific family word levels can be used simply "as a starting point as an initial framework of reference" (Nation, 2016, p. 36). That is, they are one interpretation of how to systematically count words for a frequency dictionary. 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 & New, 2009, pp. 982–983).

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 & Nation, 1993, p. 253).

There is evidence to suggest a positive correlation between vocabulary size and morphological knowledge (Mochizuki & Aizawa, 2000; Schmitt & Meara, 1997), and between morphological knowledge and reading comprehension (Jeon, 2011). If this is the case, then using higher-level word families to create frequency dictionaries, such as Nation's *BNC2000* list (2006) or Coxhead's *Academic Word List* (2000), may not be appropriate for learners with limited knowledge of vocabulary—the very learners that many of these lists target.

When creating a frequency dictionary, then, the unit of word counting needs to suit the list's purpose and target audience. 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. This is especially troublesome when used in frequency lists for language learners, whose morphological knowledge is often not well developed. 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.

Given the similar target audience, and using the same reasoning as Brezina and Gablasova (2015), I have chosen to use lemmas as the word unit to measure in creating the *Frequency Dictionary of Spoken Hebrew.*

One last note regarding Bauer and Nation's (1993) word family levels: they are specific to English. Because they are based entirely on affixation of morphemes, they cannot be readily applied to other languages. Whereas types and lemmas can be more easily understood to be equivalent across languages (with some deviation for highly agglutinative or synthetic languages), extending the concept of word family levels beyond English requires creating a similar taxonomy for each specific language. This is an area of study that has yet to receive more attention.

### 2.2.3 Objective design

Many frequency dictionaries—including some of the most widely-known ones—take what could be called a semi-objective approach. They begin by creating a list that bases word rankings on statistical measures such as frequency, range, and dispersion. Then, because certain words don't fit the researcher's intuitions, or because some rankings simply seem out of order, the list is tweaked here and there (Nation, 2016, p. 133).

For example, one common tweak is to group lexical sets together on a list, such as days of the week or numbers (Nation, 2016, pp. 118–119). This is true of West's GSL, resulting in a list that "brought a large element of subjectivity into the final product" (Brezina & Gablasova, 2015, p. 3). West himself laid out his argument as to why he chose to use such an approach (West, 1953, pp. ix–x). Nation has also defended the use of subjective criteria (2016, pp. 119–120).

Despite a few pedagogical advantages, however, a semi-objective approach (which is therefore also a semi-subjective approach) has important implications for reproducibility. This alone makes it unfit for the present project, since one of the primary goals of this thesis is to present an easily reproducible process that can be used to create frequency dictionaries in many different languages. Additionally, the simple fact is that by inserting subjective criteria into the list-creation process, it ceases to be based on the data directly. Rather than letting a particular corpus speak for itself, the whims and opinions of the researcher come into play. This can affect secondary tests that may be performed using the list, such as a lexical decision test.

Some frequency dictionaries that use strictly objective criteria include *Word Frequencies in Written and Spoken English* (Leech, Rayson, & Wilson, 2001), Brezina and Gablasova's *New General Service List* (2015), and Dang and Webb's *Essential Word List* (Nation, 2016, pp. 153–167). This thesis also uses exclusively objective criteria to create the *Frequency Dictionary of Spoken Hebrew*: frequency, range, and dispersion. I will now discuss each of these in turn.

**2.2.3.1 Frequency** Frequency can refer to either raw frequency (sometimes called absolute frequency) or normalized frequency. Raw frequency is simply the

total number of times that a specific word is attested in the corpus. Normalized frequency is a measure of how many times the item appears *for every x tokens* in the corpus. This is usually calculated to be per-million-tokens, though the exact count can vary. Using normalized frequency is more meaningful since it is easier to compare with frequencies found in other corpora.

Frequency forms the core of frequency dictionaries, and it is also their most simple measure. A word list can be created using frequency alone. However, other measures, such as range, help take into account important factors that frequency ignores.

**2.2.3.2 Range** Range is a measure of the number of sub-corpora—or sections of a corpus—in which the word can be found (Fries & Traver, 1960). Range is also sometimes referred to as *contextual diversity* (Brysbaert & New, 2009). To measure this, a corpus must first be divided into a series of sub-corpora. As of now, there is no real consensus on a specific way to do this, so different frequency dictionaries may contain very different range measures based on the method chosen by the researcher. Like frequency, range can also be normalized to make the number more meaningful for inter-study comparison.

Nation has gone as far as to suggest that "range figures are more important than frequency figures, because a range figure shows how widely used a word is" (Nation, 2016, p. 103). This conclusion is corroborated by studies such as that of Adelman et al. (2006), which found that range better explained the findings of lexical decision tasks by 1%–3%. Similar results were found by Ellis, who attributed better predictive power to range than to word frequency (Ellis, 2002a, 2002b).

The value of calculating range is that it provides a simple way to evaluate skewed frequency results. For example, a word may be rare overall in a language, but if it happens to be very common in only a few texts, it can still attain an inappropriately high place on the frequency list. This often occurs with specialized words that are only used by a very specific subset of the population but with high frequency. By calculating range, it becomes easy to identify these words.

The question then becomes, what to do once these words are found. How can range and frequency be used in tandem? One possibility, suggested by Nation (2016, pp.

121–122) and used by Coxhead (2000), is to decide on a minimum range, discard any words that fall below this threshold, and rank only the remaining words by frequency. This approach, however, relies on a subjective decision that becomes difficult to replicate with other corpora. The fate of words with range measures close to the cutoff point is to be either completely thrown out or kept in their original position. Shifting the word's position on the list—its rank—is more sensical, but this can quickly become messy and subjective as well. Dispersion tries to solve this problem.

**2.2.3.3 Dispersion** In a (simplistic) nutshell, dispersion is a combination of both frequency and range. It serves as a single number—a distributional statistic—that incorporates the benefits of both of these measures, while also allowing a list to be ranked in a methodical, objective manner.

Whereas frequency and range are found simply by counting, dispersion requires a calculation that incorporates multiple variables. Unfortunately, there is still little agreement on how best to measure dispersion. Many ideas have been proposed, such as Juilland's *D* (Juilland, Brodin, & Davidovitch, 1970), Carroll's $D_2$ (1970), Rosengren's *S* (1971), Lyne's $D_3$ (1985), and Zhang's *Distributional Consistency* (*DC*) (Zhang, Huang, & Yu, 2004). One additional measure, *Average Reduced Frequency* or *ARF* (Hlaváčová, 2006; Savický & Hlavácová, 2002) was used by Brezina and Gablasova to create the *New General Service List* (2015, p. 8) mentioned above. *ARF* takes a different approach, in that it sees the entire corpus as one long string of text rather than a series of subcorpora.

A thorough overview of all these and more dispersion measures was published by Gries, who then provided his own suggested method: *deviation of proportions*, or *DP* (Gries, 2008, 2010). Unlike earlier proposals, however, Gries's *DP* stands out as a comparatively simple calculation that takes into account some of the biggest shortcomings he identified in the others. Gries himself lists the advantages of *DP* as: flexibility to use differently sized subcorpora, simplicity, extendability to different scenarios, and appropriate sensitivity.

The idea behind *DP* is simple. For each word, it aims to find the difference between the frequency one would expect to find in each subcorpus (if the word was perfectly

evenly distributed) and the word's actual frequency. Finding the sum of the absolute values of all these distances from perfect dispersion, and then dividing the result in half (since the differences are found in both directions—higher and lower frequencies than expected), one is left with a value between 0 and 1. A *DP* of 0 represents a perfectly even dispersion, and a *DP* close to 1 means a more uneven distribution, where fewer subcorpora contain a larger load of the word's overall frequency. A *DP* of 1 is not actually possible, though Gries explains how to use a normalized value, $DP_{norm}$, for those who prefer a true 0–1 range (Gries, 2008, p. 419; Lijffijt & Gries, 2012). The entire equation looks like this:

$$\mathbf{DP} \;=\; 0.5 \sum_{i=1}^{n} \left| \frac{tokens\ in\ subcorpus_i}{tokens\ in\ corpus} \;-\; \frac{frequency\ of\ lemma_x\ in\ subcorpus_i}{frequency\ of\ lemma_x\ in\ corpus} \right|$$

Because frequency does not play a direct role in calculating *DP*, Gries suggests—as a quick fix—using the product of *DP* and frequency (Gries, 2008, p. 426). This is similar to previous adjusted frequency measures such as Juilland's (1970) usage coefficient *U*. Gries goes on to explain how his proposed $U_{DP}$ may obscure what is actually being measured. However, he does not elaborate on a better measure that could be used to rank items on a frequency dictionary. $U_{DP}$, therefore, continues to be used for this purpose (Matsushita, 2012, p. 99; Sorell, 2013, p. 89). It is also the ranking measure used to create the *Frequency Dictionary of Spoken Hebrew*.

## 2.3 SUMMARY AND APPLICATIONS

This literature review has outlined some of the most pressing issues that must be considered when creating a word frequency dictionary. As we have seen, research into some of these questions has led to general agreement, in other areas the research is only beginning, and a few issues have generated much discussion but still no true consensus. This overview has laid the groundwork for the decisions that underlie the methods used to create the *Frequency Dictionary of Spoken Hebrew*.

On the matter of corpus design, I have chosen to work with a corpus of *at least* 20 million tokens, and preferably 50 million, in accordance with Sorell's (2013) find-

ings. As for the corpus's text type, because the FDOSH aims to be a list based on interpersonal interactions, it is created entirely from a *conversation* corpus.

Though not a true core vocabulary list, the FDOSH has been created to serve as a foundation for learners of Hebrew, with the goal of reaching conversational proficiency in a wide range of areas, rather than in a specific discipline or setting. Due to the lack of large, high-quality corpora of spoken Hebrew, the FDOSH is based on a corpus of film subtitles. This approach is justified by the findings of studies that compare subtitle corpora to traditional corpora of spoken language, though this area of research is admittedly in need of further study (Brysbaert & New, 2009; New et al., 2007). The specific details of the corpus used for the FDOSH will be addressed more in depth in the following chapter.

Because the FDOSH is designed primarily for language learners, Bauer and Nation's (1993) higher word family levels were deemed inappropriate, based on evidence of learners' weak morphological knowledge and word-building ability (Brezina & Gablasova, 2015; Mochizuki & Aizawa, 2000; Schmitt & Meara, 1997; Ward & Chuenjundaeng, 2009). Instead, it uses the lemma—or level 2 in Bauer and Nation's taxonomy—in its counting and arrangement.

Finally, the FDOSH seeks to establish an entirely objective approach to frequency dictionary creation. It does this by ranking words based on a usage coefficient of Gries's deviation of proportions, or $U_{DP}$ (Gries, 2008, 2010). This allows for all three key factors of frequency, range, and dispersion to play a role in deciding the order of the words. The FDOSH also includes normalized frequency and range for each item.

# 3 Methods: Creating the *Frequency Dictionary of Spoken Hebrew* (FDOSH)

As we have seen, the majority of research into high-quality 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 can be difficult to find well-researched frequency dictionaries, if they exist at all. Why have not more educators—those who may benefit from these dictionaries the most—decided to undertake such a task? Does it simply seem like too daunting of a project?

Some tools already exist that aid in the process of creating a frequency dictionary. One affordable example is the web tool *SketchEngine*[5], a European-based database of hundreds of corpora in many different languages. As is common for similar products, however, SketchEngine does not provide access to the raw corpora themselves—even though most of the corpora are available free of charge from their creators. Instead, it acts as a search portal through which one may peek into a corpus's data. This and other restrictions severely limit what researchers can do and the insights they can gain.

Rather than using SketchEngine or similar tools, I chose to create a series of simple scripts to create the *Frequency Dictionary of Spoken Hebrew*. They are designed to be easily customizable to suit researchers' needs.

The two most widely-used languages for the type of data analysis involved in creating a frequency dictionary 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 frequency lists. R, on the other hand, requires a deeper familiarity with the syntax and conventions of the language in order to understand and modify its scripts.

The second characteristic that makes Python ideal for an open-source project of this

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[5]https://www.sketchengine.eu

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 that end, this chapter will carefully explain what, exactly, the code does.

Though all of the code is included in this thesis (*Appendix B*), it can also be found as part of the project's supplementary materials (Pinto, 2018) at *https://doi.org/10.5281/zenodo.1239886*. This DOI serves as a permanent link to the latest stable release of the materials. Alternatively, the development repository can be accessed directly through GitHub at *https://github.com/juandpinto/frequency-dictionary*. This repository can be cloned, or individual files can be downloaded, for modification and use. The repository uses the version control system *Git*[6], which keeps track of all changes that have been made to each file. This makes it possible to search through the file histories to observe the project's creation process or to revert to an earlier stage.[7]

Suggestions for improvements can also be submitted through the GitHub interface, allowing for a system of cooperation and incremental innovation among researchers. The exported *Frequency Dictionary of Spoken Hebrew*, in its entirety, can also be found within the repository.

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

## 3.1 THE CORPUS

Before any coding or analyzing can be done, it's important to find an appropriate corpus to use and to become familiar with its structure. A useful place to begin is OPUS[8], which is part of the Nordic Language Processing Laboratory (NLPL),

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[6]https://git-scm.com

[7]For a thorough introduction to Git and GitHub, see Chacon and Straub (2014).

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

and hosted by the CSC IT center in Finland. OPUS is a database of many open, parallel corpora. These include corpora of film and television subtitles, TED talks, web-crawled data, newspapers, and of course, books. The corpora are all free and open to the public.

The FDOSH was created using one of OPUS's corpora, the *OpenSubtitles2018*[9] corpus. The corpus can be found in a variety of formats, and it can be downloaded either as a *parallel* corpus or as a monolingual corpus. A parallel corpus consists of two or more 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. This means that each line of the corpus will theoretically carry the same meaning in multiple languages. The creation of parallel corpora has made possible many interesting and useful tools for linguists, translators, and language learners. These include the open-source CASMACAT[10] project and the ReversoContext[11] tool.

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

Though it is possible to download plain text files, the most useful format available is XML. Indeed, this is the most common file format used for large corpora. 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—a similar format of nested tags based on the JavaScript language—which we will use in the next chapter to extract specific movie metadata directly from an online 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):

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

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

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

```
<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>
  <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 FDOSH came from a monolingual parsed corpus of Hebrew. The parsing was all done automatically—a process that will be discussed in the *automatic parsing* section of the next chapter.

## 3.2 Cleaning 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 cleaning is often the most laborious part of the process. However, there is one task that must be addressed before the corpus can be used to create a frequency 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 straightforward, but there is the issue of having duplicate 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*[12] 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. A few of the variant files do seem to be different translations.

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[12]https://www.opensubtitles.org/

Part of cleaning 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,`single_file_extract.py`, in *Appendix B.2*. 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`).

```
4  import shutil
5  import os
6
7  source = '../OpenSubtitles2018_parsed'
8  destination = './OpenSubtitles2018_parsed_single'
```

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

```
10  # Copy the directory tree into a new location
11  shutil.copytree(source, destination,
12                  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 the first file, 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.

31

```python
14   # Copy the first file in each folder into the new tree
15   for dirName, subdirList, fileList in os.walk(source):
16       for fname in fileList:
17           if fname == '.DS_Store':
18               fileList.remove(fname)
19       if len(fileList) > 0:
20           del fileList[1:]
21           src = dirName + '/' + fileList[0]
22           dst = destination + dirName[27:] + '/'
23           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 FDOSH, I will skip that step here. However, a description of that entire process will be discussed in the next chapter under *using original-language movies exclusively*.

## 3.3   Extracting data

Before calculating any measures, such as frequency or range, 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".

