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**Word Relations: Analysis of Antonymic Relations
in English Adjective Clusters**

**Odnosi među riječima: Analiza antonimijskih odnosa na
primjeru skupova pridjeva u engleskom jeziku**

Završni magistarski rad

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Abstract

This thesis evaluates the "dumbbell model" used for the representation of adjectival antonyms in the Open English WordNet 2021 (OEWN2021) within the framework of the most recent linguistic evidence. It also discusses the extent to which OEWN2021, a lexical resource, includes contextual information and the extent to which it can be improved with the findings which clearly indicate that antonymy is not a lexical, but a conceptual relation. Most studies have looked at the Princeton WordNet and judged its dumbbell model as an inadequate organization of antonyms. This thesis, therefore, looks at the most recent version of OEWN2021 which is based on Princeton WordNet but significantly improved. The analysis of the selected antonym pairs suggests that OEWN2021 is not exclusively lexical and that adjectives can have different direct antonyms depending on their senses and the nouns they modify. Furthermore, the analysis also indicates that the current dumbbell model has the potential to be improved by including the intensity scales, relating adjectives to the nouns they modify and reviewing the glosses of the entries. While Open English WordNet is not completely devoid of contextual information, the extent to which context is included can undoubtedly be improved. The thesis, therefore, proposes ways of doing this.

Key words: lexical semantics, mental lexicon, antonyms, word relations, WordNet

Sažetak

U ovom magistarskom radu evaluiran je „model bučice“ koji se koristi za predstavljanje pridjevskih antonima u Open English WordNet-u 2021 (OEWN2021) u okviru savremenih istraživanja u lingvistici. Također, u radu se analizira u kojoj mjeri leksički resurs OEWN2021 uključuje kontekstualne informacije i u kojoj mjeri se može poboljšati sa zaključcima najnovijih istraživanja koji jasno ukazuju da antonimija nije leksički, već konceptualni odnos. Većina studija je analizirala Princeton WordNet i ocijenila njegov „model bučice“ kao neadekvatan za organizaciju antonima. Ovaj završni magistarski rad se, s tim u vezi, bavi najnovijom verzijom resursa OEWN2021 koja je bazirana na Princeton WordNetu ali koja je značajno poboljšana. Analiza odabranih antonimijskih parova pokazuje da OEWN2021 nije isključivo leksički resurs i da pridjevi mogu imati različite direktne antonime u zavisnosti od njihovog značenja i imenica koje opisuju. Također, analiza pokazuje i da trenutni „model bučice“ može biti unaprijeđen tako što bi se uključile skale intenziteta, pridjevi povezali s imenicama koje opisuju i pregledale i izmijenile definicije natuknica. Iako Open English WordNet nije u potpunosti lišen kontekstualnih informacija, njihovo pristustvo bi nesumnjivo moglo biti znatno poboljšano. Ovaj magistarski rad predlaže i načine kako da se to uradi.

Ključne riječi: leksička semantika, mentalni leksikon, antonimi, odnosi među riječima, WordNet

Contents

1. Introduction

Many linguists have had trouble describing antonyms. Researching lexical semantics and word relations is in no way a straightforward task, but antonyms have been torn between lexical and conceptual frameworks. To advocate a categorically lexical approach is to disregard the possibility of a word having different antonyms in different contexts.

Using phrases such as "word relations" or "lexical relations" is also problematic in the sense that we cannot easily distinguish words from the concepts they represent. Psycholinguistic experiments will rely on words to elicit data but the words will inevitably evoke concepts. The question is then whether the relations we are researching are *lexical* or *conceptual*. This is the reason we have two main theoretical frameworks.

Therefore, the aim of the present thesis is to compare the lexical and conceptual approaches with a special focus on adjectival antonyms. The comparison will be carried out analyzing antonymy in Open English WordNet, a database of lexical relations, a thesaurus and a sense inventory.

Open English WordNet is derived from Princeton WordNet, the "mother of all WordNets" (Fellbaum, 1998b). Even though it has been conceived on the grounds of psycholinguistic research, the recent studies in psycholinguistics have improved our understanding of word relations. However, WordNet has not changed its structure. It has been characterized as an example of a categorical-lexical approach (Jones et al., 2012) but Fellbaum (1998b) calls its relations "conceptual-semantic and lexical relations". Here, it is important to explain the term "conceptual". The basic units in WordNet are indeed concepts and the relations between them are conceptual, but saying that antonymy is a conceptual relation means that choosing an antonym for an adjective is highly dependent on the context and the noun this adjective modifies.

Adjectives are highly polysemous and their semantics is "difficult to capture in an enumerative lexicon like WordNet, which attempts to capture and distinguish all the senses of a polysemous word form." (Fellbaum, 1998b) With adjectives being highly polysemous, it can be expected of them to have different antonyms in different contexts. Thus, the main research question (RQ1) is whether the current dumbbell model is an appropriate representation of adjectival antonymy and if not, how to represent and account for antonymy, a conceptual relation, in WordNet, a lexical resource. The second research question (RQ2) is whether and to what extent does WordNet include context information,

and is there any way WordNet could be improved to be more conceptual and include information on collocates (RQ3).

The thesis provides a descriptive study of WordNet from a linguistic perspective but in this case with its applications and current initiatives in mind. Despite the recent trends in natural language processing, WordNet is the most widely used language resource, especially for word sense *disambiguation*. Even though its purpose was to be a model of the mental lexicon, it has become much more than that and applied in areas not envisioned in its genesis. Because of that, many researchers were looking for ways to improve it or adapt it to their own applications and suggesting improvements is now easier than ever with the open-source methodology adopted by the Open English WordNet project.

This master's thesis is structured as follows: Chapter 2 offers an overview of theoretical frameworks in lexical semantics in general, with a special attention to antonymy. The discussion regarding antonymy is presented in four heavily intertwined questions and proposed answers to these questions in previous research. After that, the findings of the most recent multi-method research on antonymy are presented. The thesis moves on to present the most important models of the mental lexicon which guided the design of WordNet. WordNet was based on psycholinguistic research on semantic memory which is also covered as much as the scope of the thesis allows and as much as it is sufficient to understand the current trends and issues in the fields. What follows is a closer look at Open English WordNet, derived from Princeton WordNet. More specifically, its structure, limits, extensions and use are discussed in order to better understand this resource and its significance.

Analysis of antonymic adjectival clusters in Open English WordNet will be conducted through the lense of the most recent research on antonymy carried out by Kotzor (2021). The research is cross-linguistic and multi-method and it tackles all the questions there are around antonyms in a comprehensive way.

The topics of word relations, mental lexicon, and lexical resources are complex and heavily intertwined. Lexical relations in general are hard to define. After all, what is a lexical item or a word? This discussion calls for an intradisciplinary and interdisciplinary approach. Because of that, certain topics will have to be anticipated and treated more extensively in the sections to follow. In order to avoid repetition, the thesis will also include hyperlinks to certain subheadings and references.

2. Theoretical Frameworks

The discussion of antonyms often boils down to logic and whether the relation is that of "incompatibility", "contrast", "oppositeness", etc. In the thesis I will not deal much with philosophy, logic or reasoning, nor will I focus on different types of antonymy. Instead, in this section, I will present the theoretical frameworks within which linguists have studied and described antonymy. Murphy (2003) notes that researchers in general started focusing more on how lexical relations affect lexical organization and less on their logical properties.

Structuralist frameworks see relations between words as stable and the lexicon is organized around lexico-semantic relations. The relations can be either paradigmatic or syntagmatic. The units of language derive their meanings from their relationships with other words. Paradigmatic relations between words involve potential substitution of one word for the other, they are of the same grammatical category and may share some semantic characteristics. Syntagmatic relations are relations between words which collocate and co-occur. However, antonymy tests this dichotomy since, as we will see, it is both a paradigmatic and syntagmatic relation (§2. 2. 3.).

One branch of structural semantics is *associative semantics* which places focus on word associations which are the result of either similarity or co-occurrence, and can be semantically, syntactically, or morphologically based. In the syntagmatic or distributional approach, on the other hand, a word's meaning is its usage in different contexts.

Cognitive framework, on the other hand, sees meaning as encyclopedic-like and not dictionary-like. A symbolic unit is a form-meaning pairing and there is a direct link between the word forms and concepts. The cognitive framework does not differentiate between lexical and conceptual relations. However, what cognitive linguists do not agree on is whether semantic structure and cognitive structure can be differentiated (Evans, 2019).

As for WordNet (§2. 4.), it is grounded in structural semantics and based on relational analysis. The initial guiding principle and the hypothesis its creators sought to test was that it was possible to infer the meaning of a word based on its relations to other words. However, as the WordNet project showed and as it was acknowledged, it is not enough to just link words and conclude their meaning based on relations between them. They needed to add definitions too.

Furthermore, syntagmatic relations are given more attention in distributional semantics. Importance is given to words that frequently co-occur and we will see that antonyms

frequently come in pairs (§2. 2. 3.). Their co-occurrence and syntagmatic nature poses some challenges for natural language processing, which will be discussed in 2. 4. 2.