```xml
<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 lemmatized. 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 FDOSH, `create-freq-list.py`. As with the other code, the script in its entirety can be found in *Appendix B*.

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.

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



47  # Search for lemmas and add counts to "lemma_by_file_dict{}".
48  def find_and_count(doc):
49      file = str(f)[40:-3]
50      match_pattern = re.findall(r'lemma="[א-ת]+"', doc)
```

```
51    for word in match_pattern:
52        if word[7:-1] in lemma_by_file_dict:
53            count = lemma_by_file_dict[word[7:-1]].get(file, 0)
54            lemma_by_file_dict[word[7:-1]][file] = count + 1
55        else:
56            lemma_by_file_dict[word[7:-1]] = {}
57            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 the `corpus_path` variable).

```
67    for dirName, subdirList, fileList in os.walk(corpus_path):
68        if len(fileList) > 0:
69            total_files_int = total_files_int + 1
70            f = dirName + '/' + fileList[0]
71            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 underlying structure looks like this:

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

A Python 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—thus 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 particular file (frequency).

34

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

```
'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 necessary calculations.

## 3.4  CALCULATIONS

For each lemma, the FDOSH includes three measures: frequency, range, and dispersion. Dispersion is used as the sorting value. Though the theoretical underpinnings of each have already been discussed in the *objective design* section of the previous chapter, I will here give a brief reminder of what each measure is and explain how it is calculated by the `create-freq-list.py` script. Range will be addressed afterward in the (*sort and export*)[#sort-and-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 straightforward. 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',` `'lemma3':'frequency3', . . . }.`

```
119  # Calculate total raw frequencies per lemma
120  for lemma in lemma_by_file_dict:
121      lemma_totals_dict[lemma] = \
122          sum(lemma_by_file_dict[lemma].values())
```

Following the simplified example from the previous section, this would result in the following dictionary:

'ב':262,
'פרק':3,
'קודם':9

We now have raw frequency counts, but we need to turn them into normalized frequencies, using 1,000,000 as our normalizing figure. To do this, we perform the following equation for each lemma:

$$\textbf{normalized frequency} \ = \ \frac{frequency \ of \ lemma}{total \ tokens \ in \ corpus} \ \times \ 1,000,000$$

In order to find the token count for the entire corpus, we first make a dictionary—`token_count_dict`—that contains an entry for each file in the corpus and the number of tokens in that file, using the *key*:*value* pairs of *file*:*tokens*. Since we already have a dictionary variable that contains the number of times 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.

```
124  # Calculate token count per file
125  for lemma in lemma_by_file_dict:
126      for file in lemma_by_file_dict[lemma]:
127          token_count_dict[file] = token_count_dict.get(
128              file, 0) + lemma_by_file_dict[lemma][file]
```

We can now add each of these entries to find the total count and save it in an integer variable, `total_tokens_int`. We took the intermediary step of creating the dictionary `token_count_dict` because we will later need the values it holds (tokens in each file) in order to calculate dispersion.

```
130   # Calculate total token count
131   for file in token_count_dict:
132       total_tokens_int = \
133           total_tokens_int + token_count_dict.get(file, 0)
```

The script now calculates all the normalized frequencies using the equation described earlier. The value by which the frequencies will be normalized can easily be modified in line 136 of the code.

```
135   # Set value for normalized frequency (freq per x words)
136   freq_per_int = 1000000
137
138   # Calculate normalized frequencies per lemma
139   for lemma in lemma_totals_dict:
140       lemma_norm_dict[lemma] = \
141           lemma_totals_dict[lemma] / total_tokens_int * freq_per_int
```

The dictionary `lemma_norm_dict` now contains the normalized frequency of each lemma.

### 3.4.2 Dispersion ($U_{DP}$)

Calculating 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 frequency list. The model of dispersion I have chosen to follow for this project is a usage coefficient of Gries's deviation of proportions, or $U_{DP}$ (Gries, 2008, 2010).

In order to calculate $U_{DP}$ for lemma$_x$, we must first make two calculations for each file in the corpus (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 than 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 that originally existed in both a positive and a negative direction), we now have Gries's *DP*. Where **n** is the number of files:

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

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's usage coefficient, or $U_{DP}$, 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 $U_{DP}$ is as follows:

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

In order to calculate this, the script must first find the number of tokens in each file. Luckily, we already did this while calculating normalized frequency, above. The dictionary `token_count_dict` contains these token counts. We've also already taken the step of adding these values together into the integer variable `total_tokens_int`, also while preparing to calculate normalized frequency.

With all of these measures in place, the script can now calculate $DP$ and then $U_{DP}$ using the equations described above. It does this for each lemma, saving the new measures into their respective dictionaries, `lemma_DPs_dict` and `lemma_UDPs_dict`.

```python
143  # Calculate DPs
144  for lemma in lemma_by_file_dict.keys():
145      for file in lemma_by_file_dict[lemma].keys():
146          lemma_DPs_dict[lemma] = lemma_DPs_dict[lemma] + abs(
147              (token_count_dict[file] /
148               total_tokens_int) -
149              (lemma_by_file_dict[lemma][file] /
150               lemma_totals_dict[lemma]))
151  lemma_DPs_dict = {lemma: DP/2 for (lemma, DP) in
152                    lemma_DPs_dict.items()}
153
154  # Calculate UDPs
155  lemma_UDPs_dict = {lemma: (1-DP)*lemma_norm_dict[lemma] for
156                     (lemma, DP) in lemma_DPs_dict.items()}
```

With these values calculated and saved for each lemma, the only thing left is to sort and export 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 and discarding words below this threshold (see the *objective design* section in the previous chapter).

Rather than setting an arbitrary bar, the FDOSH is sorted entirely by $U_{DP}$. 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 $U_{DP}$ for each lemma, sorting the list is simple.

```
163  # Sort entries by UDP
164  UDP_sorted_list = [(k, lemma_UDPs_dict[k]) for k in sorted(
165      lemma_UDPs_dict, key=lemma_UDPs_dict.__getitem__,
166      reverse=True)]
```

A final table is then created (using a list of tuples, `table_list`), with each line consisting of a lemma, its rank, its $U_{DP}$, its normalized frequency, and its normalized range. The table is created in an already-sorted order.

Because the script has not yet calculated range by this point, it must do so on the spot as it is entering each lemma into the table. It does this with a simple dictionary comprehension that quickly adds the number of files included in the `lemma_by_file_dict`. Since the FDOSH will display range as a percentage, the script takes this new sum of files in which each lemma appears, divides it by the total number of files in the corpus (`total_files_int`), and multiplies the result by 100.

Here is the resulting code:

```
170  i = 0
171  for k, v in UDP_sorted_list[:list_size_int]:
172      i = i + 1
173      row = (k,
174              i,
175              '{0:,.2f}'.format(v),
176              '{0:,.2f}'.format(lemma_norm_dict[k]),
177              '{0:,.2f}'.format(sum(1 for count in
```

```
178                                              lemma_by_file_dict[k].values() if
179                                    count > 0) /
180                                total_files_int * 100))
181        table_list.append(row)
```

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

```
226  result = open('./export/frequency-dictionary.tsv', 'w')
227  result.write('LEMMA\tRANK\tDISPERSION\tFREQUENCY\tRANGE\n')
228  for i in range(list_size_int):
229      result.write(str(table_list[i][0]) + '\t' +
230                   str(table_list[i][1]) + '\t' +
231                   str(table_list[i][2]) + '\t' +
232                   str(table_list[i][3]) + '\t' +
233                   str(table_list[i][4]) + '\n')
234  result.close()
```

The frequency dictionary is now complete. The next chapter will explore the FDOSH itself more in-depth.

# 4  The FDOSH: A vocabulary list of conversational Modern Hebrew

The *Frequency Dictionary of Spoken Hebrew* in its entirety can be accessed in electronic form as part of this thesis's supplementary materials at *https://doi.org/10.5281/zenodo.1239886* (Pinto, 2018), or at the project's GitHub repository: *https://github.com/juandpinto/frequency-dictionary*. The FDOSH contains the most common 5,000 lemmas of conversational Modern Hebrew, as found in the *OpenSubtitles2018* corpus. A sample of the first 1,000 lemmas is included in *Appendix A*.

For discussion purposes, a small sample of the first 30 entries is here presented.

Table 1: Sample of the first 30 entries on the FDOSH.

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| הוא | 1 | 114,718.51 | 121,008.92 | 99.99 |
| ה | 2 | 47,244.93 | 50,841.12 | 100.00 |
| את | 3 | 32,811.28 | 35,337.28 | 99.92 |
| ל | 4 | 27,415.19 | 29,102.77 | 99.97 |
| לא | 5 | 24,888.86 | 27,213.76 | 99.94 |
| זה | 6 | 23,817.89 | 26,418.69 | 99.96 |
| ב | 7 | 23,081.75 | 24,839.48 | 99.98 |
| של | 8 | 18,214.68 | 20,088.89 | 99.97 |
| ש | 9 | 18,203.83 | 20,028.64 | 99.95 |
| היה | 10 | 11,861.33 | 13,312.52 | 99.91 |
| מה | 11 | 10,879.07 | 12,192.80 | 99.87 |
| ו | 12 | 8,711.82 | 9,840.85 | 99.93 |
| על | 13 | 8,246.82 | 9,119.70 | 99.93 |
| כול | 14 | 6,062.08 | 6,842.01 | 99.90 |
| ידע | 15 | 5,328.40 | 6,205.85 | 99.69 |
| כן | 16 | 5,011.86 | 6,232.26 | 99.46 |
| מ | 17 | 4,871.00 | 5,479.15 | 99.89 |
| יש | 18 | 4,840.57 | 5,519.12 | 99.81 |
| עשה | 19 | 4,180.99 | 4,941.68 | 99.66 |

Table 1 (continued)

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| אבל | 20 | 4,052.79 | 4,757.33 | 98.86 |
| טוב | 21 | 3,954.48 | 4,891.35 | 99.61 |
| רצה | 22 | 3,949.30 | 4,671.67 | 99.41 |
| אם | 23 | 3,846.61 | 4,444.59 | 99.68 |
| עם | 24 | 3,756.06 | 4,333.17 | 99.71 |
| אמר | 25 | 3,515.24 | 4,128.07 | 99.39 |
| אז | 26 | 3,370.31 | 4,052.24 | 99.41 |
| סדר | 27 | 3,197.62 | 4,305.52 | 98.33 |
| צריך | 28 | 2,862.13 | 3,501.64 | 99.18 |
| רק | 29 | 2,543.93 | 2,996.30 | 99.65 |
| חשב | 30 | 2,511.54 | 3,021.85 | 99.09 |

Besides each lemma and its respective rank on the list, the FDOSH includes three pieces of information: frequency, range, and dispersion. 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 this normalized frequency measure makes the number more meaningful since it aims to reflect the per-million count of all spoken Hebrew, not just the OpenSub-titles2018 corpus. It also makes it easier to compare frequencies with those found in other corpora.

The range has also been normalized. It describes the percentage of the number of sub-corpora—or, in this case, movies—that the lemma appears in, in proportion to the number of movies in the entire corpus.

The most important piece of information the list provides, however, is dispersion, which acts as the ranking measure for the FDOSH and is discussed more in-depth in the *dispersion* section of the previous chapter.

The percentage of the corpus that is covered by the first *n* entries on the list is referred to as coverage. Calculating coverage is typically 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* entries. With the *normalized* frequencies that the

FDOSH uses, it's even easier—simply dividing the sum of the first $n$ entries by 1,000,000 provides the coverage.

For example, the sum of the frequencies of the first 30 lemmas in *Table 1* is 479,669.22. Dividing by 1,000,000 results in .47966922, or nearly 48%. In theory, this means that by knowing just the first 30 lemmas on the FDOSH one would be able to understand about 48% of the words in the entire OpenSubtitles2018 corpus! Coverage provides a clear example of the power of Zipf's Law (see the *introduction* for more on Zipf's Law).

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

Table 2: Breakdown of coverage percentages.

| $n$ Lemmas | Normalized Frequency Sum | Coverage % |
| --- | --- | --- |
| 278 | 700,105.97 | 70% |
| 888 | 800,064.46 | 80% |
| 4,013 | 900,011.21 | 90% |
| 5,000 | 911,207.66 | 91% |

The entire FDOSH consists of 5,000 lemmas. This number was chosen in order for it to include the necessary items for 90% coverage, while also making it an even factor of 1,000. In its entirety, the FDOSH covers over 91% of the corpus from which it is created.

## 4.1 USE

The purpose of the *Frequency Dictionary of Spoken Hebrew* is to provide a list of the most commonly-used lemmas in conversational Modern Hebrew. As described in this thesis's *introduction*, frequency dictionaries can serve a number of purposes, generally classified as either research applications or practical applications. Though primarily designed with the goal of aiding vocabulary acquisition, the FDOSH can similarly fill a multitude of roles.

This project originally began with a desire to evaluate whether the findings of some influential studies regarding English vocabulary would hold true for Hebrew vocabulary. Specifically, I was interested in measuring the amount of vocabulary necessary for learners of Hebrew to comfortably read extensively for pleasure, following the lead of previous studies by Schmitt et al. (2011), Nation (2006), and Hirsch and Nation (1992), among others. I quickly realized that the frequency dictionary necessary for such a project did not exist for Hebrew, so I chose to focus on designing such a dictionary first.

With the FDOSH now created, my hope is that it will serve as a basis for future studies of this type. As Gries (2010) explains:

> In some theoretical approaches, such as cognitive linguistics or usage-based grammar, frequency data are now regularly used in the domains of first- and second/foreign-language acquisition, the study of language and culture, grammaticalization, phonological reduction, morphological processing, syntactic alternations, etc. (p. 197)

The possible research applications of such a dictionary are the reason I chose to include so much data with each entry.

I also hope that educators will find use in the lemmas and their rankings, either for identifying the vocabulary to include in their textbooks, to teach in their classrooms, or to focus on in their conversation groups. The FDOSH can similarly serve independent learners or students of Hebrew who wish to take greater control of the vocabulary they deliberately study.

Even more than all of this, however, the FDOSH can serve as an example for future frequency dictionaries. I have chosen to place heavy emphasis on the creation process itself in order to make it easily reproducible for comparable projects in other languages. In so doing, my hope is that similar educational resources and research tools will become widely available.

## 4.2 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 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.

### 4.2.1 Methodological challenges

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

**4.2.1.1   Ideal vs. practical corpora**   The use of a subtitle corpus has both positive and negative aspects. As described in the literature review, the early research that has been done on the topic indicates that movie subtitles share many features with spontaneous, spoken language (Brysbaert & New, 2009; New et al., 2007). 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 OpenSubtitles[13] and OPUS[14], very large corpora are available to the public for free. And as an additional incentive for the time-constrained researcher, they can be downloaded in a pre-processed, and even parsed,

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[13]http://opensubtitles.com
[14]http://opus.nlpl.eu

format.

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 the necessary types of data-collection more accessible, the costs remain too high for many less-commonly taught languages. 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)[15], 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 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 (Dekel, 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, some of which are addressed below under *functional challenges*.

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[15]http://cosih.com/

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

Are movie and television subtitles a suitable substitute for spontaneous, spoken language? Early studies suggest that they are, but much more research is needed to answer this question definitively. For now, it remains as a practical and appealing option.

**4.2.1.2   Using original-language movies exclusively**   One of the potential downsides of using the OpenSubtitles2018 corpus is that it includes all subtitles of a specific language, even *translated* subtitles from movies that were filmed in other languages. But 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 do not need to try to approximate the utterance length and visual cues that a dubbed script does, their 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. Another possibility is to calculate frequency measures for original and translated subtitles separately, then average them. This latter approach was used by New et al. (2007). Either way, the first step is to extract the subtitle files that represent the original language of the movie, in this case Hebrew. In theory, each XML file in a monolingual *OpenSubtitles2018* file contains a tag that identifies the original language of the movie (Lison & Tiedemann, 2016). 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 movie's IMDb identifier, which is a unique ID registered with the Internet Movie Database[16]. 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)[17]. 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 used to obtain the desired information 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, `OMDb-fetch.py`, is found in Appendix B.3. It uses an imported Python wrapper for the API, written by Derrick Gilland[18], 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 a 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.

I also found that, unfortunately, OMDb does not contain every movie in its database. However, these mystery movies were few.

---

[16]http://www.imdb.com/
[17]http://www.omdbapi.com/
[18]https://github.com/dgilland

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

```
14  # Create list of all movie directory paths for desired year
15  for name in glob.glob(
16          './OpenSubtitles2018_parsed_single/parsed/he/' +
17          year + '/*/'):
18      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. 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.

```
20  # Trim list of directories to only the movie IDs
21  IDs = [os.path.basename(os.path.dirname(str(i))) for i in IDs]
22
23  # Add additional zeros to beginning of IDs to match with database
24  for i in IDs:
25      while len(i) < 7:
26          IDs[IDs.index(i)] = '0' + i
27          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 33, but be sure to replace `906517b3` with your own key, which can be obtained at *http://www.omdbapi.com/*.

```
33  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.

```python
35    # Print table header
36    print('# ' + year + '\n' +
37          'IMDb ID\tTitle\tYear\tLanguage(s)')
38
39    # Fetch and print movie ID, title, year, and language(s)
40    for i in IDs:
41        doc = omdb.imdbid('tt' + i)
42        print('tt' + i + '\t' +
43              doc['title'] + '\t' +
44              doc['year'] + '\t' +
45              doc['language'])
```

Using a simple search program that allows for extraction of specific lines, such as those labeled with the language `Hebrew`, one can make a list of all the subtitle files that represent the original primary language of the movie. I used the open-source coding program *Atom*[19] to do this, though many options exist.

I modified the main script to use only movies from this list. The instructions for how to do this are included in the comments within the main script itself, `create-freq-list.py`, which can be found in *Appendix B.1*.

For those who wish to pursue the path outlined in this section, *Appendix B.4* is a separate, simple script, `list_comparison.py`, whose whole purpose is to compare two frequency lists. Its methodology follows the comparison method used by Sorell (2013), *Dice distance*, and which is described in detail in the *corpus size* section of the literature review of this thesis. The script identifies the entries that are found on both lists and provides a total. This can be used to find the percentage of similarity—or, conversely, difference—between the two lists. It is designed to compare a frequency dictionary created from original-language-subtitles exclusively with one created from the entire corpus of subtitles. However, it can be used to compare any two dictionaries.

In the end, however, I found that the total token count for the entire mini-corpus

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[19]https://atom.io

of original Hebrew subtitles was only 615 thousand. This was well below my minimum goal of a 20-million-token corpus. In comparison, the entire Hebrew *Open-Subtitles2018* corpus that I used (with translated and original language subtitles) contains over 194 million tokens. This section of the thesis has explained how to use the scripts so that they can be used for languages that do have sufficient original-language subtitles. The *Frequency Dictionary of Spoken Hebrew*, however, is created using the entire corpus. As I mention in the *conversation text type* section of the literature review, the findings of a study by New et al. (2007) suggest that translated subtitles may be a valid alternative, but more research is needed in this area.

### 4.2.2 Functional challenges

A quick scan of the FDOSH reveals some notable entries. 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 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 the spoken dialogue of many languages (especially the first and second person pronouns), 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" (entry 15) and "דיבר" (entry 63).

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

Other issues, however, are more difficult to explain.

**4.2.2.1  Textual ambiguity of Hebrew orthography**    The flexible spelling conventions of Hebrew are at the root of many of the deficiencies in the FDOSH. For example, דִּבֶּר *he spoke* can be written as either דיבר using "full spelling" or דבר using "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" (entry 33) includes instances of both the verb and the noun, which are completely unrelated. A 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" (entry 63), is the expected lemma for the verb since it follows the traditional dictionary conjugation form. 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, the issue appears to be 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=Act" upos="VERB" lemma="דיבר" id="1451.20"
↪  deprel="obl">מדבר</w>
```

To complicate matters more, we also find the unexpected lemmas "דיברה" (entry 1410), "שדיבר" (entry 3178), and "שדיברה" (entry 4942). Based on the contexts in which they are found, these should be parsed as two separate lemmas, "ש" and "דיבר."

These sorts of ambiguities are not exclusive to forms that use defective spelling. The general lack of vowels in written Hebrew makes it impossible to tell the difference between עם (people) and עם (with) when devoid of context. Because they are both parsed as belonging to the same lemma, their frequencies are conflated into a single entry in the FDOSH. The lemma "עם" (entry 24), should therefore be two separate entries, both of which would be ranked lower on the list than their current status.

One possible solution to this problem is to alter the word counting script so that it accounts for lemma *and* part of speech (POS), rather than just the former. The following entries in the corpus could then be counted separately—note that one is tagged as NOUN and the other as ADP (for adposition):

```
<w xpos="NOUN" head="893.2" feats="Gender=Masc|Number=Sing"
↪  upos="NOUN" misc="SpaceAfter=No" lemma="עם" id="893.5"
↪  deprel="nsubj">עם</w>
```

```
<w xpos="ADP" head="78.7" upos="ADP" lemma="עם" id="78.6"
↪  deprel="case">עם</w>
```

If counted in this way, the frequency dictionary would be able to distinguish more accurately between words that vary in part of speech, which is one of the standard criteria for identifying different lemmas. Due to time constraints, this technique has not yet been used on the *Frequency Dictionary of Spoken Hebrew.*

Other issues in the FDOSH include separate lemmas for two forms of the same word, such as "מ" (entry 17) and "מן" (entry 69), as well as non-existent or ancient lemmas where they should not be found, such as "והיי" (entry 55), which the automatic parser used for the borrowed greeting היי (hey/hi).

These are just a few examples of the types of difficulties caused by a combination of an ambiguous writing system and an automatic parser. Though the parsing was carried out by the OPUS team as part of the corpus's pre-processing stage, a basic understanding of how the magic is done can prove valuable for understanding some of the deficiencies in the FDOSH. I will here explain the basic principles of the process and some of the implications entailed.

**4.2.2.2 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 intelligence assistants 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 FDOSH. This decision is discussed under *identifying words (word family levels)* in the background section of this thesis.

Two distinct types of syntactic parsers exist, constituency 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 depen-

dency 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 words and punctuation marks.

Most automatic parsers are "trained" using a small corpus that has been manually parsed by a team of humans, or at least one that was automatically parsed and then checked and corrected by the researchers (Gretz et al., 2015). These "gold-standard" pre-parsed corpora are called treebanks, and repositories of them have been created for many languages. Building on existing databases of knowledge, many of these parsers use statistical models to determine the most likely syntactic structure and conjugation for each word in each sentence.

Some parsers 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. The dependency parser used by the OPUS team for the OpenSubtitles2018 corpus is *UDPipe*[20]. Tests carried out with this parser have been documented for various languages, including Hebrew (Institute of Formal and Applied Linguistics, 2018). If starting from an untokenized Hebrew corpus, UDPipe has been found to identify lemmas and parts

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[20]http://ufal.mff.cuni.cz/udpipe

of speech with 79.6% and 80.9% accuracy, respectively. If used on a gold-standard tokenized corpus (i.e. tokenized by humans), these accuracies jump to 93.2% and 95.1%.

Because the files parsed for the OpenSubtitles2018 corpus began as a raw, untokenized text, the accuracy can be expected to be at around 80%. When dealing with such a large corpus, which consists of nearly 200 million tokens, a 20% error threshold results in about 40 million incorrectly parsed words. This, then, helps explain many of the issues found in the FDOSH. Hebrew's orthographic ambiguity simply compounds the problem.

Still, the need for only minimal resources to create a frequency dictionary using automatic parsers provides an invaluable opportunity for many educators and researchers. The alternative is to manually parse and lemmatize a corpus—a task that is made practically impossible by the resources needed to do this on such a large scale.

The good news is that automatic parsers are continually improving in accuracy. The funding and efforts being invested into natural language processing research are expected to lead to more accurate results over time. And though the tools and techniques outlined in this thesis do not directly deal with the task of parsing, they are nonetheless affected by it. Some of the suggestions described here, such as using both lemma and part of speech in tandem, are likely to produce even better results.

# 5   Conclusion

This thesis has served as an in-depth look at the creation of the *Frequency Dictionary of Spoken Hebrew* (FDOSH). It has explained both the theory and the process, and in so doing has provided tools to facilitate the creation of similar frequency lists.

By identifying the decisions and outcomes of past studies, the literature review set the background for the most important factors to consider when undertaking such a project. These include corpus size and text type(s), the purpose of the frequency dictionary, the word family level to use, and the criteria by which to rank the list.

The methods chapter described—in detail—the process used to create the FDOSH. It explained how the corpus was found and cleaned, how the necessary data was extracted from it, how various measures were calculated, and how the frequency list was then sorted and exported into a full frequency dictionary. The relevant code was also explained, as well as instructions on specific changes that can be made depending on the needs of other researchers.

The organization and uses of the FDOSH were described in the last chapter. Most importantly, some of the challenges encountered during the process were discussed, along with possible directions for future projects. Some of the weaknesses of the FDOSH were also described.

Finally, the appendices to this thesis include a limited list of the FDOSH, along with all of the scripts used in their entirety. The code and full dictionary can be accessed as part of this thesis's supplementary materials at *https://doi.org/10.5281/zenodo.1239886* (Pinto, 2018), or at the project's GitHub repository: *https://github.com/juandpinto/frequency-dictionary.*

The primary research question asked at the outset of this thesis was the following:

> What are the most common words in spoken Modern Hebrew?

Despite some deficiencies in the *Frequency Dictionary of Spoken Hebrew*, this question has been tentatively answered by the ranking of its words. *Most common words* in this case has been operationalized to mean most highly ranked lemmas by the usage

coefficient of Gries's deviation of proportions, or $U_{DP}$ (Gries, 2008, 2010). Of course, there can be no absolute, definitive answer to such a question, but the FDOSH provides one possibility.

The secondary research questions have been answered thus:

> What is an effective alternative for a corpus of spoken language when one is lacking in the desired language, as is often the case for less commonly taught languages?

A corpus of film and television subtitles offers an effective alternative. Though more study is needed in this area, the preliminary studies are in agreement on this point (Brysbaert & New, 2009; New et al., 2007). Importantly, this thesis has shown how obtaining and using such a corpus can be done easily despite the lack of resources that often plagues research for less commonly taught languages.

> How can the process of creating a frequency dictionary be simplified so that it is easy to reproduce while maintaining a high level of customizability?

This project aimed at making the entire dictionary-creation process as reproducible as possible while allowing for flexibility and transparency in the tools used. By using well-documented open-source scripts written in an easily readable programming language (Python) the result succeeds in this regard. The scripts themselves are a product of this project as much as the frequency dictionary is.

> What implications might these findings have for frequency list creation and use as it pertains to other less commonly taught languages?

The findings of this thesis are applicable to the task of frequency list creation for all languages. They are especially useful, however, to languages that lack the resources to compile and use corpora of spoken language. By tackling this problem, I hope that the current project serves as a catalyst for future research that may build upon

the ideas discussed here. The development and open dissemination of tools such as these can only lead to greater cooperation among educators and researchers, to the benefit of all involved.