When talking about WordNet as grounded in structural semantics, it is necessary to mention FrameNet, grounded in conceptual semantics. While WordNet takes a single word and explores its meanings and relations, FrameNet takes frames or cognitive schemas and explores all of the linguistic units which can evoke that frame (Fillmore, 2009). Each frame is characterized by a set of linguistic units which can have frame-specific meanings and roles. FrameNet is based on corpus evidence, unlike WordNet, which was based on intuition and other thesauri. Grounded in different frameworks and approaching meaning from different perspectives, these two resources are different but complementary.

Geeraerts (2010) gives *senses* much more credit, claiming that relations do not constitute our knowledge of semantics but it is the other way round. Knowing the semantics of words, we are able to conceive relations. However, we are sometimes able to compare, discern or learn the meanings of words based on their relations, by contrasting them or looking up how they relate to other words. In order to better understand the contrast, language learners are often taught words in pairs, as is the case with antonyms.

2. 1. Antonymy

Antonymy seems to be the most researched lexical relation (Geeraerts, 2010). The main reason why antonymy grabbed the attention of researchers and why antonymy was used for the organization of adjectives in WordNet (§2. 4. 1.) are *word association tests* or *lexical naming tasks*. When given familiar adjectives, the most common associations participants had were the antonyms of the given adjectives. These associations go both ways and are most probably the result of their co-occurrences (Deese 1964, 1965; Charles & Miller 1989; Justeson & Katz 1991, 1992). According to Jones (2002), many antonym pairs seem to be entrenched in the mental lexicon.

Semantic behavior of adjectives is rather peculiar and analyzing them as a part of lexical semantics analysis is not a trivial task. This is mainly caused by their sense change (Mendes, 2006) depending on the context and is especially present in antonymy relations. Antonyms are especially problematic and difficult to define or classify. The issues regarding antonyms can be summarized into four intertwining questions that I discuss below.

2. 1. 1. Antonymy—lexical or conceptual?

While there is debate over whether two words are absolute or near-synonyms and whether or how much they differ, antonymy is not disputed in that sense. Everyone agrees that there is some kind of contrast or oppositeness. These contrasts may be on a scale and some examples may be better than others but the oppositeness is indisputable. The question which remains, however, is whether antonymy is a relation between word forms or concepts. This question is not present when we discuss synonymy, since synonyms represent a single concept and hence synonymy can only be lexical (Murphy, 2003). However, in antonymy, the distinction between lexical and conceptual still has not been resolved, and as we will see below, it is difficult to draw the line between words and concepts in the first place (§2. 3.).

The reason why some advocate that antonymy as well is lexical is because some examples of antonymy seem to be better than other pairs. This would then mean that antonymy is a relation between two word forms, not just the concepts they stand for, since the synonyms of the two members of an antonym pair, do not seem to be good examples of antonymy. This question is strongly linked to the question whether there is antonymy canon discussed in the next section (§2. 2. 2.).

There are two proposals that can be put forward: (1) antonymy is only lexical, between conventionalized pairings, while opposite concepts are just opposites or (2) there are conventionalized canonical antonyms and non-canonical antonyms. Murphy (2003), for example, suggests we use "opposite" for the semantic relation of incompatibility and "antonym" to refer to the conventionalized pairings of two particular words with opposite meanings.

Jones et al. (2012) present two approaches to antonymy - the lexical-categorical and conceptual approach. The latter is also called the cognitive-prototype approach whereby any two words can be antonyms in a certain context and their opposition is realized through a construal. Antonymy is then judged by how well it resembles the *antonymy prototype* such as *alive—dead*. As an example of the lexical-categorical approach, they give WordNet. They sum it up by saying that antonymy is treated as a relation between words and that word relations are seen as stable properties of words. They call the approach categorical because "an adjective either has a direct antonym or it does not" (p. 44).

Creators of the WordNet have made it clear that lexical and conceptual structures are distinct. The argument is that certain concepts are not lexicalized in some languages. Even

though the lemmas are mapped onto concepts, their approach is not conceptual since it does not allow any two concepts to be in an antonymous relation. That is why they differentiate between *direct* and *indirect antonyms*. However, more on WordNet's treatment of antonymy will be presented in 2. 4. 1.

Justeson and Katz (1991) are also proponents of the lexical approach. According to them, antonymy is not simply semantic, since synonyms can have different antonyms. As an example, they give *big—little* and *large—small* as good examples of antonymy and point out that *large—little* is not a good example.

However, Jones et al. (2012), criticize previous studies on antonymy and mention a couple of confounding factors. Special attention is given to critically examining the word naming tasks mentioned earlier. Words were presented in isolation to exclude the confounding factors but that itself was a confounding factor since antonymy depends on the context. As an example, they give "black'" and "white" and emphasize that the antonym of "white" would be "red" if we talked about wines. They also criticize the subjectivity of the study designs and already preconceived notions of *antonym canonicity*. Nevertheless, they acknowledge the lack of study equipment back in the day and propose reexamining these studies with the methods available today.

2. 1. 2. Antonymy—canonical or canonless?

Canonical pairs are those pairs which have been conventionalized and we see them as better examples of antonymy than their synonyms. When talking about canonical pairs, Jones et al. (2012, p. 17) also add that canonical pairs are the pairs acquired "by competent members of the language community". This is crucial since canonicity makes sense only if we consider the judgments of the competent language users of a certain language. Those members who have not reached considerable competence may contrast antonyms in a non-canonical fashion if they had not been taught the "right" pair.

Canonical antonyms are expected to be entrenched in the mind and to co-occur frequently. Their frequency of co-occurrence is what some cite as the cause of their canonicity. Others say that it is their collocational and contextual constraints. Pastena and Lenci (2016) ascribe canonicity to the canonical pair describing the same things and being used in the same contexts. For Van de Weijer et al. (2012, p. 255) canonicity is conceptual in nature, "caused by the strength and the salience of the relation of opposition rather than the frequency of the lexical pairings." Justeson and Katz (1991) seem to take the middle

ground. For them, antonyms are the often semantically opposed words which co-occur and can be substituted for one another in identical or parallel phrases.

Word naming tasks also contributed to the notion of canonicity. Participants in studies carried out by Herrmann et al. (1979, Gross et al. (1989) and Charles et al. (1994) identified some pairs of antonyms faster than other pairs. Also, Becker (1980) showed that direct antonyms prime one another more strongly than indirect antonyms.

Another question arises when it comes to canonicity—whether it is gradable or non-gradable. Jones et al. (2012) and Justeson and Katz (1991) believe that canonicity has a scale, while WordNet has been designed in the way to clearly distinguish between direct and indirect antonyms. More about direct and indirect antonyms can be found in 2. 4. 1. We might be tempted to say that the dichotomy of the terms direct and indirect is the same as the one between the terms canonical and non-canonical, but for Jones et al. (2012) "canonical" does not imply the fixedness that the term "direct" implies. For them canonicity is scalar. Nevertheless, they acknowledge the English antonym canon, even though they allow any two words to be antonyms in an appropriate context.

2. 1. 3. Antonymy—paradigmatic or syntagmatic?

Justeson and Katz (1991), using a 25 million word corpus, showed that antonyms co-occur more often than they would by chance. Jones (2002) used a larger corpus and arrived at the same conclusion. The replicability of the study showed that antonymy is both a syntagmatic and a paradigmatic relation. The fact that antonymy can occur between different parts of speech blurs the line between syntagmatic and paradigmatic even more.

What nouns they can modify, in which context they can appear and whether the antonym pair depends on the context also makes antonymy syntagmatic in the collocational sense. Their syntagmatic nature poses challenges to natural language processing and word sense disambiguation, which will be discussed in §2. 4. 2.

2. 1. 4. Antonymy—semantic or pragmatic?

Another question which is being raised is whether antonymy is a pragmatic relation too. The reason for advocating the pragmatic/contextual approach is that sometimes non-semantic factors affect semantic relations. Jones et al. (2012) note that this depends on which property of a word needs to be contrasted in a particular context. Murphy (2003) acknowledges that the most basic requirement for two words to be antonyms is *semantic relatedness* and hence, does not call them 'pragmatic relations' but 'semantic relations'

which are nevertheless dependent on the context. The cognitive-contextual argument is "supported by the observation that one lexical concept may enter into different relations of contrast depending on a particular construal in a given text" (Geeraerts, 2010, p. 88).

As Jones et al. (2012) noted, presenting words in isolation in lexical naming tasks was itself a confounding factor. Murphy and Andrew (1993) carried out two lexical naming tasks with different conditions—with no context provided and with the adjective modifying a noun. The subjects did not give the same responses in those two conditions which indicates that antonymy is context-dependent or, in other words, pragmatic. For them, these results support the conceptual basis of antonymy and cannot be accounted for by lexical associations.

It is true, however, that we can contrast the pairs that are not as entrenched in our mental lexicons as the canonical pairs. These non-systematic antonyms can be contrasted in specific contexts, both textual and situational. But the question is: should we then call them antonyms, indirect antonyms, non-canonical antonyms or simply opposites?

Murphy (2003) believes that antonym relations are pragmatic and in the pragmatic approach, any two words could be opposites in an appropriate context. The contrast between them is realized by minimal difference. There is always some degree of similarity in an opposition. "Hot" and "cold" are antonyms because they are also similar. But how much similarity and how much opposition should there be for two words to be considered antonyms? Relation by contrast proposed by Murphy (2003) specifies only that one relevant property of the words is contrasted which is therefore dubbed "minimal difference".