# Appendix A: Frequency Dictionary of Spoken Hebrew (FDOSH)

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| הוא | 1 | 114,718.51 | 121,008.92 | 99.99 |
| ה | 2 | 47,244.93 | 50,841.12 | 100.00 |
| את | 3 | 32,811.28 | 35,337.28 | 99.92 |
| ל | 4 | 27,415.19 | 29,102.77 | 99.97 |
| לא | 5 | 24,888.86 | 27,213.76 | 99.94 |
| זה | 6 | 23,817.89 | 26,418.69 | 99.96 |
| ב | 7 | 23,081.75 | 24,839.48 | 99.98 |
| של | 8 | 18,214.68 | 20,088.89 | 99.97 |
| ש | 9 | 18,203.83 | 20,028.64 | 99.95 |
| היה | 10 | 11,861.33 | 13,312.52 | 99.91 |
| מה | 11 | 10,879.07 | 12,192.80 | 99.87 |
| ו | 12 | 8,711.82 | 9,840.85 | 99.93 |
| על | 13 | 8,246.82 | 9,119.70 | 99.93 |
| כול | 14 | 6,062.08 | 6,842.01 | 99.90 |
| ידע | 15 | 5,328.40 | 6,205.85 | 99.69 |
| כן | 16 | 5,011.86 | 6,232.26 | 99.46 |
| מ | 17 | 4,871.00 | 5,479.15 | 99.89 |
| יש | 18 | 4,840.57 | 5,519.12 | 99.81 |
| עשה | 19 | 4,180.99 | 4,941.68 | 99.66 |
| אבל | 20 | 4,052.79 | 4,757.33 | 98.86 |
| טוב | 21 | 3,954.48 | 4,891.35 | 99.61 |
| רצה | 22 | 3,949.30 | 4,671.67 | 99.41 |
| אם | 23 | 3,846.61 | 4,444.59 | 99.68 |
| עם | 24 | 3,756.06 | 4,333.17 | 99.71 |
| אמר | 25 | 3,515.24 | 4,128.07 | 99.39 |
| אז | 26 | 3,370.31 | 4,052.24 | 99.41 |
| סדר | 27 | 3,197.62 | 4,305.52 | 98.33 |
| צריך | 28 | 2,862.13 | 3,501.64 | 99.18 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|------:|-----:|-----------:|----------:|------:|
| רק | 29 | 2,543.93 | 2,996.30 | 99.65 |
| חשב | 30 | 2,511.54 | 3,021.85 | 99.09 |
| כאן | 31 | 2,490.39 | 3,217.62 | 96.09 |
| הלך | 32 | 2,450.30 | 3,297.97 | 99.04 |
| דבר | 33 | 2,378.76 | 2,835.26 | 99.39 |
| איש | 34 | 2,307.24 | 2,904.93 | 98.85 |
| אל | 35 | 2,298.28 | 2,829.27 | 99.52 |
| כך | 36 | 2,269.89 | 2,777.32 | 99.29 |
| יותר | 37 | 2,260.37 | 2,682.46 | 99.42 |
| שם | 38 | 2,165.61 | 2,640.94 | 99.19 |
| יכול | 39 | 2,041.18 | 2,531.17 | 99.27 |
| ראה | 40 | 1,985.58 | 2,399.17 | 99.22 |
| עכשיו | 41 | 1,944.48 | 2,398.62 | 98.39 |
| אחד | 42 | 1,897.50 | 2,308.83 | 99.11 |
| משהו | 43 | 1,795.76 | 2,190.14 | 98.41 |
| למה | 44 | 1,793.48 | 2,234.96 | 98.04 |
| בא | 45 | 1,743.70 | 2,166.77 | 99.06 |
| זאת | 46 | 1,712.67 | 2,365.90 | 96.46 |
| או | 47 | 1,691.60 | 2,131.42 | 98.47 |
| זמן | 48 | 1,689.91 | 2,054.03 | 99.02 |
| נכון | 49 | 1,632.87 | 2,037.30 | 98.25 |
| כמו | 50 | 1,610.77 | 2,002.99 | 98.60 |
| אין | 51 | 1,607.85 | 1,945.44 | 98.70 |
| איך | 52 | 1,567.05 | 1,898.80 | 98.29 |
| מי | 53 | 1,543.35 | 1,927.41 | 98.23 |
| זו | 54 | 1,441.80 | 2,012.55 | 88.36 |
| והיי | 55 | 1,379.86 | 2,006.58 | 84.39 |
| כמה | 56 | 1,377.28 | 1,691.00 | 97.91 |
| גם | 57 | 1,332.74 | 1,657.26 | 98.26 |
| אולי | 58 | 1,280.63 | 1,630.97 | 97.19 |
| נראה | 59 | 1,279.60 | 1,603.47 | 97.94 |
| בית | 60 | 1,236.65 | 1,689.04 | 94.08 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| כדי | 61 | 1,217.36 | 1,580.41 | 94.69 |
| קרה | 62 | 1,208.12 | 1,541.01 | 97.01 |
| דיבר | 63 | 1,179.13 | 1,495.64 | 95.83 |
| פעם | 64 | 1,176.27 | 1,479.18 | 97.08 |
| דרך | 65 | 1,123.95 | 1,431.59 | 96.47 |
| כ | 66 | 1,113.82 | 1,396.49 | 96.82 |
| באמת | 67 | 1,100.74 | 1,443.69 | 95.70 |
| הגיע | 68 | 1,095.14 | 1,383.15 | 96.61 |
| מן | 69 | 1,077.03 | 1,342.58 | 96.81 |
| חייב | 70 | 1,062.55 | 1,399.35 | 94.33 |
| אחר | 71 | 1,054.79 | 1,319.13 | 96.47 |
| עוד | 72 | 1,051.41 | 1,343.73 | 96.74 |
| יום | 73 | 1,050.26 | 1,374.21 | 95.22 |
| פשוט | 74 | 1,043.34 | 1,427.29 | 93.05 |
| תודה | 75 | 1,039.36 | 1,390.71 | 93.83 |
| כי | 76 | 1,034.28 | 1,431.30 | 89.69 |
| כבר | 77 | 1,015.89 | 1,292.23 | 96.34 |
| ילד | 78 | 1,011.91 | 1,478.80 | 89.75 |
| אהב | 79 | 1,011.48 | 1,378.72 | 92.60 |
| חיים | 80 | 1,009.68 | 1,325.23 | 95.52 |
| בן | 81 | 978.82 | 1,397.82 | 92.11 |
| מישהו | 82 | 954.85 | 1,230.50 | 94.16 |
| קיבל | 83 | 944.08 | 1,258.75 | 93.83 |
| מאוד | 84 | 929.61 | 1,249.26 | 93.05 |
| לפני | 85 | 917.78 | 1,165.26 | 94.91 |
| אלה | 86 | 907.66 | 1,205.87 | 87.61 |
| אף | 87 | 899.84 | 1,156.10 | 93.95 |
| עד | 88 | 891.54 | 1,126.08 | 94.78 |
| הרבה | 89 | 873.90 | 1,109.41 | 94.77 |
| רגע | 90 | 865.02 | 1,138.53 | 93.84 |
| שנה | 91 | 846.03 | 1,131.09 | 91.30 |
| עדיין | 92 | 840.75 | 1,074.35 | 93.91 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| עצמו | 93 | 835.57 | 1,058.48 | 94.34 |
| האם | 94 | 826.99 | 1,301.20 | 73.10 |
| ניסה | 95 | 813.33 | 1,041.05 | 93.58 |
| חזר | 96 | 803.77 | 1,047.71 | 93.37 |
| מצא | 97 | 787.55 | 1,067.02 | 91.19 |
| מקום | 98 | 785.48 | 1,022.76 | 92.76 |
| מת | 99 | 779.75 | 1,080.04 | 89.81 |
| איפה | 100 | 759.84 | 1,029.43 | 87.91 |
| אלוהים | 101 | 757.35 | 1,088.19 | 81.96 |
| אדם | 102 | 735.17 | 1,032.75 | 87.64 |
| הצטער | 103 | 729.92 | 983.47 | 88.71 |
| עבר | 104 | 726.66 | 935.03 | 92.62 |
| הכיל | 105 | 721.00 | 947.86 | 78.96 |
| הבין | 106 | 717.29 | 921.06 | 92.27 |
| חבר | 107 | 707.96 | 964.33 | 88.48 |
| גדול | 108 | 704.79 | 940.92 | 90.22 |
| איזה | 109 | 700.02 | 924.60 | 91.13 |
| ממש | 110 | 699.63 | 984.20 | 85.99 |
| בוא | 111 | 686.35 | 946.82 | 87.72 |
| נתן | 112 | 686.02 | 887.93 | 90.78 |
| קצת | 113 | 684.83 | 904.88 | 88.71 |
| שמע | 114 | 683.28 | 883.99 | 90.89 |
| עבודה | 115 | 678.67 | 926.65 | 85.94 |
| הנה | 116 | 672.49 | 911.68 | 89.07 |
| קדימה | 117 | 670.69 | 1,026.32 | 79.11 |
| שני | 118 | 664.10 | 871.35 | 90.31 |
| עזר | 119 | 645.67 | 861.50 | 89.29 |
| יצא | 120 | 642.56 | 838.60 | 90.59 |
| ובכן | 121 | 642.13 | 974.64 | 62.40 |
| כש | 122 | 632.63 | 819.06 | 89.49 |
| שוב | 123 | 626.95 | 812.25 | 90.64 |
| לילה | 124 | 626.85 | 873.88 | 82.54 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| יד | 125 | 620.79 | 840.78 | 85.78 |
| היום | 126 | 619.67 | 831.50 | 87.42 |
| בדיוק | 127 | 613.66 | 795.28 | 89.58 |
| אחת | 128 | 612.17 | 795.49 | 90.08 |
| פה | 129 | 601.90 | 924.87 | 74.53 |
| בבקשה | 130 | 599.85 | 823.33 | 84.87 |
| הגיד | 131 | 583.51 | 786.67 | 81.35 |
| אי | 132 | 573.45 | 758.57 | 88.11 |
| קטן | 133 | 570.58 | 767.54 | 86.64 |
| שום | 134 | 568.39 | 755.65 | 84.65 |
| הרגיש | 135 | 561.78 | 767.59 | 85.08 |
| אמא | 136 | 560.48 | 862.25 | 61.48 |
| בטוח | 137 | 559.73 | 731.46 | 88.42 |
| אפילו | 138 | 558.97 | 721.87 | 88.48 |
| קשר | 139 | 554.24 | 757.66 | 83.45 |
| קרא | 140 | 547.23 | 722.63 | 85.88 |
| חדש | 141 | 546.60 | 736.64 | 86.03 |
| תמיד | 142 | 545.28 | 715.90 | 87.31 |
| אחרי | 143 | 543.47 | 712.94 | 87.05 |
| אבא | 144 | 535.06 | 820.11 | 67.23 |
| בשביל | 145 | 533.18 | 732.76 | 82.15 |
| האמין | 146 | 518.41 | 691.02 | 85.32 |
| בעיה | 147 | 515.14 | 687.42 | 83.71 |
| הכיר | 148 | 512.17 | 677.77 | 83.61 |
| התכוון | 149 | 508.17 | 697.25 | 80.85 |
| סיפר | 150 | 505.56 | 691.75 | 82.05 |
| מר | 151 | 491.41 | 757.16 | 61.14 |
| שלום | 152 | 489.62 | 694.08 | 78.60 |
| תן | 153 | 486.46 | 653.40 | 82.27 |
| אה | 154 | 482.37 | 813.58 | 52.37 |
| בטח | 155 | 475.12 | 643.27 | 81.96 |
| כסף | 156 | 467.64 | 701.11 | 64.63 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---|---|---|---|
| שעה | 157 | 466.93 | 629.52 | 80.40 |
| עבד | 158 | 462.44 | 615.84 | 81.39 |
| הביא | 159 | 461.67 | 608.22 | 84.36 |
| מדי | 160 | 459.28 | 605.77 | 78.45 |
| נמצא | 161 | 457.04 | 624.10 | 79.81 |
| בגלל | 162 | 455.18 | 627.50 | 78.12 |
| אחרון | 163 | 452.98 | 597.58 | 83.38 |
| הרג | 164 | 451.62 | 665.89 | 68.86 |
| ספר | 165 | 449.54 | 650.41 | 74.55 |
| מוכן | 166 | 449.26 | 595.09 | 82.03 |
| עניין | 167 | 443.88 | 596.93 | 79.88 |
| לקח | 168 | 431.40 | 566.91 | 82.04 |
| גרם | 169 | 430.29 | 572.16 | 80.92 |
| גבר | 170 | 428.33 | 616.60 | 72.25 |
| סיבה | 171 | 428.26 | 587.32 | 79.20 |
| לב | 172 | 424.35 | 578.66 | 78.91 |
| ראש | 173 | 422.60 | 577.71 | 77.42 |
| אפשר | 174 | 422.23 | 577.08 | 77.23 |
| שאל | 175 | 413.95 | 548.02 | 78.70 |
| חברה | 176 | 408.91 | 581.20 | 72.35 |
| עמד | 177 | 402.70 | 532.42 | 79.28 |
| אכל | 178 | 402.39 | 545.16 | 79.05 |
| חדר | 179 | 401.80 | 562.65 | 73.60 |
| קשה | 180 | 395.98 | 520.41 | 80.36 |
| אדוני | 181 | 394.93 | 617.58 | 53.52 |
| התחיל | 182 | 394.86 | 515.97 | 80.57 |
| רב | 183 | 392.01 | 537.32 | 75.03 |
| הניח | 184 | 387.25 | 518.51 | 78.21 |
| עולם | 185 | 387.18 | 548.18 | 72.90 |
| נשאר | 186 | 380.76 | 507.27 | 77.96 |
| תראה | 187 | 378.02 | 517.75 | 72.87 |
| שב | 188 | 376.71 | 492.98 | 78.49 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| מקרה | 189 | 375.80 | 506.88 | 75.90 |
| משפחה | 190 | 375.65 | 539.47 | 68.62 |
| בוקר | 191 | 372.69 | 511.84 | 70.63 |
| עזאזל | 192 | 360.31 | 517.82 | 65.84 |
| כלום | 193 | 353.91 | 480.33 | 71.95 |
| חוץ | 194 | 353.91 | 468.18 | 75.61 |
| נכנס | 195 | 352.28 | 466.72 | 76.00 |
| שבוע | 196 | 351.65 | 475.15 | 70.81 |
| הו | 197 | 350.18 | 560.98 | 39.94 |
| הכי | 198 | 349.75 | 479.66 | 71.92 |
| אמור | 199 | 348.92 | 462.96 | 76.71 |
| די | 200 | 346.59 | 474.97 | 71.93 |
| חושב | 201 | 342.94 | 479.44 | 66.63 |
| עסק | 202 | 342.92 | 471.81 | 68.96 |
| חלק | 203 | 341.92 | 453.04 | 75.44 |
| סוף | 204 | 338.98 | 453.48 | 72.77 |
| בת | 205 | 336.98 | 483.08 | 65.31 |
| ביותר | 206 | 331.01 | 456.85 | 66.65 |
| עזב | 207 | 325.30 | 438.85 | 71.42 |
| מצב | 208 | 322.42 | 434.39 | 72.24 |
| זהו | 209 | 322.32 | 456.73 | 64.44 |
| אינו | 210 | 321.85 | 502.82 | 50.63 |
| שמר | 211 | 317.92 | 419.67 | 73.36 |
| פנים | 212 | 317.30 | 428.38 | 72.46 |
| בלי | 213 | 317.15 | 425.60 | 71.57 |
| יפה | 214 | 316.26 | 430.19 | 68.26 |
| חיפש | 215 | 316.21 | 427.55 | 71.37 |
| הביתה | 216 | 314.34 | 429.84 | 67.49 |
| עובד | 217 | 312.02 | 417.59 | 70.28 |
| עבור | 218 | 310.46 | 443.04 | 56.82 |
| בין | 219 | 309.11 | 411.64 | 71.61 |
| רע | 220 | 308.16 | 411.00 | 70.89 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| הפך | 221 | 307.03 | 412.11 | 71.26 |
| אמת | 222 | 306.55 | 419.64 | 68.39 |
| כאילו | 223 | 306.54 | 422.08 | 69.30 |
| אוקיי | 224 | 305.25 | 499.98 | 26.71 |
| כמובן | 225 | 302.61 | 410.97 | 67.32 |
| עיר | 226 | 298.46 | 433.88 | 60.03 |
| הספיק | 227 | 297.32 | 389.09 | 73.49 |
| אוכל | 228 | 296.04 | 407.47 | 67.38 |
| מעולם | 229 | 296.00 | 398.10 | 66.34 |
| השתמש | 230 | 295.21 | 395.83 | 70.66 |
| שמח | 231 | 294.56 | 400.63 | 69.21 |
| זכר | 232 | 293.72 | 397.52 | 68.77 |
| המשיך | 233 | 292.62 | 385.28 | 71.28 |
| דקה | 234 | 290.57 | 394.64 | 65.86 |
| אמיתי | 235 | 290.03 | 392.30 | 67.32 |
| העליי | 236 | 289.22 | 399.75 | 57.05 |
| יחיד | 237 | 288.04 | 380.58 | 72.16 |
| בעל | 238 | 284.38 | 395.08 | 63.93 |
| נהדר | 239 | 282.88 | 398.01 | 60.48 |
| אכפת | 240 | 281.91 | 375.84 | 68.98 |
| קודם | 241 | 280.72 | 369.46 | 73.40 |
| אלו | 242 | 280.47 | 412.35 | 49.71 |
| תוכנית | 243 | 280.06 | 398.15 | 61.26 |
| כדאי | 244 | 279.43 | 381.19 | 66.09 |
| משחק | 245 | 278.67 | 418.83 | 55.37 |
| חשוב | 246 | 275.19 | 364.04 | 68.92 |
| ביקש | 247 | 274.71 | 367.36 | 66.66 |
| נעשה | 248 | 274.53 | 363.45 | 69.24 |
| נשמע | 249 | 271.99 | 360.32 | 69.65 |
| מכונית | 250 | 271.64 | 406.22 | 48.95 |
| לעולם | 251 | 270.78 | 367.12 | 65.88 |
| מספר | 252 | 270.45 | 375.71 | 59.62 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| סליחה | 253 | 267.60 | 375.07 | 59.50 |
| נחמד | 254 | 266.50 | 361.55 | 63.64 |
| התקשר | 255 | 265.76 | 366.95 | 58.75 |
| עין | 256 | 263.71 | 355.23 | 65.68 |
| קיווה | 257 | 257.45 | 339.39 | 68.33 |
| סיפור | 258 | 256.80 | 359.30 | 60.08 |
| שאלה | 259 | 256.49 | 346.90 | 63.92 |
| בחור | 260 | 255.74 | 353.18 | 58.89 |
| חכה | 261 | 255.11 | 353.50 | 59.62 |
| קרוב | 262 | 253.32 | 334.26 | 67.11 |
| שינה | 263 | 252.25 | 333.20 | 68.11 |
| הפסיק | 264 | 250.12 | 332.59 | 66.29 |
| לעזאזל | 265 | 248.74 | 354.18 | 55.63 |
| הודה | 266 | 248.56 | 338.13 | 61.89 |
| כתב | 267 | 248.00 | 352.64 | 54.34 |
| עלה | 268 | 247.77 | 327.08 | 64.47 |
| מהר | 269 | 246.33 | 336.87 | 62.24 |
| מוות | 270 | 245.02 | 348.60 | 56.35 |
| אופן | 271 | 243.60 | 327.33 | 61.95 |
| טלפון | 272 | 241.79 | 344.31 | 52.23 |
| ישן | 273 | 240.41 | 324.50 | 63.19 |
| תרא | 274 | 238.90 | 329.43 | 59.02 |
| מחר | 275 | 238.41 | 325.52 | 58.14 |
| לאן | 276 | 237.46 | 319.10 | 62.76 |
| בכלל | 277 | 236.95 | 314.78 | 63.73 |
| אך | 278 | 235.45 | 385.52 | 35.90 |
| כוח | 279 | 233.82 | 340.59 | 53.74 |
| רעיון | 280 | 232.52 | 312.93 | 61.15 |
| לגבי | 281 | 232.47 | 325.87 | 54.88 |
| ילך | 282 | 230.18 | 305.77 | 62.19 |
| עצר | 283 | 229.43 | 313.61 | 60.24 |
| מוזר | 284 | 228.13 | 313.45 | 59.44 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| ללא | 285 | 227.75 | 318.60 | 56.58 |
| מזל | 286 | 227.34 | 305.24 | 61.30 |
| הצליח | 287 | 224.20 | 305.24 | 59.59 |
| שנייה | 288 | 224.03 | 302.19 | 60.16 |
| צדק | 289 | 223.60 | 298.74 | 62.90 |
| גברת | 290 | 223.51 | 331.04 | 46.59 |
| חיכה | 291 | 223.28 | 295.03 | 63.22 |
| נוסף | 292 | 223.11 | 303.43 | 58.84 |
| דלת | 293 | 222.89 | 312.74 | 55.40 |
| אח | 294 | 222.88 | 321.28 | 50.92 |
| חזרה | 295 | 222.68 | 303.50 | 59.48 |
| חודש | 296 | 222.22 | 301.43 | 57.18 |
| מתי | 297 | 220.96 | 293.94 | 62.07 |
| חזק | 298 | 220.12 | 298.58 | 59.77 |
| משטרה | 299 | 217.30 | 323.01 | 42.20 |
| במקום | 300 | 217.17 | 284.12 | 64.20 |
| סוג | 301 | 216.08 | 294.47 | 56.91 |
| שיחק | 302 | 215.72 | 302.95 | 54.25 |
| למד | 303 | 215.17 | 294.15 | 57.41 |
| שלח | 304 | 214.87 | 291.17 | 58.66 |
| חץ | 305 | 214.76 | 288.29 | 59.08 |
| אחי | 306 | 214.57 | 329.83 | 41.09 |
| דם | 307 | 214.07 | 320.20 | 46.70 |
| חלה | 308 | 213.85 | 310.72 | 48.88 |
| כמעט | 309 | 213.85 | 281.40 | 62.38 |
| צוות | 310 | 213.40 | 310.61 | 48.51 |
| ברור | 311 | 213.32 | 286.40 | 59.60 |
| ערב | 312 | 213.21 | 296.13 | 53.37 |
| וה | 313 | 213.06 | 279.53 | 61.81 |
| דולר | 314 | 212.44 | 314.65 | 42.20 |
| בחר | 315 | 212.23 | 282.89 | 60.19 |
| חי | 316 | 210.37 | 284.29 | 59.05 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| כלל | 317 | 209.68 | 278.64 | 59.66 |
| החזיק | 318 | 209.68 | 282.37 | 58.78 |
| בדק | 319 | 208.91 | 285.13 | 57.00 |
| לאחר | 320 | 208.21 | 287.91 | 53.36 |
| כנראה | 321 | 206.82 | 280.36 | 57.42 |
| כדור | 322 | 206.50 | 303.73 | 46.81 |
| רוח | 323 | 205.42 | 288.02 | 53.87 |
| הבחור | 324 | 204.84 | 286.50 | 51.38 |
| מאוחר | 325 | 203.40 | 269.37 | 59.32 |
| השאיר | 326 | 203.30 | 268.59 | 61.25 |
| קנה | 327 | 202.33 | 277.93 | 55.14 |
| רצח | 328 | 201.55 | 310.41 | 37.19 |
| הוציא | 329 | 199.54 | 266.24 | 58.76 |
| איתך | 330 | 198.55 | 262.46 | 58.47 |
| מבין | 331 | 196.81 | 260.84 | 58.63 |
| סיים | 332 | 193.82 | 257.89 | 58.53 |
| התראה | 333 | 193.55 | 266.97 | 52.55 |
| פחד | 334 | 193.23 | 267.35 | 52.45 |
| שלוש | 335 | 193.23 | 263.61 | 52.44 |
| למעשה | 336 | 193.00 | 264.72 | 52.96 |
| משרד | 337 | 192.73 | 277.96 | 45.19 |
| ככה | 338 | 192.64 | 261.25 | 54.76 |
| שילם | 339 | 192.54 | 265.52 | 51.50 |
| כאשר | 340 | 192.01 | 289.88 | 36.29 |
| גרוע | 341 | 190.41 | 254.92 | 58.14 |
| כבוד | 342 | 190.23 | 266.43 | 50.20 |
| הבטיח | 343 | 190.15 | 255.29 | 56.37 |
| חסר | 344 | 189.02 | 252.86 | 56.51 |
| תמונה | 345 | 188.79 | 268.53 | 47.96 |
| מלא | 346 | 187.81 | 248.01 | 57.96 |
| לכן | 347 | 187.64 | 257.71 | 52.52 |
| לבד | 348 | 187.53 | 253.05 | 56.70 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| שוטר | 349 | 187.16 | 290.24 | 34.34 |
| איבד | 350 | 187.01 | 251.51 | 56.14 |
| נסע | 351 | 186.91 | 264.57 | 46.83 |
| השיג | 352 | 185.24 | 249.66 | 54.79 |
| לגמרי | 353 | 184.51 | 251.39 | 53.29 |
| החוצה | 354 | 184.43 | 252.68 | 52.01 |
| לפחות | 355 | 183.48 | 241.21 | 59.20 |
| נ | 356 | 182.95 | 242.49 | 57.30 |
| במשך | 357 | 181.51 | 244.12 | 53.83 |
| פרק | 358 | 181.35 | 246.34 | 62.67 |
| איתי | 359 | 181.24 | 241.34 | 55.77 |
| חושבת | 360 | 180.30 | 248.37 | 51.72 |
| פגע | 361 | 180.05 | 245.53 | 54.00 |
| הת | 362 | 179.43 | 238.73 | 56.64 |
| בחייך | 363 | 178.82 | 250.63 | 47.83 |
| סרט | 364 | 176.56 | 270.08 | 37.79 |
| שכח | 365 | 176.16 | 234.51 | 55.13 |
| בבקש | 366 | 176.08 | 236.31 | 53.17 |
| צעיר | 367 | 175.76 | 242.48 | 49.47 |
| ישב | 368 | 175.29 | 233.75 | 53.77 |
| בהחלט | 369 | 175.05 | 236.73 | 52.15 |
| שונה | 370 | 174.57 | 235.15 | 53.14 |
| קח | 371 | 173.93 | 237.86 | 50.03 |
| א | 372 | 173.77 | 246.98 | 47.40 |
| צריכה | 373 | 173.21 | 242.19 | 49.81 |
| מעל | 374 | 171.99 | 233.18 | 52.90 |
| קל | 375 | 171.68 | 227.86 | 55.62 |
| מטה | 376 | 171.27 | 240.09 | 46.64 |
| ותק | 377 | 170.96 | 249.98 | 41.43 |
| לשם | 378 | 170.83 | 225.19 | 55.33 |
| אהבה | 379 | 170.76 | 249.54 | 42.09 |
| יחד | 380 | 170.56 | 234.73 | 49.78 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| קורה | 381 | 169.46 | 230.18 | 52.98 |
| הקשיב | 382 | 169.18 | 228.03 | 52.05 |
| אתמול | 383 | 169.13 | 234.91 | 49.36 |
| מילה | 384 | 168.96 | 229.60 | 50.72 |
| נקודה | 385 | 168.85 | 231.75 | 49.83 |
| הכול | 386 | 168.62 | 269.42 | 26.86 |
| צורה | 387 | 168.36 | 229.16 | 51.63 |
| נגע | 388 | 167.80 | 235.17 | 48.48 |
| בלתי | 389 | 166.79 | 227.90 | 50.14 |
| מים | 390 | 166.16 | 241.56 | 43.35 |
| למעלה | 391 | 166.03 | 229.19 | 47.96 |
| מושג | 392 | 166.02 | 222.77 | 53.61 |
| פתח | 393 | 165.93 | 224.93 | 51.60 |
| נהג | 394 | 165.75 | 228.98 | 47.96 |
| סתם | 395 | 165.39 | 226.73 | 49.72 |
| היכן | 396 | 165.38 | 249.05 | 36.85 |
| סלח | 397 | 165.00 | 226.18 | 48.80 |
| הסתכל | 398 | 164.83 | 221.65 | 51.17 |
| בתוך | 399 | 164.25 | 224.12 | 50.58 |
| כוונה | 400 | 164.20 | 219.25 | 53.77 |
| מייד | 401 | 163.89 | 221.99 | 50.53 |
| מערכת | 402 | 163.87 | 236.45 | 43.68 |
| נגמר | 403 | 163.47 | 221.22 | 52.35 |
| הזדמנות | 404 | 162.97 | 220.09 | 51.64 |
| תינוק | 405 | 162.81 | 253.53 | 34.25 |
| הראה | 406 | 162.39 | 216.72 | 52.56 |
| הערב | 407 | 161.93 | 232.61 | 42.96 |
| עזרה | 408 | 161.69 | 218.48 | 52.99 |
| אלא | 409 | 161.12 | 215.41 | 52.68 |
| אתן | 410 | 160.15 | 220.47 | 49.53 |
| סיכוי | 411 | 159.13 | 216.52 | 50.78 |
| הפעם | 412 | 158.99 | 211.44 | 53.61 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| ניצח | 413 | 158.95 | 225.98 | 45.25 |
| הציל | 414 | 158.90 | 227.24 | 45.47 |
| נשק | 415 | 158.83 | 231.36 | 41.68 |
| רופא | 416 | 157.77 | 234.77 | 38.33 |
| שלושה | 417 | 157.69 | 216.13 | 48.26 |
| י | 418 | 155.57 | 217.36 | 46.86 |
| קול | 419 | 154.70 | 224.59 | 41.31 |
| אוי | 420 | 154.66 | 231.73 | 37.85 |
| כאב | 421 | 153.91 | 216.83 | 45.67 |
| שתי | 422 | 153.26 | 206.35 | 49.88 |
| אעשה | 423 | 152.46 | 203.70 | 52.09 |
| כפי | 424 | 151.87 | 210.91 | 45.83 |
| רציני | 425 | 151.28 | 204.36 | 49.26 |
| הציע | 426 | 150.88 | 205.25 | 48.68 |
| ואו | 427 | 150.62 | 227.03 | 35.91 |
| כלא | 428 | 150.58 | 224.46 | 35.87 |
| אדיר | 429 | 150.29 | 218.21 | 40.99 |
| כלומר | 430 | 149.98 | 219.69 | 39.09 |
| דין | 431 | 148.77 | 226.93 | 32.94 |
| ביחד | 432 | 148.04 | 208.36 | 44.50 |
| בעוד | 433 | 147.82 | 200.88 | 48.87 |
| כרגע | 434 | 147.16 | 205.01 | 45.97 |
| שיר | 435 | 146.93 | 220.27 | 36.09 |
| מלחמה | 436 | 146.01 | 222.93 | 33.55 |
| דעה | 437 | 145.35 | 198.70 | 47.63 |
| כלב | 438 | 145.35 | 222.64 | 33.51 |
| לפעמים | 439 | 145.23 | 197.11 | 48.33 |
| כעת | 440 | 145.09 | 223.23 | 32.61 |
| נעלם | 441 | 145.00 | 202.86 | 46.00 |
| שיחה | 442 | 144.86 | 200.39 | 45.78 |
| למען | 443 | 144.62 | 200.50 | 45.80 |
| חמש | 444 | 144.42 | 200.75 | 44.09 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| רחוב | 445 | 143.55 | 206.14 | 40.28 |
| נורא | 446 | 143.44 | 198.72 | 45.41 |
| שניים | 447 | 142.72 | 193.25 | 47.83 |
| מיוחד | 448 | 142.44 | 196.17 | 46.15 |
| האליי | 449 | 142.22 | 199.52 | 42.87 |
| ירד | 450 | 141.36 | 192.70 | 46.57 |
| ודה | 451 | 141.14 | 190.54 | 48.50 |
| קבוצה | 452 | 140.27 | 209.25 | 36.39 |
| שאר | 453 | 140.18 | 190.62 | 47.67 |
| זונה | 454 | 140.05 | 207.61 | 35.53 |
| שכן | 455 | 140.05 | 190.95 | 48.53 |
| נגד | 456 | 139.76 | 196.68 | 42.99 |
| אלי | 457 | 139.28 | 191.31 | 45.89 |
| יצר | 458 | 138.97 | 197.48 | 42.54 |
| יופי | 459 | 138.92 | 199.93 | 41.59 |
| ארץ | 460 | 138.07 | 206.49 | 36.05 |
| מדינה | 461 | 137.93 | 201.80 | 36.28 |
| תפס | 462 | 137.85 | 189.40 | 46.09 |
| חוק | 463 | 137.62 | 198.36 | 39.12 |
| גר | 464 | 136.55 | 194.35 | 41.38 |
| החזיר | 465 | 134.47 | 185.84 | 46.26 |
| גש | 466 | 133.53 | 183.49 | 44.84 |
| אקדח | 467 | 133.31 | 206.18 | 29.83 |
| שה | 468 | 132.88 | 179.04 | 47.86 |
| מידע | 469 | 132.61 | 194.28 | 37.14 |
| טיפל | 470 | 132.26 | 182.77 | 45.35 |
| משפט | 471 | 131.62 | 202.09 | 30.47 |
| גנב | 472 | 131.38 | 189.43 | 39.75 |
| מסוגל | 473 | 131.22 | 183.37 | 43.42 |
| תורגם | 474 | 129.97 | 183.74 | 45.73 |
| ארוחה | 475 | 129.52 | 182.99 | 42.09 |
| שקט | 476 | 129.42 | 180.46 | 42.85 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| צד | 477 | 129.00 | 178.71 | 44.24 |
| אש | 478 | 128.53 | 192.82 | 34.68 |
| מצטער | 479 | 128.12 | 177.03 | 45.04 |
| אב | 480 | 127.75 | 187.02 | 37.09 |
| ליד | 481 | 127.31 | 173.76 | 46.14 |
| טעות | 482 | 127.07 | 175.47 | 44.74 |
| פחות | 483 | 126.65 | 172.52 | 45.98 |
| רגיל | 484 | 126.21 | 173.06 | 45.04 |