The question arising from this discussion is then whether the adjective has as many senses as it has antonyms or contextual opposites. For some, this approach results in sense distinctions which are too fine-grained and for certain applications of WordNet, for instance, it is a drawback to have senses which are too fine-grained. Murphy (2003) also argues against this, saying that "sweet" has only one sense, whether it is contrasted with "sour" or "bitter".

It is certainly possible to contrast almost anything in an appropriate context but we would not think of all those possibilities if we were asked to name antonyms of some stimuli. Are then those concepts simply not antonyms or do we need to redefine antonymy?

2. 1. 5. The most recent research (Kotzor, 2021)

Since it has been some time since the research on antonymy has been performed, in this section, we will pay special attention to the most recent research conducted by Kotzor (2021). The author takes a cognitive and psycholinguistic approach which in turn allows for the integration of conceptual and lexical factors which affect the different properties of antonymic relations. The research is cross-linguistic, exploring the antonymic pairs in English and German, and it consists of more than one method which allows for the evaluation of the methods themselves. Unlike in this thesis, Kotzor (2021) examines all parts of speech. The definition of antonymy Kotzor adopts is "a concept which subsumes all phenomena of lexical opposition which are perceived as such by the average native speaker of a language" (2021, p. 10)

The first method used was corpus analysis, the aim of which was to explore the lexical-associative strength of an antonym pair by analyzing how often the pair is used together. The second method was a judgment task in which participants judged antonymic strength, while the third method was a decision task in which participants had to decide whether a pair is antonymic or not but with their reaction times being measured. In this research, associative strength refers to frequency of co-occurrence or lexical association, while antonymic strength refers to how participants judged an antonymic pair - GOE (goodness of exemplar).

By analyzing data from English and German, Kotzor also sets out to answer the question whether antonymy is conceptual or lexical. Comparing the results obtained from the corpus analysis and the judgment tasks from both English and German. If co-occurrence plays a role in antonymic strength, then the frequency of co-occurrence (FOC) and goodness of exemplar (GOE, judgment task) should correlate. Furthermore, if antonymy is conceptual then the results obtained analyzing English antonymic pairs should correlate with those obtained analyzing German antonymic pairs because if antonymy is conceptual it would not depend on different lexicalizations of antonymic concepts in the two different languages.

Also, the effect of frequency of co-occurrence and judgment scores were compared to reaction times in the decision tasks. The results showed that reaction times were affected by both co-occurrence and antonymic strength and the pairs that were recognized the fastest overall were those pairs with excellent judgment rating. However, FOC (lexical aspect) has more influence than GOE (conceptual aspect). A high degree of lexical association leads

to very efficient automatic co-activation of the two members of a pair. The strength of the lexical factor can best be seen in the results from two morphologically related pairs – "easy" and "uneasy", and "flammable" and "inflammable". These two pairs are in fact pseudo-antonymic but they received higher scores which means that the participants were misled by their morphology.

Kotzor (2021) defines antonymy or lexical opposition as "a cognitive relation of opposed concepts which are encoded by lexical items" (p. 149). While certainly recognizing that there is a lexical component to conceptual phenomena, Kotzor does not think that there should be a categorical division between canonical and noncanonical pairs. On the other hand, Jones et. al. (2012) see antonymy as conceptual and canonicity as gradable but acknowledge that there is a small number of antonyms which are highly canonical since they had high scores in all experiments, and for them, this is the evidence that "some meaning dimensions lend themselves to antonymous construals more easily than others, and that lexical items that are expressive of such dimensions apply in a wide range of domains and contexts" (p. 70).

The evidence obtained provides support for the conceptual basis of antonymy but it also showed that a number of other factors impact the degree of opposition. Kotzor (2021) also recognizes the factor of semantic range saying that "a larger amount of shared semantic range will provide lexemes with more opportunities to co-occur and therefore strengthen their associative relationship" (p. 55). Another important factor is the symmetry of distribution of antonyms on a scale. This means that if antonyms are on an equal distance from "the midpoint", they are more likely to be judged as good antonyms than adjectives at an unequal distance from the midpoint. Symmetry on the scale affects judgment ratings.

Kotzor (2021) draws a conclusion that antonymy is "a fundamentally conceptual relation with an additional lexical component for highly conventionalised pairs" (p. 150). Lexical association is then a consequence of conceptual entrenchment. Because of this conceptual entrenchment, the pair co-occurs frequently and that then leads to conventionalisation. The members of the pairs had to fulfill certain conceptual criteria to have the strong opposition and to be used together frequently.

Kotzor (2021) stresses that this conclusion was possible only because the whole spectrum of canonicity was considered and because the research relied on different methods of which each gave different information. That is, the conceptual criteria were more evident in the judgment task since participants had to consciously rate the goodness of example without time constraints. The lexical aspect affected the decision task more and that is why

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there were faster reaction times for pairs which are not antonymic but only have similar morphology. An important takeaway which does not only apply to antonyms is that "each methodological approach prioritizes different mechanisms, and it is therefore crucial to include several methods as each individual measure will only provide part of the story" (Koztor, 2021, p. 150).

2. 2. Approaches to the Mental Lexicon

The theoretical construct around the term "the mental lexicon" implies that *words or parts of words* are stored and represented in our mind, but the answers to questions such as what it consists of and how it is organized depend on different theoretical frameworks within which it is described. These frameworks also discuss the very definition of "word". Chromý (2020) warns us of this bias and various models focusing on different features of the mental lexicon "because they are grounded in a certain theory or a framework which emphasizes certain things and ignores other things." Nevertheless, that words exist in our long-term memory and that they are linked seems indisputable.

Apart from not being sure how and of what it is structured, another problem is the (lack of) distinction between lexical and conceptual systems. Whether it is possible to separate lexical and conceptual information and where the boundary is would be difficult to investigate. The methods used for researching word representation and processing are not without confounding factors since researchers use words either as stimuli or output (Murphy, 2003). Traxler (2012) points to important word processing research which suggests that word forms and word meanings are stored separately—word forms in lexical networks and word meanings in semantic memory or conceptual store. Despite being stored separately they are nevertheless linked.

Traxler (2012, p. 80) goes on to say that "to understand how words are represented and processed, we have to be clear whether we are talking about form or meaning" but as we see it, the boundary is not clear-cut. Cognitive semantics framework sees lexical and conceptual information as inseparable. Meaning is considered to be encyclopedic and therefore the mental lexicon is much more difficult to model within that framework. What is worse, Elman (2004) explicitly states that words themselves do not have meaning, but instead provide clues to meaning which is arguably always context-dependent. In the cognitive framework, words are compared to other kinds of sensory stimuli and as such they act on mental states and create a construal in a given context.

This issue is especially relevant when discussing antonyms, since some see it as a relation between word forms, while others see it as a relation between word meanings and concepts. If we take into account the word processing research Traxler (2012) points to, we could easily hypothesize, like Murphy (2003) does, that antonymy can be both lexical and conceptual at the same time.

Even though we are not sure about the exact mental representations of forms and meanings, almost everyone agrees that the paradigmatic relations among words are relevant to both lexical and conceptual structure (Murphy, 2003). However, we have seen and we will see further evidence that syntagmatic relations are also part of our mental lexicons.

When discussing lexical relations and the mental lexicon, the two polarizing opinions are that semantic relations are either stored and stable, the stance taken in structuralism, or derived every time we encounter them, also known as 'construal' in cognitive linguistics. In other words, lexical relations can be considered to be intralexical or metalexical. Murphy (2003) advocates that they are metalexical, or represented in the conceptual system, but does not exclude the possibility that they are intralexical as well.

Kumar (2021) presents a complete and up-to-date overview of the models of semantic memory and concludes:

> Although the current modeling enterprise has come very far in decoding the statistical regularities humans use to learn meaning from the linguistic and perceptual environment, no single model has been successfully able to account for the flexible and innumerable ways in which humans acquire and retrieve knowledge. Ultimately, integrating lessons learned from behavioral studies showing the interaction of world knowledge, linguistic and environmental context, and attention in complex cognitive tasks with computational techniques that focus on quantifying association, abstraction, and prediction will be critical in developing a complete theory of language. (p. 72)

Given that there are many models of semantic memory, discussing all of them would exceed the scope of this thesis. Therefore, I will only present the models of the mental lexicon that inspired the creation and organization of WordNet.

The first model of semantic memory proposed by Collins and Quillan (1969) was a hierarchical semantic network which suggested that hierarchy plays an important role in how fast we can verify a statement. They reported that to verify "*A robin is a bird"* took shorter time than to verify *"A robin is an animal"*. This was considered sound

psychological evidence of the hypothesis that the longer the distance in the lexical hierarchy, the longer the distance in our mental representation of words.