| תיק | 485 | 126.16 | 189.62 | 32.84 |
| גבוה | 486 | 125.89 | 173.98 | 43.16 |
| מלך | 487 | 125.08 | 207.75 | 22.84 |
| מדוע | 488 | 124.68 | 192.68 | 29.46 |
| ניתן | 489 | 123.81 | 171.44 | 43.46 |
| הגן | 490 | 123.53 | 175.92 | 41.03 |
| הצלחה | 491 | 123.35 | 169.09 | 44.49 |
| מספיק | 492 | 123.25 | 167.51 | 46.60 |
| רכב | 493 | 123.06 | 182.51 | 34.79 |
| כיוון | 494 | 123.02 | 173.34 | 41.40 |
| פשע | 495 | 122.99 | 183.46 | 33.51 |
| הורה | 496 | 122.54 | 178.63 | 37.53 |
| הסכים | 497 | 122.35 | 169.25 | 43.19 |
| הוריד | 498 | 121.29 | 169.55 | 42.05 |
| לחץ | 499 | 121.19 | 172.52 | 39.72 |
| דאג | 500 | 120.55 | 169.20 | 42.22 |
| יכולת | 501 | 120.27 | 166.59 | 43.79 |
| נפלא | 502 | 120.25 | 174.49 | 36.99 |
| תדאג | 503 | 118.78 | 164.66 | 43.78 |
| תחת | 504 | 118.33 | 164.84 | 41.40 |
| הכין | 505 | 118.30 | 165.99 | 42.91 |
| עץ | 506 | 118.20 | 176.20 | 34.28 |
| הודעה | 507 | 117.69 | 169.29 | 38.41 |
| חרא | 508 | 117.38 | 184.92 | 25.65 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| מוח | 509 | 117.32 | 172.45 | 36.39 |
| מטרה | 510 | 117.20 | 170.87 | 36.70 |
| גוף | 511 | 117.18 | 170.08 | 37.95 |
| הא | 512 | 115.96 | 178.76 | 29.37 |
| אצל | 513 | 115.70 | 162.63 | 40.47 |
| מצחיק | 514 | 114.66 | 163.76 | 39.10 |
| שנא | 515 | 114.47 | 162.46 | 39.85 |
| לפ | 516 | 114.34 | 160.76 | 40.08 |
| בגד | 517 | 113.84 | 161.62 | 39.65 |
| סימן | 518 | 113.58 | 162.60 | 39.08 |
| שווה | 519 | 113.36 | 157.99 | 41.68 |
| קטע | 520 | 113.24 | 164.09 | 37.72 |
| דוד | 521 | 112.99 | 177.08 | 27.63 |
| עלול | 522 | 112.17 | 158.56 | 40.32 |
| רוב | 523 | 112.09 | 158.26 | 39.41 |
| כוכב | 524 | 111.92 | 174.76 | 28.47 |
| העביר | 525 | 111.76 | 155.94 | 41.36 |
| אפשרי | 526 | 111.14 | 156.08 | 40.63 |
| פגישה | 527 | 111.10 | 163.23 | 34.52 |
| אור | 528 | 110.93 | 159.84 | 37.41 |
| מין | 529 | 110.51 | 160.27 | 36.73 |
|ביי | 530 | 110.25 | 167.40 | 29.85 |
| מנהל | 531 | 110.17 | 163.33 | 33.04 |
| בנה | 532 | 109.72 | 155.16 | 39.68 |
| ארוך | 533 | 109.65 | 151.52 | 42.18 |
| זוכר | 534 | 109.29 | 156.21 | 38.98 |
| תפקיד | 535 | 108.84 | 158.07 | 35.75 |
| נעל | 536 | 108.59 | 157.99 | 36.44 |
| ציפה | 537 | 108.29 | 149.55 | 42.40 |
| מוקדם | 538 | 107.96 | 149.54 | 42.09 |
| בקרוב | 539 | 107.59 | 150.88 | 41.51 |
| מתוק | 540 | 107.45 | 158.32 | 35.12 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| הסביר | 541 | 107.20 | 149.51 | 41.04 |
| אסור | 542 | 106.07 | 152.51 | 37.85 |
| איתן | 543 | 105.56 | 151.03 | 38.06 |
| לבש | 544 | 105.53 | 151.09 | 38.26 |
| לפי | 545 | 105.43 | 150.84 | 37.82 |
| מעבר | 546 | 105.37 | 148.95 | 38.99 |
| דירה | 547 | 105.31 | 160.75 | 30.09 |
| סם | 548 | 104.96 | 166.80 | 24.92 |
| רחוק | 549 | 104.93 | 147.68 | 39.81 |
| שתיים | 550 | 104.63 | 151.05 | 36.00 |
| ניו | 551 | 104.63 | 163.64 | 25.61 |
| בדיקה | 552 | 104.60 | 158.91 | 30.45 |
| מאשר | 553 | 104.47 | 145.52 | 40.57 |
| זוג | 554 | 104.14 | 152.22 | 35.37 |
| עובדה | 555 | 104.04 | 145.57 | 39.79 |
| הופיע | 556 | 103.57 | 146.45 | 38.53 |
| אוויר | 557 | 103.25 | 151.69 | 34.38 |
| החלטה | 558 | 103.24 | 148.45 | 36.77 |
| זז | 559 | 102.93 | 148.03 | 37.06 |
| גידי | 560 | 102.92 | 149.70 | 36.06 |
| מעט | 561 | 102.80 | 146.86 | 37.49 |
| כרטיס | 562 | 102.79 | 153.30 | 32.14 |
| טיפש | 563 | 102.68 | 147.63 | 37.05 |
| מפה | 564 | 102.26 | 152.42 | 32.65 |
| שירות | 565 | 102.21 | 148.24 | 36.28 |
| אישי | 566 | 101.44 | 143.37 | 38.25 |
| ערך | 567 | 101.31 | 143.65 | 38.67 |
| קיים | 568 | 101.12 | 144.55 | 37.63 |
| שחור | 569 | 101.00 | 151.78 | 31.18 |
| עורך | 570 | 100.98 | 154.40 | 28.23 |
| זקוק | 571 | 100.87 | 146.62 | 36.12 |
| בחורה | 572 | 100.87 | 149.06 | 33.73 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| התמודד | 573 | 100.73 | 143.53 | 38.45 |
| נלחם | 574 | 99.82 | 150.51 | 31.64 |
| מיטה | 575 | 99.38 | 145.10 | 35.00 |
| הזמין | 576 | 99.18 | 141.84 | 37.52 |
| מתחת | 577 | 98.82 | 140.67 | 38.20 |
| מחדש | 578 | 98.77 | 141.67 | 37.24 |
| אלך | 579 | 98.46 | 139.13 | 39.89 |
| מפקד | 580 | 98.23 | 169.23 | 15.49 |
| אימא | 581 | 97.80 | 170.32 | 14.49 |
| המ | 582 | 97.21 | 143.47 | 33.35 |
| הלו | 583 | 97.14 | 145.96 | 30.80 |
| משך | 584 | 97.08 | 137.63 | 38.07 |
| מהלך | 585 | 97.02 | 140.43 | 35.67 |
| בערך | 586 | 96.87 | 137.83 | 37.36 |
| חומר | 587 | 96.47 | 143.05 | 32.25 |
| אית | 588 | 96.38 | 135.28 | 39.55 |
| חלום | 589 | 96.26 | 146.78 | 29.42 |
| שחרר | 590 | 95.53 | 139.94 | 34.85 |
| בתור | 591 | 95.05 | 137.75 | 35.91 |
| ברח | 592 | 94.92 | 138.25 | 35.70 |
| שולחן | 593 | 94.91 | 138.30 | 34.43 |
| הוטרף | 594 | 94.58 | 136.60 | 35.85 |
| נפגש | 595 | 94.47 | 134.66 | 36.94 |
| למרות | 596 | 94.43 | 135.05 | 36.92 |
| צעד | 597 | 94.31 | 136.83 | 34.80 |
| צוחק | 598 | 94.20 | 140.05 | 31.92 |
| קפה | 599 | 93.78 | 141.11 | 30.51 |
| שאמר | 600 | 93.72 | 131.03 | 39.83 |
| מאחורי | 601 | 93.51 | 132.70 | 37.82 |
| יחסים | 602 | 92.12 | 137.74 | 31.64 |
| גב | 603 | 91.87 | 139.40 | 29.29 |
| חג | 604 | 91.54 | 154.76 | 17.68 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| מס | 605 | 91.34 | 144.25 | 24.65 |
| חדשות | 606 | 91.27 | 132.52 | 35.39 |
| לבן | 607 | 91.21 | 134.60 | 32.32 |
| נרגע | 608 | 91.10 | 134.64 | 32.48 |
| ספק | 609 | 91.06 | 130.46 | 35.98 |
| מושלם | 610 | 91.00 | 131.33 | 35.73 |
| צהריים | 611 | 90.83 | 131.93 | 34.26 |
| רשימה | 612 | 90.81 | 136.18 | 30.84 |
| גמור | 613 | 90.10 | 130.97 | 34.35 |
| יורק | 614 | 89.98 | 143.43 | 22.62 |
| חשבון | 615 | 89.67 | 131.59 | 32.83 |
| זכות | 616 | 89.63 | 131.24 | 32.80 |
| שר | 617 | 89.61 | 142.37 | 23.82 |
| ארבע | 618 | 89.43 | 130.65 | 32.90 |
| התאים | 619 | 89.32 | 127.22 | 37.08 |
| עלייך | 620 | 89.01 | 131.93 | 33.36 |
| חם | 621 | 88.99 | 129.91 | 33.78 |
| שלומך | 622 | 88.89 | 130.64 | 31.47 |
| עתיד | 623 | 88.67 | 133.23 | 30.80 |
| נפל׳ | 624 | 88.67 | 127.96 | 34.94 |
| ים | 625 | 88.37 | 138.23 | 26.25 |
| הכניס | 626 | 88.15 | 125.56 | 36.44 |
| ברוך | 627 | 88.12 | 128.21 | 34.48 |
| טעם | 628 | 88.11 | 127.69 | 35.23 |
| כיף | 629 | 88.08 | 131.81 | 32.38 |
| נשיא | 630 | 87.94 | 151.43 | 14.64 |
| תא | 631 | 87.63 | 134.30 | 28.82 |
| סביבה | 632 | 87.58 | 126.17 | 35.11 |
| נהנה | 633 | 87.43 | 126.79 | 35.28 |
| חמוד | 634 | 87.17 | 130.86 | 31.34 |
| רצינות | 635 | 87.15 | 126.73 | 34.80 |
| קו | 636 | 87.10 | 130.14 | 30.45 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| קפטן | 637 | 86.96 | 151.94 | 13.83 |
| תחנה | 638 | 86.89 | 132.88 | 28.48 |
| מיליון | 639 | 86.81 | 134.79 | 25.18 |
| תקשיב | 640 | 86.71 | 127.70 | 32.78 |
| זקן | 641 | 86.44 | 130.64 | 29.54 |
| הוביל | 642 | 86.13 | 125.32 | 34.38 |
| מאה | 643 | 86.07 | 126.35 | 32.78 |
| אמצע | 644 | 86.01 | 122.43 | 36.63 |
| זכה | 645 | 85.97 | 128.73 | 30.64 |
| משימה | 646 | 85.96 | 135.30 | 25.95 |
| מותק | 647 | 85.74 | 132.18 | 28.21 |
| סמך | 648 | 85.67 | 125.34 | 34.03 |
| מטוס | 649 | 85.64 | 140.52 | 19.84 |
| מיני | 650 | 85.13 | 125.26 | 33.18 |
| אזור | 651 | 84.85 | 127.80 | 30.21 |
| פנימה | 652 | 84.72 | 123.61 | 33.38 |
| חנות | 653 | 84.66 | 129.09 | 29.17 |
| פעולה | 654 | 84.47 | 124.84 | 31.95 |
| שטח | 655 | 84.33 | 127.03 | 30.38 |
| הרגל | 656 | 84.16 | 123.80 | 32.42 |
| סבל | 657 | 84.15 | 122.28 | 34.08 |
| תשובה | 658 | 83.94 | 121.96 | 34.23 |
| אקח | 659 | 83.74 | 119.79 | 36.29 |
| עשר | 660 | 83.60 | 123.75 | 31.52 |
| תפסיק | 661 | 83.23 | 123.12 | 32.08 |
| הזכיר | 662 | 83.00 | 118.09 | 36.66 |
| נשא | 663 | 82.44 | 121.55 | 31.89 |
| ו | 664 | 82.26 | 118.91 | 34.75 |
| נקרא | 665 | 81.97 | 118.08 | 35.09 |
| אבי | 666 | 81.84 | 130.11 | 24.05 |
| מכר | 667 | 81.76 | 121.68 | 30.41 |
| ראייה | 668 | 81.69 | 126.22 | 26.71 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
| --- | --- | --- | --- | --- |
| צא | 669 | 81.47 | 122.33 | 30.11 |
| לתוך | 670 | 81.32 | 119.92 | 32.30 |
| כה | 671 | 80.81 | 123.13 | 28.65 |
| הצטרך | 672 | 80.76 | 116.10 | 35.18 |
| החליט | 673 | 80.58 | 116.23 | 34.49 |
| ביצע | 674 | 80.51 | 119.32 | 31.49 |
| בניין | 675 | 80.23 | 125.13 | 25.81 |
| מול | 676 | 80.15 | 117.33 | 32.96 |
| קצר | 677 | 80.09 | 115.08 | 34.72 |
| מחשב | 678 | 80.02 | 129.25 | 22.19 |
| נעים | 679 | 79.97 | 117.80 | 31.66 |
| במיוחד | 680 | 79.79 | 114.45 | 34.85 |
| מלון | 681 | 79.58 | 126.80 | 22.70 |
| המון | 682 | 79.28 | 118.28 | 30.50 |
| אדום | 683 | 79.12 | 120.91 | 27.54 |
| שן | 684 | 79.11 | 115.04 | 34.84 |
| מוצא | 685 | 79.07 | 114.63 | 33.66 |
| שייך | 686 | 79.03 | 116.56 | 32.31 |
| הבחורה | 687 | 78.86 | 120.11 | 28.53 |
| בצד | 688 | 78.77 | 114.58 | 33.38 |
| ניסיון | 689 | 78.69 | 114.03 | 33.99 |
| תרופה | 690 | 78.68 | 126.29 | 23.06 |
| חקירה | 691 | 78.67 | 125.22 | 23.21 |
| שש | 692 | 78.40 | 117.74 | 29.51 |
| עשוי | 693 | 78.29 | 117.16 | 30.72 |
| יחידה | 694 | 78.16 | 119.76 | 27.82 |
| החליף | 695 | 78.09 | 113.59 | 33.69 |
| התחלה | 696 | 78.06 | 112.05 | 34.89 |
| גילה | 697 | 78.04 | 113.89 | 33.73 |
| תוך | 698 | 77.98 | 114.03 | 32.61 |
| חתיכה | 699 | 77.94 | 115.55 | 31.43 |
| אתר | 700 | 77.88 | 119.61 | 28.18 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| נוח | 701 | 77.84 | 113.84 | 33.10 |
| חתך | 702 | 77.82 | 115.55 | 31.19 |
| צבע | 703 | 77.62 | 118.29 | 27.79 |
| מצוין | 704 | 77.60 | 117.77 | 28.60 |
| צורך | 705 | 77.23 | 112.41 | 33.55 |
| אדון | 706 | 77.06 | 124.45 | 21.24 |
| שער | 707 | 77.05 | 119.87 | 25.67 |
| יקר | 708 | 76.86 | 112.60 | 32.43 |
| העדיף | 709 | 76.81 | 111.09 | 34.24 |
| ככל | 710 | 76.51 | 111.53 | 33.08 |
| מסוכן | 711 | 76.44 | 113.11 | 32.18 |
| חבל | 712 | 76.30 | 112.44 | 32.11 |
| הגנה | 713 | 76.28 | 116.55 | 27.78 |
| גיל | 714 | 76.25 | 114.61 | 29.36 |
| הצטרף | 715 | 76.01 | 111.71 | 32.55 |
| ישר | 716 | 75.93 | 110.98 | 31.73 |
| שינוי | 717 | 75.90 | 112.46 | 31.56 |
| דובר | 718 | 75.67 | 114.53 | 28.82 |
| אראה | 719 | 75.40 | 109.54 | 33.57 |
| הרס | 720 | 75.36 | 111.16 | 32.84 |
| שותף | 721 | 75.32 | 116.14 | 26.59 |
| תהי | 722 | 75.26 | 111.41 | 32.08 |
| לכי | 723 | 75.24 | 115.25 | 28.04 |
| אדמה | 724 | 75.20 | 117.03 | 26.09 |
| ענה | 725 | 75.03 | 109.98 | 34.03 |
| אחראי | 726 | 74.91 | 111.20 | 31.25 |
| מסר | 727 | 74.90 | 111.96 | 30.16 |
| קורבן | 728 | 74.64 | 123.17 | 19.34 |
| סכנה | 729 | 74.62 | 111.46 | 31.22 |
| פיטר | 730 | 74.59 | 127.62 | 15.62 |
| הרשה | 731 | 74.45 | 108.65 | 32.46 |
| זרק | 732 | 74.31 | 110.00 | 31.34 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| שיעור | 733 | 74.01 | 114.08 | 26.87 |