Hierarchical semantic network theory did not hold primarily because it could not explain the typicality effect Rosch and Mervis (1975) demonstrated. Their research measured how much time participants needed to decide if a statement is true or false. It showed that the participants verified the statement "*A robin is a bird*" faster than "*A chicken is a bird*", even though both "robin" and "chicken" are at an equal distance from "bird". Or, in other words, the number of nodes between "robin" and "bird" and "chicken" and "bird" is the same. This showed that hierarchical organization is not as important as previously thought and that in the future models of semantic memory, we need to account for typicality too. Despite this research, the organization of nouns in WordNet has not been changed and there are no plans to do so, as nouns are still organized hierarchically. One of the reasons for that is that for Miller (1998b) the typicality effect does not necessarily refute the hierarchical organization and he proposed that hierarchy and typicality coexist, just like imagery is associated with words without disrupting their organization.

Spreading activation theory was proposed by Collins and Loftus (1975). It is an alternative to the hierarchical semantic network and was framed as a semantic network but without hierarchical organization. Semantic network theory is a cognitive and computational approach and it has been "the mainstay of psycholinguistics for decades" (Lakoff, 2008, p. 19). Feldman (2008) draws the parallel with the brain which is itself "a massively interconnected system, and spreading activation is its basic mode of operation" (p. 193). The neural theory of language is supposed to specify how spreading activation can be mapped onto neural connections and neurons firing off. Therefore, more on the neural theory of language will be explained in the lines that follow.

But how far does the activation spread? What prevents it from activating everything and spreading to all of the nodes? Research in priming showed that spreading of the activation diminishes considerably beyond one or two links in the network (Traxler, 2012). It seems that there is a limit to the amount of nodes that can be activated which may be a way to reduce the strain on our working memory.

Miller (1998b) suggests that the mental dictionary most probably, among the aforementioned information, also includes associations between words that frequently co-occur. Arnon and Snider (2010) showed that we are sensitive to and seem to store the frequency information about four-word phrases (e.g., "don't have to worry"). These phrases are processed faster and hence are probably stored as such, or the frequency and

distributional information about them is stored as a part of their entries in our semantic memory. What is certain is that we have access to this information during language processing and that means syntagmatic relations, not just paradigmatic relations, are important for the organization of the mental lexicon.

It is still not clear if priming and faster processing happens as the result of the words sharing meaning and links in the semantic network or as the result of their frequent co-occurrence. Van de Weijer et al. (2012) showed that antonyms do prime each other but that frequency of co-occurrence is not the cause. Lexical association based on co-occurrence does not account for priming but instead it is the association based on semantic relatedness. This is another argument for the conceptual approach to antonymy.

Perea and Rosa (2002) also suggest that it is possible for frequently co-occurring words to become connected in the mental lexicon or semantic network. This can be explained by the neural theory of language. In NTL models, concepts consist of a group of linked neurons. According to Friedemann Pulvermüller, word representations can be seen as Hebbian cell assembly, named after Donald O. Hebb. The argument is that when one neuron member of the group becomes active, the activation spreads and all of the other neurons in the group also become active. Groups of neurons form when they are active at the same time, or put differently "neurons that fire together, wire together".

The way this ties in with antonymy is that canonicity is most probably caused by frequent co-occurrence. This is also suggested by Lam and Sheng (2020) who showed that L2 learners were more likely to respond with antonyms to adjective stimuli than native speakers were, while native speakers were more likely to respond with synonyms. As the possible explanation, the authors suggest that this may result due to language learning experience in which antonyms are taught in pairs, which is something Justeson and Katz (1991) also suggest. Through the learning experience the canonical antonym pairs may have been firing off together and the association between them strengthened.

2. 3. WordNet

WordNet is a lexical database which links senses based on relations between them. The project was started in the 1980s and the original idea behind it was to model semantic memory. But it grew into something else not envisaged at the time and it has been used for different purposes and made for numerous other languages.

Due to unavailability of digital corpora at the time of its development, WordNet was mainly based on intuitions of its creators (Fellbaum, 2006). The creators also believed that

componential semantics was not suitable for natural language processing by computers (Miller, 1998a) and that is why they employed the relational lexical semantics approach. They wanted to see if a definition could be inferred from those lexical relations, or the links between the nodes, which is why the first versions of the WordNet did not include definitions. Another reason is because it seemed to be consistent with the evidence of the organization of the mental lexicon (Fellbaum, 1998). As words and concepts were seen as an interrelated system or a semantic network, WordNet was organized as "a large network of linguistically labeled nodes" (Miller & Fellbaum, 2007, p. 210).

Relational lexical semantics, however, proved insufficient and they adapted WordNet and included definitions, as well as example phrases. They learned the hard way what is well known in lexicography − that definition by lexical relations is inadequate. Because of this they have gained more respect for traditional lexicographers (Miller, 1998a).

WordNet consists of synonym sets (synsets) which represent concepts. If a word has more than one sense, it is represented in more than one synset. Synsets consist of all the words that express a given concept. Fellbaum (1998a) explains how WordNet separates lexical from the conceptual level and that semantic-conceptual relations exist between synsets, while lexical relations are relations among words. The explanation is as follows: concepts do not necessarily need to be lexicalized. Not every concept is mapped onto a word and therefore there will be certain gaps. These lexical gaps are "a product of WordNet's relational structure, which may link two concepts via a third that happens not to be lexicalized in English" and "they reveal conceptual structures as distinct from lexical structures" (p. 6). The distinction between lexical and conceptual relations is slightly different when it comes to adjectives, as discussed in the next section.

In cases when a concept is not lexicalized it is still in the inventory and its lexicalization is improvised. For example, Murphy (2003) criticizes WordNet for not having an antonym of "angry" but what would be its antonym? The creators chose to have "unangry" or, in other cases, they opted for "non-" prefix. Thesauri, on the other hand, consist only of lexicalized concepts. This is why wordnets are also great tools for the study of lexicalization patterns across languages.

WordNet does not contain syntagmatic properties of the words but some definitions include some syntactic information. For example, the definition of "able" includes "*usually followed by 'to'*". As the argument for not including syntactic relations, Fellbaum (2006) stresses that WordNet is, after all, a lexical resource and, therefore, does not contain any

syntactic information. However, as we have seen, in antonymy, the line between syntagmatic and paradigmatic is not always clear-cut. Members of synsets may be interchangeable in many contexts but not in all contexts. This then poses a problem for the treatment of adjectives/antonyms.

Murphy (2003) criticizes the structure of WordNet, listing many arguments especially against its organization of adjectives. We have to keep in mind, however, that in 2003 the version of WordNet was 1.6. The latest Princeton version 3.0 was released in 2006. McCrae et al. (2019) forked Princeton WordNet and started developing an open-source updated version of it.
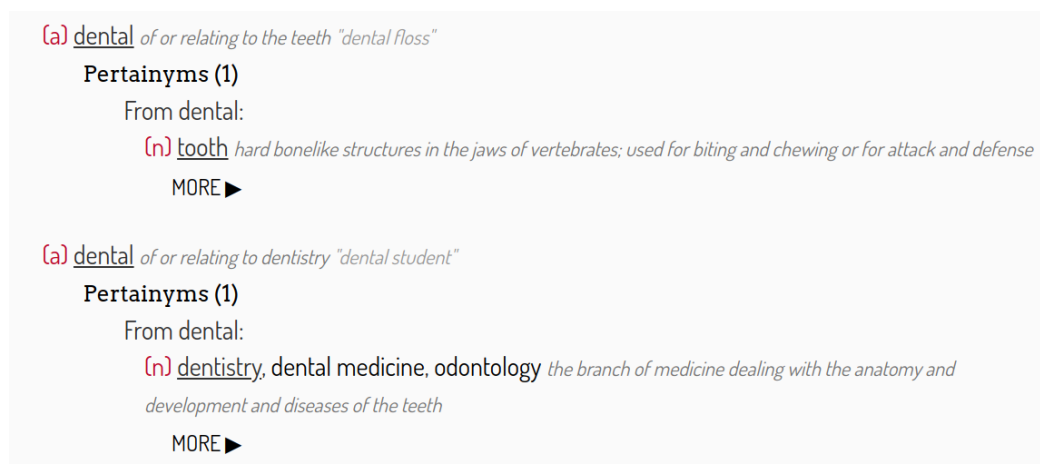
2. 3. 1. Adjectives and antonyms in WordNet

Princeton WordNet distinguished between descriptive and relational adjectives. However, they admitted that the distinctions between them are not always clear-cut and that they may overlap (K. J. Miller, 1998). Descriptive adjectives are organized into antonym clusters while relational adjectives do not have antonyms and are linked to nouns they pertain to. For example, "dental" is linked to "tooth" or "dentistry" (see Figure 2. 1.).

For the authors of GermaNet, however, the criteria for differentiating between descriptive and relational adjectives is "not at all clear" and they organize adjectives into 16 semantic classes (see: *Adjectives in GermaNet*).

Antonymy is used as the basis for organizing descriptive adjectives. Adjective clusters are organized around anonymous pairs or head synsets. Head synsets have one or more satellite synsets or concepts similar in meaning. This model is called the *Dumbbell Model* and was proposed by Gross, Fischer and Miller (1989). *Head synsets* are *direct antonyms* while *satellite synsets* are *indirect antonyms* of the head synset on the other side of the dumbbell and its satellite synsets. This model differentiates *conceptual opposites* that are lexically paired from conceptual opposites which are *not* lexically paired (K. J. Miller, 1998).

Figure 2. 1.

"Dental" as pertainym

(a) dental *of or relating to the teeth "dental floss"*
    Pertainyms (1)
        From dental:
            (n) tooth *hard bonelike structures in the jaws of vertebrates; used for biting and chewing or for attack and defense*
                MORE ▶

(a) dental *of or relating to dentistry "dental student"*
    Pertainyms (1)
        From dental:
            (n) dentistry, dental medicine, odontology *the branch of medicine dealing with the anatomy and development and diseases of the teeth*
   MORE ▶

Note. Screenshot retrieved from en-word.net.

Antonymy is used as the basis for organizing descriptive adjectives. Adjective clusters are organized around anonymous pairs or head synsets. Head synsets have one or more satellite synsets or concepts similar in meaning. This model is called the *Dumbbell Model* and was proposed by Gross, Fischer and Miller (1989). Head synsets are direct antonyms while satellite synsets are indirect antonyms of the head synset on the other side of the dumbbell and its satellite synsets. This model differentiates conceptual opposites that are lexically paired from conceptual opposites which are not lexically paired (K. J. Miller, 1998).

Direct antonyms are thought to be more *psychologically salient* (Fellbaum, 1998b) and their frequency of co-occurrence is often cited as the reason for this. However, as we have seen, there are many opposing views. In WordNet, antonym is a lexical relation between direct antonyms, rather than between all the members of the clusters. Satellites are conceptually antonymous to the other side of the dumbbell but they do not constitute the antonym canon.

Figure 2. 2.

The Dumbbell Model
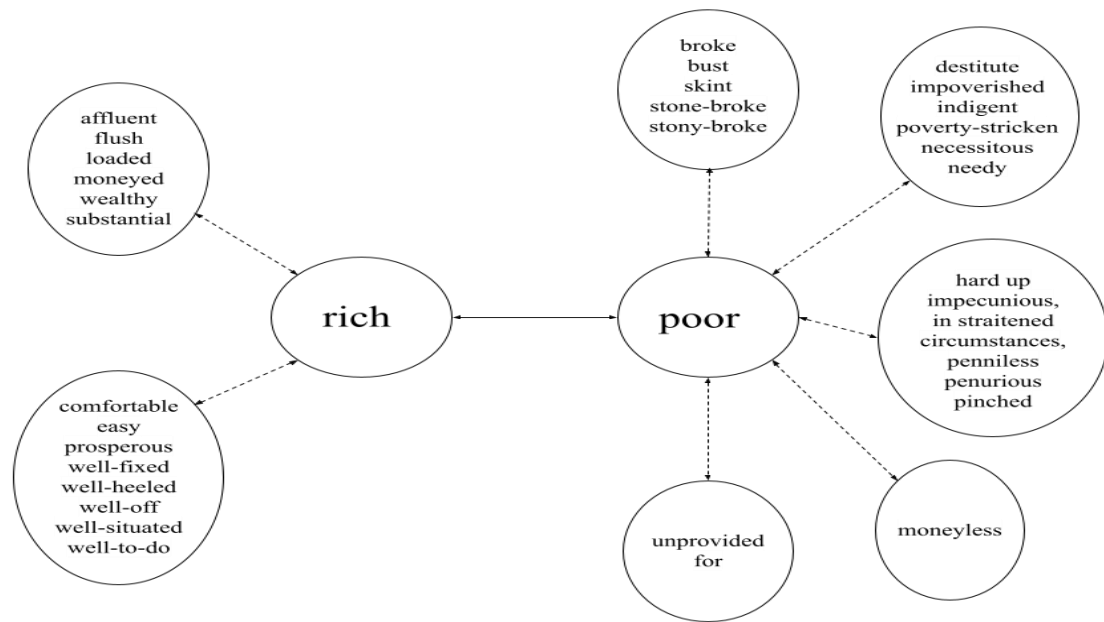
Note. Illustration original. Synsets retrieved from <u>en-word.net</u>.

As a comparison, the creators of GermaNet do not organize adjectives into the dumbbells, but instead, structure them hierarchically.

For Fellbaum (<u>1998b</u>), on the other hand, adjectives do not lend themselves to a hierarchical organization, unlike nouns and verbs. As the argument for the lexical approach, K. J. Miller (<u>1998</u>, p. 49) poses the question: "When two adjectives have closely similar meanings, why do they not have the same antonym?" Murphy and Andrew (<u>1993</u>), on the other hand, criticize WordNet for seeing antonymy as just lexical. They tested the hypothesis that antonymy is a lexical relation against the view that it is a conceptual relation in a lexical naming task. Adjectives provided in isolation did not elicit the same antonyms and synonyms as when provided in a noun phrase. This important role of context is emphasized in the conceptual approach and cannot be accounted for by the lexical approach. Their results provided the support for the conceptual theory of antonymy as well as understanding of which senses can be combined.

Whether antonymy is associative or semantic, the co-occurrence of antonymic pairs, whether causing psychological salience and canonicity or not, is definitively relevant for WordNet's most frequent application discussed in the next section.

2. 3. 2. Word sense disambiguation

WordNet is the most widely used resource in natural language processing, especially word sense disambiguation (McCrae et al., 2020). Natural language processing refers to understanding and production of language by computers, in the form of text or voice. For computers to be able to "understand" natural language, it is crucial that word senses are disambiguated. Bevilacqua et al. (2021) call WordNet the de facto standard sense inventory for word sense disambiguation.

Fellbaum (1998b) distinguishes between highly polysemous and highly frequent adjectives and those not so polysemous and frequent. The meaning of polysemous and frequently occurring adjectives can be disambiguated while the adjectives that are less polysemous and less frequent tend to be picky about the nouns they modify which may help disambiguate the noun, if necessary. Fellbaum (1998b) notes how word sense disambiguation was not the motivation to distinguish between these two groups of adjectives but it is reflected in the dumbbell model which distinguishes between direct and indirect antonyms.

Whether we need to disambiguate an adjective or a noun it modifies, information about *collocation* is important for language understanding. McCrae et al. (2020a) note that collocations cannot be applied to two or more senses of a polysemous word. Based on that statement, their aim is to extend WordNet with quantitative information based on corpora, for the purposes of sense disambiguation. In the case of adjectives, including collocations helps us distinguish the sense of each member of an antonymous pair but it also helps us to choose the appropriate antonym of an adjective, depending on which nouns they modify.

When calculating sense similarity with WordNet, what is being measured is the distance between the concepts. The problem with the dumbbell model is that "within a cluster, all semantically similar adjectives are arranged equidistantly from a centroid" (Sheinman et al., 2013, p. 799). As a result, the distance between the head synset and the satellites is always one and the distance between two satellites is always two, since they are connected via the head synsets. This then suggests that all the satellites are equally similar to the head synset, which is not the case (Sheinman et al., 2013).

In addition, Fellbaum (1998a) acknowledges that context is important for knowing a word's meaning. We use context to disambiguate polysemous words but WordNet does not contain any syntagmatic or distributional information. Models for word sense disambiguation based on distributional semantics easily confuse antonyms. Since they are

often found in close proximity, these models assign similar meaning to two opposing antonyms. Indeed, they are very similar, but they are also contrasted with respect to some relevant properties. Lexical resources which represent antonymy, like WordNet, help circumvent this drawback (Saedi et al., 2018; Jurafsky & Martin, 2020). Therefore, if WordNet is especially useful for antonymy, it should be the gold standard of it. This thesis is, therefore, a further attempt to investigate that.

2. 3. 3. Limitations and extensions

Fellbaum (1998) contrasts syntax and the lexicon in the context of computational language modeling saying that the lexicon is less "clean" than syntax and is a challenge to anyone who attempts to model it the way it is presented in the mind. The lexicon is constantly evolving and any model of it would need continuous updates. Fellbaum (1998) addresses this saying "everyone who has worked on WordNet is keenly aware of its shortcomings, and there has never been a moment when we felt that we were done" (p. 1). However, trying to model it by means of computational methods also provides a good ground for testing cognitive behavior.

The Open English WordNet community recognizes that language is not static and that it is necessary for any lexicon to be continually updated (McCrae et al., 2020). Because of that, there is an initiative to extend the Princeton WordNet with neologisms and colloquial terms (McCrae et al., 2017) as well as continuously update the Open English WordNet using open-source methodology. This, at least partially, responds to the argument that WordNet is strictly following structural semantics—seeing relationships among words and the lexicon as stable.

Currently, there are plans to replace the dumbbell model with a new property which will relate adjectives to their scales (McCrae, 2020). For example, "hot" is already related to the noun "temperature" since it expresses that attribute. Adjectives will then relate to where they are on the scale when it comes to the attribute they describe. Sheinman et al. (2013) demonstrated how to enrich WordNet with gradability and intensity but they did not express the need to replace the dumbbell model altogether. They acknowledge its deficiencies and propose solutions.

Another argument against structural semantics is that word meaning is encyclopedic-like. The way in which WordNet compensates for this is by being linked to Wikidata which is supposed to "close the gap between the lexical and encyclopedic information in the two resources" (McCrae & Cillessen, 2021).