| הדבר | 734 | 73.95 | 108.74 | 32.46 |
| אידיוט | 735 | 73.79 | 112.21 | 28.01 |
| מפני | 736 | 73.69 | 117.21 | 24.33 |
| שליטה | 737 | 73.32 | 109.77 | 30.16 |
| עונה | 738 | 73.31 | 109.04 | 37.54 |
| אשר | 739 | 73.19 | 116.53 | 22.47 |
| כלשהו | 740 | 73.13 | 109.14 | 30.39 |
| אגיד | 741 | 73.03 | 108.06 | 31.53 |
| סגר | 742 | 73.02 | 107.96 | 31.26 |
| גדל | 743 | 72.99 | 107.92 | 31.21 |
| מבט | 744 | 72.88 | 107.36 | 31.41 |
| צפה | 745 | 72.85 | 107.34 | 32.32 |
| הדה | 746 | 72.78 | 108.86 | 30.15 |
| ספינה | 747 | 72.68 | 127.94 | 12.90 |
| ניתוח | 748 | 72.67 | 121.60 | 18.25 |
| אלף | 749 | 72.59 | 114.09 | 23.65 |
| מהיר | 750 | 72.35 | 107.88 | 30.27 |
| רמה | 751 | 71.34 | 106.85 | 29.49 |
| תוצאה | 752 | 71.10 | 107.69 | 28.30 |
| חכם | 753 | 70.87 | 104.96 | 30.89 |
| פרטי | 754 | 70.60 | 105.91 | 29.14 |
| השתנה | 755 | 70.57 | 105.04 | 30.88 |
| מתנה | 756 | 70.44 | 107.54 | 27.87 |
| ירה | 757 | 70.28 | 109.72 | 24.66 |
| הפריע | 758 | 70.26 | 103.19 | 32.12 |
| טיפול | 759 | 69.74 | 109.18 | 25.11 |
| אמריקני | 760 | 69.72 | 111.85 | 21.48 |
| שקר | 761 | 69.57 | 105.60 | 28.44 |
| נושא | 762 | 69.54 | 104.50 | 28.73 |
| מחלקה | 763 | 69.36 | 108.70 | 24.29 |
| עוזב | 764 | 69.15 | 102.84 | 30.58 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| שמחה | 765 | 69.09 | 103.53 | 30.09 |
| חייל | 766 | 69.01 | 115.20 | 18.08 |
| מייקל | 767 | 68.88 | 122.72 | 11.63 |
| ניהל | 768 | 68.87 | 102.32 | 29.75 |
| חשבתי | 769 | 68.81 | 100.66 | 33.34 |
| עקב | 770 | 68.78 | 103.58 | 29.62 |
| הסתובב | 771 | 68.73 | 101.50 | 30.78 |
| אי | 772 | 68.64 | 116.05 | 16.43 |
| חופשי | 773 | 68.51 | 102.71 | 29.49 |
| כלי | 774 | 68.44 | 105.06 | 27.12 |
| צבא | 775 | 68.39 | 111.92 | 19.90 |
| מועדון | 776 | 68.35 | 110.87 | 20.64 |
| גמר | 777 | 68.18 | 102.83 | 28.32 |
| מחיר | 778 | 68.15 | 103.97 | 27.50 |
| הלוואה | 779 | 67.98 | 101.61 | 30.42 |
| היקח | 780 | 67.92 | 100.47 | 30.99 |
| ביטחון | 781 | 67.77 | 103.94 | 26.92 |
| פעל | 782 | 67.66 | 101.72 | 29.23 |
| הצעה | 783 | 67.25 | 103.81 | 25.85 |
| לקוח | 784 | 67.03 | 107.94 | 21.29 |
| תאונה | 785 | 66.81 | 105.63 | 23.75 |
| מפתח | 786 | 66.76 | 104.54 | 24.69 |
| לישון | 787 | 66.60 | 100.94 | 28.29 |
| הגיוני | 788 | 66.37 | 99.27 | 30.04 |
| מתוך | 789 | 66.15 | 98.82 | 29.47 |
| לחלוטין | 790 | 66.05 | 99.56 | 28.78 |
| אפשרות | 791 | 66.00 | 98.89 | 29.42 |
| ודאי | 792 | 65.35 | 104.29 | 22.65 |
| שחקן | 793 | 65.10 | 105.82 | 19.91 |
| סוכן | 794 | 64.98 | 106.83 | 19.72 |
| תני | 795 | 64.92 | 98.64 | 28.39 |
| רץ | 796 | 64.68 | 98.53 | 26.76 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| ההוא | 797 | 64.63 | 99.43 | 26.66 |
| שלם | 798 | 64.47 | 95.55 | 30.74 |
| שלב | 799 | 64.40 | 98.98 | 26.46 |
| פתוח | 800 | 64.34 | 96.43 | 29.52 |
| חלון | 801 | 64.25 | 98.73 | 26.26 |
| איתה | 802 | 64.06 | 96.34 | 29.75 |
| עמוק | 803 | 63.96 | 96.44 | 28.67 |
| מרכז | 804 | 63.91 | 99.29 | 25.15 |
| שומר | 805 | 63.75 | 97.66 | 27.22 |
| פ | 806 | 63.62 | 97.73 | 26.47 |
| מעמד | 807 | 63.55 | 96.65 | 27.24 |
| שעשה | 808 | 63.39 | 93.56 | 31.16 |
| חשש | 809 | 63.38 | 96.14 | 28.29 |
| ק | 810 | 63.36 | 104.35 | 18.97 |
| חך | 811 | 63.36 | 97.29 | 27.03 |
| הוכיח | 812 | 63.29 | 96.36 | 27.50 |
| ייתכן | 813 | 63.27 | 100.63 | 23.32 |
| שנוכל | 814 | 63.11 | 94.29 | 30.69 |
| טום | 815 | 63.11 | 109.65 | 13.41 |
| אצטרך | 816 | 63.01 | 93.98 | 30.70 |
| תקופה | 817 | 62.79 | 95.31 | 27.61 |
| כבד | 818 | 62.76 | 95.19 | 27.57 |
| מהירות | 819 | 62.71 | 97.15 | 25.25 |
| שכר | 820 | 62.66 | 96.45 | 25.66 |
| שלט | 821 | 62.61 | 95.73 | 27.68 |
| התחתן | 822 | 62.54 | 100.46 | 20.98 |
| לפה | 823 | 62.49 | 99.95 | 22.68 |
| יכל | 824 | 62.42 | 95.77 | 26.56 |
| מסוים | 825 | 62.36 | 94.24 | 28.25 |
| מרחק | 826 | 62.32 | 95.23 | 27.38 |
| מאושר | 827 | 62.25 | 96.31 | 25.40 |
| החלק | 828 | 62.17 | 93.62 | 29.14 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| בעצם | 829 | 62.13 | 95.39 | 26.12 |
| בירה | 830 | 62.08 | 97.97 | 23.84 |
| חייך | 831 | 61.94 | 93.32 | 28.94 |
| בר | 832 | 61.89 | 95.34 | 26.00 |
| עוזר | 833 | 61.81 | 94.92 | 26.86 |
| רגל | 834 | 61.81 | 94.51 | 26.36 |
| בנק | 835 | 61.63 | 102.96 | 16.71 |
| העריך | 836 | 61.47 | 92.03 | 29.18 |
| זיהה | 837 | 61.38 | 93.99 | 27.04 |
| טלוויזיה | 838 | 61.29 | 98.20 | 22.01 |
| כביש | 839 | 61.07 | 97.48 | 22.27 |
| האשים | 840 | 61.05 | 92.69 | 27.93 |
| תגיד | 841 | 60.95 | 91.94 | 28.06 |
| אכן | 842 | 60.95 | 95.50 | 24.46 |
| נצטרך | 843 | 60.92 | 92.24 | 28.75 |
| וב | 844 | 60.90 | 91.07 | 28.64 |
| שמונה | 845 | 60.87 | 93.89 | 25.39 |
| פרנק | 846 | 60.50 | 109.13 | 9.56 |
| פרט | 847 | 60.41 | 91.84 | 27.44 |
| נישואין | 848 | 60.15 | 97.21 | 21.02 |
| שדה | 849 | 60.15 | 95.58 | 22.50 |
| אביך | 850 | 60.11 | 97.35 | 21.35 |
| ם | 851 | 59.99 | 93.39 | 24.98 |
| עצור | 852 | 59.86 | 94.74 | 22.94 |
| נפגע | 853 | 59.79 | 91.83 | 26.62 |
| ידיד | 854 | 59.48 | 93.52 | 23.85 |
| קרב | 855 | 59.34 | 93.78 | 23.48 |
| ר | 856 | 59.26 | 93.64 | 23.03 |
| קלט | 857 | 59.05 | 92.53 | 24.37 |
| תסתכל | 858 | 58.74 | 90.70 | 25.87 |
| מכתב | 859 | 58.74 | 96.48 | 18.09 |
| הפחיד | 860 | 58.59 | 89.45 | 27.30 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| השנה | 861 | 58.57 | 91.50 | 24.12 |
| שכנע | 862 | 58.56 | 89.20 | 27.56 |
| התרחק | 863 | 58.50 | 90.19 | 26.52 |
| רגש | 864 | 58.37 | 91.16 | 25.05 |
| שבר | 865 | 58.34 | 89.28 | 26.86 |
| התקרב | 866 | 58.29 | 88.58 | 27.82 |
| מעניין | 867 | 58.26 | 88.40 | 27.88 |
| גישה | 868 | 58.25 | 90.20 | 25.78 |
| הוגן | 869 | 58.18 | 89.12 | 26.75 |
| ע | 870 | 58.04 | 91.50 | 23.15 |
| הללו | 871 | 57.95 | 95.52 | 18.59 |
| ויתר | 872 | 57.89 | 88.70 | 27.00 |
| קר | 873 | 57.64 | 89.51 | 25.08 |
| שופט | 874 | 57.54 | 95.67 | 17.09 |
| נפטר | 875 | 57.53 | 88.40 | 26.14 |
| צפון | 876 | 57.32 | 91.14 | 22.52 |
| עדיף | 877 | 56.98 | 86.97 | 27.27 |
| אירוע | 878 | 56.84 | 88.79 | 24.27 |
| נו | 879 | 56.81 | 90.12 | 23.19 |
| ברית | 880 | 56.65 | 92.53 | 19.56 |
| הבחר | 881 | 56.59 | 87.17 | 26.13 |
| ארבעה | 882 | 56.59 | 88.03 | 24.34 |
| סמל | 883 | 56.47 | 95.67 | 15.80 |
| רעב | 884 | 56.45 | 88.17 | 24.75 |
| רצון | 885 | 56.30 | 87.76 | 24.67 |
| דן | 886 | 56.16 | 92.91 | 17.72 |
| הכה | 887 | 56.02 | 87.37 | 24.21 |
| אבן | 888 | 56.00 | 92.09 | 18.87 |
| איום | 889 | 55.99 | 87.46 | 24.57 |
| פגש | 890 | 55.98 | 85.17 | 27.06 |
| זבל | 891 | 55.76 | 89.73 | 20.95 |
| הידי | 892 | 55.59 | 85.94 | 25.42 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| הסתיים | 893 | 55.44 | 85.13 | 26.49 |
| הלאה | 894 | 54.99 | 84.86 | 25.81 |
| נקי | 895 | 54.96 | 85.41 | 24.94 |
| לאט | 896 | 54.75 | 87.63 | 21.24 |
| סקס | 897 | 54.70 | 91.36 | 18.36 |
| לאחרונה | 898 | 54.65 | 83.74 | 27.14 |
| אחרת | 899 | 54.42 | 82.17 | 27.83 |
| תראו | 900 | 54.02 | 84.65 | 24.81 |
| זהיר | 901 | 53.98 | 83.93 | 24.78 |
| זין | 902 | 53.87 | 92.29 | 13.97 |
| התגעגע | 903 | 53.71 | 84.83 | 23.49 |
| תקווה | 904 | 53.66 | 83.91 | 24.53 |
| אבטחה | 905 | 53.63 | 88.36 | 19.53 |
| חטף | 906 | 53.59 | 85.14 | 22.70 |
| ראוי | 907 | 53.57 | 83.35 | 24.66 |
| כעס | 908 | 53.49 | 83.58 | 24.77 |
| נחש | 909 | 53.20 | 82.60 | 25.41 |
| תכנן | 910 | 53.10 | 81.84 | 26.12 |
| גיבור | 911 | 53.04 | 86.81 | 19.56 |
| מולד | 912 | 52.99 | 92.44 | 12.60 |
| פרס | 913 | 52.98 | 87.24 | 18.25 |
| מכירה | 914 | 52.92 | 84.74 | 21.50 |
| אנושי | 915 | 52.92 | 86.22 | 20.76 |
| ג | 916 | 52.82 | 87.19 | 18.43 |
| היסטוריה | 917 | 52.70 | 82.86 | 23.11 |
| שהייה | 918 | 52.64 | 80.11 | 27.10 |
| עבורך | 919 | 52.61 | 83.65 | 22.76 |
| מחשבה | 920 | 52.44 | 81.10 | 25.47 |
| סביב | 921 | 52.38 | 81.09 | 24.87 |
| סגן | 922 | 52.38 | 90.44 | 13.73 |
| פנה | 923 | 52.25 | 81.00 | 24.76 |
| התעורר | 924 | 52.09 | 81.45 | 24.47 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| הריח | 925 | 51.90 | 82.25 | 23.34 |
| תיקן | 926 | 51.89 | 81.78 | 24.27 |
| עלי | 927 | 51.89 | 79.63 | 26.53 |
| גבול | 928 | 51.69 | 82.24 | 22.46 |
| רשת | 929 | 51.65 | 83.90 | 20.47 |
| נשבע | 930 | 51.58 | 80.59 | 24.00 |
| אמריקה | 931 | 51.57 | 84.61 | 18.46 |
| יגע | 932 | 51.50 | 80.51 | 23.88 |
| מידה | 933 | 51.47 | 79.88 | 24.56 |
| זהב | 934 | 51.31 | 85.44 | 16.89 |
| כיצד | 935 | 51.25 | 84.64 | 18.36 |
| מישהי | 936 | 50.95 | 80.92 | 23.39 |
| נדבר | 937 | 50.92 | 78.53 | 25.59 |
| כניסה | 938 | 50.92 | 79.45 | 24.31 |
| מקור | 939 | 50.89 | 81.02 | 22.32 |
| מעשה | 940 | 50.82 | 79.71 | 23.77 |
| ממשלה | 941 | 50.65 | 85.59 | 15.44 |
| היטב | 942 | 50.62 | 79.21 | 24.03 |
| תיכון | 943 | 50.55 | 82.49 | 19.67 |
| מנה | 944 | 50.35 | 80.37 | 21.61 |
| ביקר | 945 | 50.30 | 78.52 | 24.09 |
| אורח | 946 | 50.22 | 79.08 | 23.23 |
| עשרה | 947 | 50.13 | 80.04 | 21.13 |
| נהרג | 948 | 50.07 | 80.13 | 21.97 |
| חתונה | 949 | 50.05 | 87.07 | 13.22 |
| הדע | 950 | 50.04 | 77.32 | 25.60 |
| ריק | 951 | 49.99 | 81.76 | 19.51 |
| דרש | 952 | 49.93 | 77.86 | 24.63 |
| בפני | 953 | 49.85 | 77.94 | 24.13 |
| מורה | 954 | 49.68 | 82.34 | 17.99 |
| הפה | 955 | 49.65 | 78.57 | 22.46 |
| צחק | 956 | 49.62 | 78.02 | 23.73 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---|---|---|---|---|
| מוכר | 957 | 49.55 | 77.12 | 24.50 |
| שטות | 958 | 49.51 | 77.72 | 22.46 |
| תלוי | 959 | 49.42 | 76.01 | 25.74 |
| החבב | 960 | 49.34 | 79.58 | 21.04 |
| הושלם | 961 | 49.30 | 77.06 | 24.45 |
| קבע | 962 | 49.27 | 76.58 | 24.47 |
| רואה | 963 | 49.26 | 77.06 | 25.19 |
| משום | 964 | 49.22 | 80.34 | 19.58 |
| גן | 965 | 49.17 | 79.64 | 20.27 |
| טיסה | 966 | 49.15 | 82.21 | 16.75 |
| אלייך | 967 | 49.12 | 78.14 | 22.92 |
| עשי | 968 | 49.09 | 76.60 | 25.30 |
| מקומי | 969 | 49.06 | 77.49 | 22.83 |
| הפסיד | 970 | 49.04 | 77.96 | 21.72 |
| סגור | 971 | 48.94 | 76.32 | 24.22 |
| חן | 972 | 48.87 | 78.86 | 20.31 |
| שלישי | 973 | 48.69 | 76.90 | 22.26 |
| חירום | 974 | 48.62 | 79.14 | 20.56 |
| גאה | 975 | 48.61 | 76.32 | 23.42 |
| התחה | 976 | 48.60 | 77.55 | 21.27 |
| תנועה | 977 | 48.58 | 77.32 | 21.60 |
| לשעבר | 978 | 48.58 | 77.90 | 21.29 |
| טען | 979 | 48.56 | 77.16 | 22.17 |
| פול | 980 | 48.55 | 85.39 | 11.51 |
| ארון | 981 | 48.47 | 79.30 | 19.75 |
| אגב | 982 | 48.35 | 75.36 | 24.81 |
| נערה | 983 | 48.20 | 79.83 | 17.85 |
| נער | 984 | 48.18 | 78.44 | 19.49 |
| העמיד | 985 | 48.15 | 75.05 | 24.81 |
| בעצמך | 986 | 48.03 | 73.90 | 25.94 |
| השקר | 987 | 48.01 | 76.21 | 22.81 |
| חש | 988 | 48.00 | 76.70 | 22.06 |