Open English WordNet is structured according to the OntoLex-Lemon model (Cimiano et al., 2016). One of the modules of this model, currently being developed, is the FrAC module (Chiarcos et al., 2020). This module adds the possibility of enriching a lexical resource with information about collocations, distributional similarity, attestations and frequency information. This information, as the authors note, is valuable both for digital lexicography and its applications in natural language processing. FrAC module extends, in this case, a relational resource with distributional information.

There are also initiatives to link WordNet with FrameNet (Svetla, 2021). Fellbaum (2010) lists some advantages of aligning the two complementary resources, but also the benefits of the process itself. Through the process of aligning the two resources, researchers had to face "a persistent, unresolved question, namely, to what extent can humans select, and agree on, the context-appropriate meaning of a word with respect to a lexical resource?" (p. 2).

The most up to date version of OEWN at the time of the writing of this thesis is the 2021 version released in November of 2021. The 2020 version was improved mainly with links to Wikidata and pronunciation information (McCrae, 2021). The initiative to include pronunciation information was done with the intention to make wordnets useful for word sense disambiguation in speech applications (Declerck et al., 2020). With this extension it will be possible to restrict the selection of senses based on the pronunciation given. It should also be noted that the dumbbell model has not been replaced yet.

3. Method

This master's thesis presents two case studies. Two antonym pairs and their representations in Open English WordNet 2021 will be studied thoroughly. The first pair is *false-true* which was judged the best rated antonym pair in research done by Kotzor, scoring 1.015 on the scale from 1 to 7. (2021, p. 160) Participants were asked to rank antonym pairs on a scale from 1 to 7. Giving a rating 1 meant 'excellent', while 7 was 'very poor'. Moreover, they are not scalar—something is either true or not. The second pair is *new-old* which was the most frequent pair in the corpus study carried out by Jones (2002, p. 110) as well as in Kotzor's data (2021, p. 160).

The reason for choosing to conduct a multiple-case study is the complexity of the OEWN and for the purposes of better illustration of its representation of antonyms. It is

beyond the scope of this thesis to analyze all of the antonyms in the OEWN. However, it will be possible to see if there are any differences in the representations of a scalar and non-scalar pair, as well as to compare the pair with the best judgment rating and the most frequent pair in the corpus.

Very briefly, the thesis will also address the antonyms of *fresh* and *sweet-dry* pairs which were included since they were examples of WordNet not including enough context and being too lexical. ***Large-small*** and ***big-little*** are also looked at since they were one of the first pairs which were used to argue for antonymy being lexical. Kotzor ([2021](#)) mentioned ***easy-uneasy*** as being antonymous in very specific contexts. This will also be looked into.

An analysis of adjective clusters has been carried out using the English WordNet 2021 available at en-word.net website. The reason Open English WordNet 2021 (McCrae et al., [2020](#)) was chosen for the analysis instead of Princeton WordNet is because it is an improved and the most up to date version of it. The overall organization of adjectives has not been changed. Using the website, it was easier to extract antonymic pairs and their glosses.

The main goal of this thesis was to see whether, and how, Open English WordNet 2021 includes any context-sensitive information. A corpus analysis of the contrasted pairs will also be performed by looking at what nouns does each member of the pairs modify and The concordances and examples will be retrieved from English Web 2020 enTenTen: Corpus of the English Web which at the time of the writing of this thesis has 36 billion words.

Using the secondary data from Kotzor (2021), corpus analysis of the largest web corpus of English and the OEWN interface, this thesis will answer the following questions: Are the members of the above-given pairs (*false-true, new-old, sweet-dry, large-small, big-little, easy-uneasy*) antonyms in OEWN2021? Does each member of a pair have indirect antonyms and what are they? What nouns do both pairs modify? Are there any nouns that one member modifies and the other one does not? What would be the appropriate antonym in that case?

The thesis will also look at the possibility, or necessity, of including scalar information or organizing adjectives on a scale. As the symmetry on the scale has also been proved to be an important factor as well as the distance between the concepts, this thesis will also look at the members of the pairs on the TEMPERATURE scale. Kotzor ([2021](#)) explored the effect of symmetry and with the adjectives in the TEMPERATURE scale and the results showed that the gradable antonyms, which can be put on a scale, have better judgment

scores if they are symmetrical on the scale and at the same distance from the midpoint. How this research can be used to make WordNet better will also be addressed. The possibility of organizing adjectival antonyms on a scale in the English WordNet 2021 will also be analyzed.

While Jones ([2002](#)) carried out a large-scale corpus based research on functions of antonyms in discourse, my research is a closer observation of adjectival antonymic pairs. The thesis provides a qualitative analysis of every member of the pairs selected, a closer look at which senses were contrasted in each pair, whether the members of the pairs are paired with other adjectives, as well as their satellites or indirect antonyms. For further research, Jones et al. ([2007](#)) recommended comparing web-searched antonyms with those in dictionaries or other lexical resources like WordNet, which this thesis will do as much as its scope permits.

4. Results and Discussion

4. 1. *False* and *true*

As mentioned above, the best rated antonyms pair in Kotzor (2021) was ***false-true***. Figure 4. 1. shows "false" and "true" as direct antonyms and their satellites as well as the nouns that were part of their glosses. We can see that OEWN does include some contextual information and the nouns these adjectives collocate. It is interesting that "untrue" is a satellite of "false" and that, despite its morphological relatedness to "true", it is not the direct antonym of "true", but its indirect antonym. It is by chance that this dumbbell is symmetrical. Figure 2. 2. showed that the dumbbell model does not have to be symmetrical, that is the two adjectives do not need to have the same number of satellites.

Figure 4. 1

"False" and "true" as direct antonyms, their satellites and nouns they modify in their glosses in OEWN2021
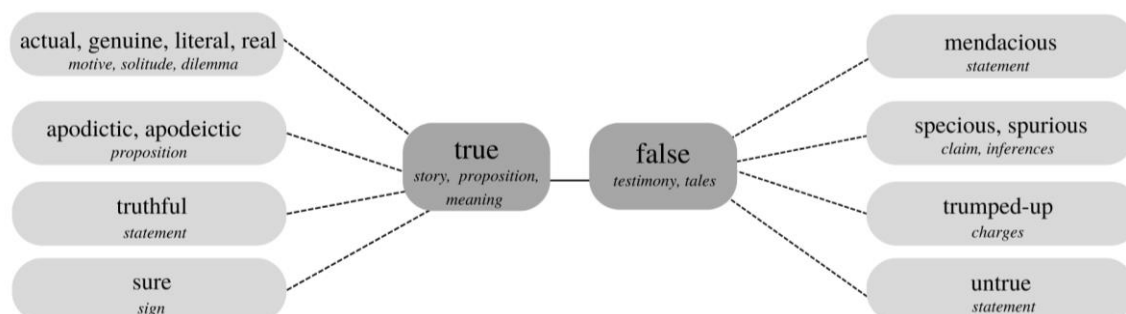
Note. Visualization original. Synsets retrieved from <u>en-word.net</u>.

"False" and "true" are direct antonyms only once in OEWN, while "true" together with "truthful" (making up one synset) is a direct antonym of "untruthful", shown in Table 4. 2. To see whether "true" in different contexts has better antonyms than "false", the nouns which are modified by "true" and never modified by "false" will be examined. After that, the reverse analysis will be performed.

Table 4. 1.

"False" and "true" as direct antonyms in OEWN2021 and their sense identifiers

oewn-02470951-a	oewn-02469730-a
false - not in accordance with the fact or reality or actuality "gave false testimony under oath" "false tales of bravery"	**true** - consistent with fact or reality; not false "the story is true" "it is undesirable to believe a proposition when there is no ground whatever for supposing it true" "the true meaning of the statement"

Table 4. 2.

"True" as a direct antonym of "untruthful" in OEWN2021 and their sense identifiers

oewn-01228271-a	oewn-01228771-a
truthful, true - expressing or given to expressing the truth "a true statement" "gave truthful testimony" "a truthful person"	**untruthful** - not expressing or given to expressing the truth "the statement given under oath was untruthful" "an untruthful person"

The nouns which "false" and "true" modify are presented in Table 4. 3. The nouns in bold in the first column are the ones which are never modified by "false". The focus will be only on those nouns and what the best antonym would be in that context.

"True" appears in OEWN2021 also as a satellite, that is, it is a synonym of adjectives which have direct antonyms. Satellites themselves do not have direct antonyms, only indirect ones, via the adjective they are the satellites of. Table 4. 4. shows the adjectives that "true" is a satellite of as well as the indirect antonyms of "true". If "false" is not always the appropriate antonym of "true" in a certain context, the possibility of indirect antonyms of "true" replacing "false" will be analyzed.

Table 4. 3.

Nouns modified by "true" and "false" in enTenTen20 obtained using Sketch Engine

mostly with "true"			equally frequent with both	mostly with "false"		
potential	love	democracy	fact	belief	testimony	tooth
fashion	believer	feeling	self	Messiah	report	charge
passion	beauty	story	identity	confession	hope	claim
enough	intention	freedom	peace	statement	narrative	allegation
freshman	hero	friendship	picture	teaching	premise	alarm
cost	character	spirit	religion	doctrine	notion	accusation
essence	power	faith	sense	perception	negative	**arrest**

fan	today	value	gospel	prophecy	dawn	eyelash
style	crime	cause	representation	god	promise	rumor
gentleman	reflection	Christian		conclusion	assertion	pretence
calling	happiness	God		consciousness	positive	imprisonment
nature	form	knowledge		prophet	start	advertising
purpose	origin	friend		memory	flag	dichotomy
meaning		color		teacher	impression	assumption
		understanding		witness		pretense
		colour		information		
		church		Prophet		
				True		

Table 4. 4.

"True" as a satellite in OEWN2021 and its indirect antonyms

Adjectives "true" is a satellite of	Indirect antonyms of "true"	Indirect antonyms of "true" via "false"
accurate	➜ inaccurate	mendacious
faithful	➜ unfaithful	specious, spurious
typical	➜ untypical, atypical, atypic	trumped-up
trustworthy, trusty	➜ untrustworthy, untrusty	untrue
sincere	➜ insincere	
real	➜ unreal	
geographical, geographic	➜ magnetic	

legitimate	➜ illegitimate	
harmonious	➜ unharmonious, inharmonious	
even	➜ uneven	

The words in bold in the first column of Table 4. 3. will be examined now, that is, the nouns which are modified by "true" but never by "false".

There seems to be no antonym of "true potential", it is possible only to realize one's true potential or not. It might be compared to "real potential" but then saying that "unreal potential" is its antonym is misleading. "Unreal potential" would mean "unbelievable potential".

"True fashion" or something being done in a true fashion of something else, could be replaced with "typical fashion". Then, following the analogy in Table 5, the antonym is "untypical/atypical/atypic fashion".

"True passion" can be compared to "true calling" – one either has it or not. "True enough" is an idiom meaning "*correct or accurate but not completely explaining something*" (*Cambridge Academic Content Dictionary*). It does not have an antonym and it is interesting that "enough" was tagged as a noun in the corpus.

"True freshman" is a phrase only used in sports. "*A true freshman is a college athlete who competes in games beginning in his or her freshman academic year. This is contrasted with a redshirt freshman, whose college athletic career doesn't officially begin until he or she is a sophomore academically.*" (*What Is A True Freshman? Definition & Meaning On SportsLingo.Com*, n.d.) In this context, the antonym of "true" is "redshirt".

The antonym of "true cost" could be "estimated cost" or "production cost", depending on the context and the complex terminology of economics.

Similarly to "true passion", "true calling" and "true potential", "true essence" does not have an antonym. While "true" could perhaps be replaced with "real" in these collocations, the antonym cannot be "unreal". Perhaps we can contrast "true passion" with "passion" itself, "true calling" with "calling" and so on. "True" seems to be just an intensifier here.

"True fan" on the other hand can be contrasted with "fake fan". "True style" has the same use as "true fashion". "True gentleman" falls into the same category of collocations in which "true" is an intensifier, "true calling" also being one of them.

What this analysis shows is that none of the indirect antonyms listed in Table 4. 4. or in Figure 4. 1. could be used as antonyms with the nouns which are never modified by "false". If a conclusion was to be drawn from this analysis only, it could be said that OEWN in not adequate and is not context sensitive. However, a more thorough analysis is needed.

The words in bold in the last column of Table 4. 3. are nouns which are modified by "true" but never by "false". The possibility of those nouns being modified by indirect antonyms of "false" shown in Table 4. 5. and the possibility of them being more appropriate antonyms of "true" in those contexts will be examined now.

The antonym of "false arrest" is "lawful arrest" and "false" is not related to "lawful" by any of the relations in the OEWN2021.

The antonym of "false eyelash" would be "natural eyelash" and "false" is an indirect antonym of "natural" via "unreal, artificial". When it comes to eyelashes, "false" and "natural" should be direct antonyms since "unreal eyelash" or "artificial eyelash" did not retrieve a lot of results. The opposite of a "false rumor" is a rumor that is "true" but it appears with "rumor" in a predicative position. This is the reason why the corpus had zero results for "true rumor". This demonstrates why predicative adjectives should also be taken into account when looking for an antonym of an adjective.

Table 4. 5.

"False" as a satellite in OEWN2021 and its indirect antonyms

Adjectives "false" is a satellite of	Indirect antonyms of "false"	Indirect antonyms of "false" via "true"
incorrect-wrong	➜ correct-right	actual, genuine, literal, real
invalid	➜ valid	apodictic, apodeictic
insincere	➜ sincere	truthful
unrealistic	➜ realistic	sure
unreal, artificial	➜ natural	
dishonorable, dishonest	➜ honorable, honest	
unharmonious, inharmonious	➜ harmonious	
counterfeit, imitative	➜ genuine-echt	
inconstant	➜ constant	

"Pretence/pretense" appears in one of the glosses of one of the senses of "false" in the OEWN2021 but its meaning already includes being false so this seems to be a pleonasm which does not have an antonym.

"False imprisonment" and "false arrest" are very similar but there is a subtle difference. Their antonyms would be "lawful imprisonment" and "lawful arrest" respectively.

"False advertising" on the other hand is contrasted with "honest advertising". "Honest" is the indirect antonym of "false" via "dishonorable/dishonest".

"Dichotomy" did not have any appropriate antonyms in the list of its modifiers. Having learned from the example with the noun "rumor", more attention was given to "dichotomy" and the predicative adjectives were also considered. The appropriate antonym, which appears in the predicative position, would be "valid" and "valid" is an indirect antonym of "false" via "invalid" (see Table 4. 5.).

The antonym of "false assumption" is "true assumption". However, "assumption" is one of those nouns which are never modified by "true". It was found that "true" does modify "assumption" but in a predicative position again. However, "correct" seems to be a better antonym here since "assumption is correct" has 2873 hits while "assumption is true" has 1548 hits in the corpus used.

To conclude, it was not possible to use indirect antonyms of "true" in OEWN to replace "false" in the contexts examined. In the case of "assumption" and "rumor", "true" was the appropriate antonym. Looking at the appropriate antonyms of "false", unlike in the case of "true", OEWN had better indirect antonyms. However, in the contexts analyzed, should they really be indirect antonyms? The problem is that "false" was not in direct antonymy with the adjectives it should have been in direct antonymy with. However, it can be concluded that even ungradable antonyms depend on the context and can have different antonyms when modifying different nouns. This analysis showed that antonymy is highly conceptual.

4. 2. *New* and *old*

New-old is the most frequently co-occurring pair in Kotzor (2021) and Jones (2002). "New" has two direct antonyms in OEWN, "old" and "worn" (see Table 4. 6.). "Old" has two direct antonyms as well, "new" and "immature/young" (see Table 4. 7.). To better understand the dumbbell model, "new" and "old" will be analyzed first in the same manner "true" and "false" were analyzed.

Table 4. 6.

Direct antonyms of "new" and their senses

oewn-01645077-a	oewn-01642580-a
new - not of long duration; having just (or relatively recently) come into being or been made or acquired or discovered "a new law" "new cars" "a new comet" "a new friend" "a new year" "the New World"	**old** - of long duration; not new "old tradition" "old house" "old wine" "old country" "old friendships" "old money"
oewn-02595137-a	oewn-02590887-a
new - unaffected by use or exposure "it looks like new"	**worn** - affected by wear; damaged by long use "worn threads on the screw" "a worn suit" "the worn pockets on the jacket"

"New" and "old" share a wider semantic range than "true" and "false" and it is no wonder they are the most frequently co-occurring pair. For example, "opportunity" is the only noun that is modified by "new" and never modified by "old". While "gentleman", "male", "adage" and "saying" are the only nouns that are modified by "old" and never modified by "new".

In the case of "new opportunity", "new" does not have the meaning in Table 4. 6. but "other than the former one(s); different". That is the meaning of "new" as a satellite of "other" whose antonym is "same". However, "same opportunity" can be ambiguous.

For "old gentleman" and "old male" the appropriate antonym would be "young" since the sense in those collocations is the second one in Table 4. 7. For "old adage" and "old saying", the antonym cannot be "new" nor "young" because adages or sayings cannot be new.

Table 4. 7.

"Old" as a direct antonym of "young" and their senses

oewn-01648062-a	oewn-01651383-a
old - (used especially of persons) having lived for a relatively long time or attained a specific age "his mother is very old" "a ripe old age" "how old are you?"	**immature, young** - (used of living things especially persons) in an early period of life or development or growth "young people"

It is not quite clear why OEWN includes adjectives from "one-year-old" to "five-year-old" and not "six-year-old" for example. However, Table 4. 8. clearly shows that the satellites of both "old" and "young" are not the same degree of being old or being young. The satellites are not in the order of their intensity but there is definitely the potential of organizing this antonym pair on a scale

Table 4. 8.