| LEMMA | RANK | DISPERSION | FREQUENCY | RANGE |
|---:|---:|---:|---:|---:|
| עצמך | 989 | 47.97 | 73.87 | 25.64 |
| הסתדר | 990 | 47.91 | 74.51 | 24.68 |
| תת | 991 | 47.89 | 75.21 | 23.70 |
| תחושה | 992 | 47.89 | 75.66 | 22.99 |
| תקף | 993 | 47.83 | 77.29 | 21.56 |
| סאם | 994 | 47.76 | 88.78 | 6.89 |
| עשית | 995 | 47.68 | 73.74 | 25.56 |
| בסיס | 996 | 47.66 | 78.21 | 18.75 |
| ראשי | 997 | 47.65 | 75.85 | 21.65 |
| דיווח | 998 | 47.60 | 76.23 | 21.61 |
| המשך | 999 | 47.54 | 74.32 | 24.05 |
| בוודאי | 1000 | 47.54 | 77.55 | 19.42 |

# Appendix B: Scripts

## APPENDIX B.1: CREATE-FREQ-LIST.PY

```python
#! /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/parsed/he'

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

total_tokens_int = 0
total_files_int = 0
table_list = []
```

```python
29  row = tuple()

30

31  # Set size of final list
32  list_size_int = 5000

33

34

35  ##############################################################
36  # ------------------ DEFINE FUNCTIONS ------------------ #
37  ##############################################################

38

39

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

45

46

47  # Search for lemmas and add counts to "lemma_by_file_dict{}".
48  def find_and_count(doc):
49      file = str(f)[40:-3]
50      match_pattern = re.findall(r'lemma="[א-ת]+"', doc)
51      for word in match_pattern:
52          if word[7:-1] in lemma_by_file_dict:
53              count = lemma_by_file_dict[word[7:-1]].get(file, 0)
54              lemma_by_file_dict[word[7:-1]][file] = count + 1
55          else:
56              lemma_by_file_dict[word[7:-1]] = {}
57              lemma_by_file_dict[word[7:-1]][file] = 1

58

59

60  ##############################################################
61  # -------------------- OPEN AND READ -------------------- #
```

94

```
62    ############################################################

63

64    # Open and read all files. If only for a specific language, comment
65    # out this code and uncomment the large block that follows.
66    #
67    for dirName, subdirList, fileList in os.walk(corpus_path):
68        if len(fileList) > 0:
69            total_files_int = total_files_int + 1
70            f = dirName + '/' + fileList[0]
71            find_and_count(open_and_read(f))

72

73    ############################################################
74    # ---------------- LANGUAGE-SPECIFIC BLOCK ----------------
75    #
76    # This large block of code is for creating a list using only #
77    # movies with a specific primary language (in this case, Hebrew). #
78    # Be sure to uncomment the relevant lines of code, and to comment #
79    # out the block above. #
80    #
81    #
82    # Create list of IDs for movies with Hebrew as primary language. #
83    # This uses a text file that must already exist with this list. #
84    #
85    # Hebrew_IDs_list = []
86    # with open('./Hebrew_originals.txt', 'r', encoding='utf-8') as f:
87    #     read_data = f.read()
88    #     Hebrew_IDs_list = re.findall(r'\s\stt[0-9]+\t', read_data)
89    # Hebrew_IDs_list = [line[4:-1] for line in Hebrew_IDs_list]
90    #
91    #
92    # Delete extra 0s at the beginning of Hebrew movie IDs. #
93    #
94    # for item in Hebrew_IDs_list:
```

```
95    #       if item[0] == 'O':
96    #           Hebrew_IDs_list[Hebrew_IDs_list.index(item)] = item[1:]
97    # for item in Hebrew_IDs_list:
98    #       if item[0] == 'O':
99    #           Hebrew_IDs_list[Hebrew_IDs_list.index(item)] = item[1:]
100   #
101   #
102   # Open and read movies files with Hebrew as the primary language. #
103   #
104   # for dirName, subdirList, fileList in os.walk(corpus_path):
105   #       if len(fileList) > 0:
106   #           f = dirName + '/' + fileList[0]
107   #           folders = re.split('/', dirName)
108   #           if folders[len(folders)-1] in Hebrew_IDs_list:
109   #               find_and_count(open_and_read(f))
110   #
111   # ------------- END OF LANGUAGE-SPECIFIC BLOCK -------------
112   ###########################################################
113
114
115   ###########################################################
116   # -------------------- CALCULATIONS -------------------- #
117   ###########################################################
118
119   # Calculate total raw frequencies per lemma
120   for lemma in lemma_by_file_dict:
121       lemma_totals_dict[lemma] = \
122           sum(lemma_by_file_dict[lemma].values())
123
124   # Calculate token count per file
125   for lemma in lemma_by_file_dict:
126       for file in lemma_by_file_dict[lemma]:
127           token_count_dict[file] = token_count_dict.get(
```

```python
128              file, 0) + lemma_by_file_dict[lemma][file]

129

130  # Calculate total token count
131  for file in token_count_dict:
132      total_tokens_int = \
133          total_tokens_int + token_count_dict.get(file, 0)

134

135  # Set value for normalized frequency (freq per x words)
136  freq_per_int = 1000000

137

138  # Calculate normalized frequencies per lemma
139  for lemma in lemma_totals_dict:
140      lemma_norm_dict[lemma] = \
141          lemma_totals_dict[lemma] / total_tokens_int * freq_per_int

142

143  # Calculate DPs
144  for lemma in lemma_by_file_dict.keys():
145      for file in lemma_by_file_dict[lemma].keys():
146          lemma_DPs_dict[lemma] = lemma_DPs_dict[lemma] + abs(
147              (token_count_dict[file] /
148               total_tokens_int) -
149              (lemma_by_file_dict[lemma][file] /
150               lemma_totals_dict[lemma]))
151  lemma_DPs_dict = {lemma: DP/2 for (lemma, DP) in
152                   lemma_DPs_dict.items()}

153

154  # Calculate UDPs
155  lemma_UDPs_dict = {lemma: (1-DP)*lemma_norm_dict[lemma] for
156                   (lemma, DP) in lemma_DPs_dict.items()}

157

158

159  ############################################################
160  # -------------- SORT LIST AND CREATE TABLE -------------- #
```

```python
161  ############################################################
162
163  # Sort entries by UDP
164  UDP_sorted_list = [(k, lemma_UDPs_dict[k]) for k in sorted(
165      lemma_UDPs_dict, key=lemma_UDPs_dict.__getitem__,
166      reverse=True)]
167
168  # Create list of tuples with all values:
169  # (Lemma, Rank, UDP, Frequency, Range)
170  i = 0
171  for k, v in UDP_sorted_list[:list_size_int]:
172      i = i + 1
173      row = (k,
174             i,
175             '{0:,.2f}'.format(v),
176             '{0:,.2f}'.format(lemma_norm_dict[k]),
177             '{0:,.2f}'.format(sum(1 for count in
178                                   lemma_by_file_dict[k].values() if
179                                   count > 0) /
180                               total_files_int * 100))
181      table_list.append(row)
182
183  ############################################################
184  # ---------------- SORT-BY-FREQUENCY BLOCK -----------------
185  #
186  # Sort entries by raw frequency (total lemma count). To sort the #
187  # final list by frequency instead of dispersion, comment out the #
188  # above code within the "SORT LIST AND CREATE TABLE" section, and #
189  # also uncomment the relevant lines of code in this block. #
190  #
191  #
192  # Sort entries by raw frequency #
193  #
```

```
194  # frequency_sorted_list = [(k, lemma_totals_dict[k]) for k in
195  #                          sorted(lemma_totals_dict,
196  #                          key=lemma_totals_dict.__getitem__,
197  #                          reverse=True)]
198  #
199  #
200  # Create list of tuples with all values #
201  #
202  # for k, v in frequency_sorted_list[:list_size_int]:
203  #     table_list.append((k, v, sum(
204  #         1 for count in lemma_by_file_dict[k].values() if
205  #         count > 0), lemma_UDPs_dict[k]))
206  #
207  # ------------- END OF SORT-BY-FREQUENCY BLOCK -------------
208  ############################################################
209
210  # Calculate list size for 80% coverage and set that as the list
211  # size. Note that if the initial list_size_int (set near the
212  # beginning of the script) provides less than the desired coverage,
213  # it will default to that instead.
214  #
215  # added_freq_int = 0
216  # count = 0
217  # for k, v in UDP_sorted_list:
218  #     if added_freq_int / total_tokens_int < 0.8:
219  #         added_freq_int = added_freq_int + lemma_totals_dict[k]
220  #         count = count + 1
221  #     else:
222  #         break
223  # list_size_int = count
224
225  # Write final tallies to TSV file
226  result = open('./export/frequency-dictionary.tsv', 'w')
```

```python
227  result.write('LEMMA\tRANK\tDISPERSION\tFREQUENCY\tRANGE\n')
228  for i in range(list_size_int):
229      result.write(str(table_list[i][0]) + '\t' +
230                   str(table_list[i][1]) + '\t' +
231                   str(table_list[i][2]) + '\t' +
232                   str(table_list[i][3]) + '\t' +
233                   str(table_list[i][4]) + '\n')
234  result.close()
235
236  # Print final tallies. Uncomment this code to see the results
237  # printed instead of writing them to a file.
238  #
239  # print('LEMMA\tRANK\tDISPERSION\tFREQUENCY\tRANGE\n')
240  # for i in range(list_size_int):
241  #     print(str(table_list[i][0]) + '\t' +
242  #               str(table_list[i][1]) + '\t' +
243  #               str(table_list[i][2]) + '\t' +
244  #               str(table_list[i][3]) + '\t' +
245  #               str(table_list[i][4]) + '\n')
```

## Appendix B.2: 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 B.3: OMDb-fetch.py

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

from sys import argv
import os
import glob
import omdb

script, year = argv

# Initialize IDs list
IDs = []

# Create list of all movie directory paths for desired year
for name in glob.glob(
        './OpenSubtitles2018_parsed_single/parsed/he/' +
        year + '/*/'):
    IDs.append(name)

# Trim list of directories to only the movie IDs
IDs = [os.path.basename(os.path.dirname(str(i))) for i in IDs]

# Add additional zeros to beginning of IDs to match with database
for i in IDs:
    while len(i) < 7:
        IDs[IDs.index(i)] = '0' + i
        i = '0' + i

# Sort IDs numerically (easier to use results)
IDs.sort()

```

```python
32    # Replace the API key here (906517b3) with your own (omdbapi.com)
33    omdb.set_default('apikey', '906517b3')
34
35    # Print table header
36    print('# ' + year + '\n' +
37          'IMDb ID\tTitle\tYear\tLanguage(s)')
38
39    # Fetch and print movie ID, title, year, and language(s)
40    for i in IDs:
41        doc = omdb.imdbid('tt' + i)
42        print('tt' + i + '\t' +
43              doc['title'] + '\t' +
44              doc['year'] + '\t' +
45              doc['language'])
```

APPENDIX B.4: LIST_COMPARISON.PY

```python
1  #! /usr/bin/env python3
2  # -*- coding: utf-8 -*-
3
4  import re
5
6  lemmas_original_list = []
7  lemmas_all_list = []
8  shared_list = []
9
10 # Import all lemmas in original-language list
11 with open('./export/frequency-dictionary-original-only.tsv', 'r',
12          encoding='utf-8') as f:
13     read_data = f.read()
14     lemmas_original_list = re.findall(r'[א-ת]+', read_data)
15
16 # Import all lemmas in list from all subtitles
17 with open('./export/frequency-dictionary.tsv', 'r',
18          encoding='utf-8') as f:
19     read_data = f.read()
20     lemmas_all_list = re.findall(r'[א-ת]+', read_data)
21
22 # Find shared lemmas
23 for item in lemmas_original_list:
24     if item in lemmas_all_list:
25         shared_list.append(item)
26
27 # Print shared lemmas and total count
28 for item in shared_list:
29     print(item)
30 print('Total shared: ' + str(len(shared_list)))
```

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# Vita

Juan Daniel Pinto was born in Cali, Colombia. He moved to New Jersey at the age of eight, where he attended West Windsor-Plainsboro High School North. After volunteering for his church in Las Vegas, Nevada for two years, he attended Brigham Young University, where he received a BA in Ancient Near Eastern Studies in 2016, with minors in Linguistics and Modern Hebrew. Along with his wife and son, he moved to Austin, Texas that same year to attend graduate school. He and his family—which now also includes a daughter—will be living in Israel during the 2018–2019 school year. While there, Juan will work as a J. William Fulbright cultural ambassador and English teaching assistant.

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