Satellites of "old" and "young"

Satellites of "old"	Satellites of "immature/young"
elderly, aged, older, senior	one-year-old
of age, aged	two-year-old
senescent, ageing, aging	three-year-old
ancient	four-year-old
anile	five-year-old
centenarian	adolescent, teenage, teen, teenaged
darkened	infantile
doddery, senile, gaga, doddering	boyish, boylike, schoolboyish
emeritus	childlike, childly
grizzly, grey-haired, white-haired, grey, gray-headed, grey-headed, gray-haired, hoary, gray, hoar	early
middle-aged	schoolgirlish, girlish

nonagenarian	junior
octogenarian	small, little
oldish	newborn
superannuated, over-the-hill, overaged, overage	preadolescent, preteen
sexagenarian	puppylike, puppyish
venerable	tender
	youngish
	young, youthful, vernal

4. 3. TEMPERATURE scale

To understand Table 4. 9. better, it is necessary to explain the groups the rating scale was divided into. Group I is a group of excellent opposites with the ratings ranging from 1 to 1.79. Group II consists of good opposites with the ratings ranging from 1.8 to 2.99. Medium opposites form the Group III which scored from 3 to 4.99. Finally, Group IV was made up of poor opposites with ratings from 5 to 7.

Table 4. 9.

Judgment ratings of the antonyms on the TEMPERATURE scale

	Word 1	Word 2	GOE
I	hot	cold	1.13
	warm	cool	1.84
II	freezing	boiling	1.98
	chilly	warm	2.27
	hot	cool	2.68
III	scorching	glacial	3.05
	sweltering	nippy	3.28

	chilly	steaming	3.57
	cold	friendly	4.05
	wintry	sultry	4.57
	cold	mild	4.82
IV	lukewarm	tepid	6.22

Note. Taken and adapted from Kotzor (2021, p. 51).

We will analyze the adjectives from Table 1 (taken from Kotzor, 2021). "Hot" and "cold" are the best judged antonyms on the list. They are direct antonyms in two contexts - TEMPERATURE and EMOTIONALISM, EMOTIONALITY. They are then accordingly related to the noun "temperature" and "emotionalism, emotionality" through the relation "attribute". Satellites of "hot" and "cold" in the context of TEMPERATURE are listed in Table 4. 10.

Table 4. 10.

Satellites of "hot" and "cold" in OEWN 2021

Satellites of "hot"	Satellites of "cold"
baking hot, baking	acold
blistery, blistering	algid
warming, calefacient	glacial, polar, arctic, frigid, gelid, icy
calefactive, calefactory	bleak, raw, cutting
calorifacient	chilly, parky
calorific	nipping, frosty, nippy, snappy, crisp
fervid, fervent	frigorific
igneous, fiery	frore
heatable	frosty, rimy, rimed
het up, heated, het, heated up	heatless
hottish	ice-cold

overheated	refrigerating, refrigerant
red-hot	refrigerated
scorching	shivery
sizzling	stone-cold
sulphurous, sultry, sulfurous, stifling	unwarmed, unheated
sweltry, sweltering	
thermal	
torrid	
tropic, tropical	
white-hot, white	

It is important to understand that the adjectives in the first column are not on the same distance from the midpoint as the adjectives in the second column. They are just in the alphabetic order as they appear on the web interface of OEWN.

It is easily noticeable that there are much more adjectives in OEWN that can be put on the TEMPERATURE scale compared to the number of adjectives in Kotzor (2021). What would be needed is to research all of them and at what distance from the midpoint should they be placed. The problem is that the dumbbell would then look like Figure 4. 1. if we were to place the adjectives based on their judgment ratings.

Figure 4. 1.

A potential dumbbell model

boiling   warm   hot   cold   cool freezing
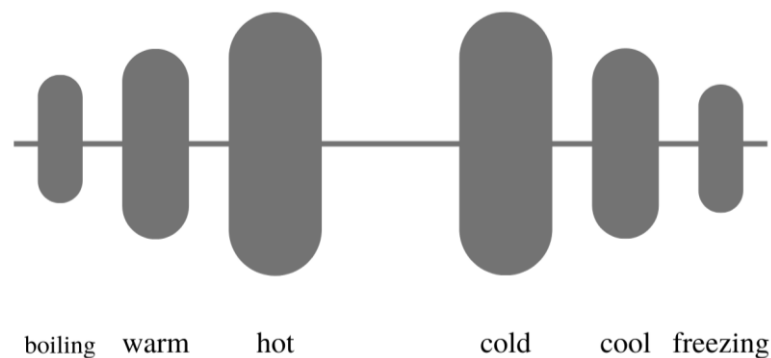
What is problematic with this version of the dumbbell is that the intensity is neither decreasing nor increasing. "Warm" is not between "hot" and "boiling" and "cool" is not between "cold" and "freezing".

What could be done instead is to place adjectives on the scale based on the intensity expressed by the adjective and not the judgment rating (Figure 4. 2.). However, there is a question of whether the symmetry on the scale is a bigger factor than the context and nouns adjectives modify. Even if we place the adjectives on the scale as shown in Figure 4. 2. the nouns may require other antonyms apart from the ones on the scale. Besides that, Figure 4. 2. cannot be called a dumbbell but it would support the findings that the most frequent pair and the pair with the best judgment ratings is on the ideal distance from the midpoint and has the greatest semantic range (Kotzor, 2021).

Figure 4. 2.

Another potential dumbbell model

boiling   hot   warm   cool   cold   freezing
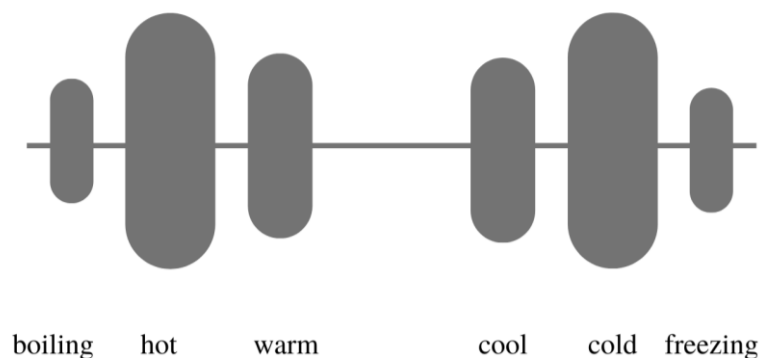
"Warm" and "cool" are also direct antonyms and their satellites, shown in Table 4. 11, could be put on one TEMPERATURE scale and one dumbbell. The members of this pair are also direct antonyms in the context of emotions and color and could be placed on those scales too.

Table 4. 11.

Warm and cool as antonyms in OEWN 2021

Satellites of "warm"	Satellites of "cool"
tepid, lukewarm	air-conditioned
warmed	air-cooled
warming	caller
	precooled
	water-cooled

"Freezing" and "boiling" are not in the OEWN inventory as adjectives. "Chilly" is a satellite of "cold". "Scorching" is a satellite of "hot" while "glacial" is a satellite of "cold". "Sweltering" is a satellite of "hot" while "nippy" is a satellite of "cold". "Steaming" is a satellite of "wet" and is related to the noun " wetness". "Wintry" belongs to the same concept as "glacial" and together they are a satellite of "cold", while "sultry" is a satellite of "hot". However, "scorching" and "glacial" have a better rating than "wintry" and "sultry" and we do not know what rating "glacial" and "sultry" would have and if "wintry" and "sultry" have a better rating because of their morphology. Nevertheless, we can conclude that there are some matches between the judgment ratings and the representation of antonyms in the OEWN2021.

4. 4. *Fresh* **and its antonyms**

As an example of antonymy's dependence on context, "fresh" is contrasted with "stale", "frozen", "rotten" or "processed" when talking about food (Murphy, 2003).

Figure 4. 3.

Fresh vs. stale

Note. Screenshot retrieved from en-word.net.

In the case of "air", as an antonym of "fresh" we would choose "stale" but WordNet made an interesting choice. "Fresh" is a direct antonym of "stale" (shown in Figure 4. 3.) but both senses of "fresh" which include "air" in their glosses are in fact satellites (shown in Figure 4. 4. and Figure 4. 5.) But how often would we refer to air as "debilitating" or "impure"?

Figure 4. 4.

Fresh vs. debilitating

(s) bracing, brisk, fresh, refreshing, refreshful, tonic *imparting vitality and energy "the bracing mountain air"*
    Derived Forms (1)
    Similar to (1)
        (a) invigorating *imparting strength and vitality "the invigorating mountain air"*
            Antonyms (1)
                From invigorating:
                    (a) debilitating *impairing the strength and vitality*
                    MORE ▶

Note. Screenshot retrieved from en-word.net.

Figure 4. 5.

Fresh vs. impure

(s) clean, fresh *free from impurities "clean water" "fresh air"*
    Derived Forms (2)
    Similar to (1)
        (a) pure *free of extraneous elements of any kind "pure air and water" "pure gold" "pure primary colors" "the violin's pure and lovely song" "pure tones" "pure oxygen"*
            Antonyms (1)
                From pure:
                    (a) impure *combined with extraneous elements*
                    MORE ▶

Note. Screenshot retrieved from en-word.net.

4. 5. Large-small and big-little

There had been a strong preference for large-small and big-little as appropriate antonym pairs. The two pairs that are most frequently mentioned when advocating lexical approach to antonymy. Big-little has been considered a better pair than large-little. OEWN however

does not differentiate between these two highly canonical pairs. It is interesting that "large" and "big" have been grouped in the same synset and together they are the direct antonym of the synset "small, little" (Figure 4. 6.). Where it is expected of OEWN to have two dumbbells, there is only one.

However, Kotzor (2021) showed how there is no difference between big-small, small-large and big-little, which scored 1.23, 1.24 and 1.24 respectively. Large-little on the other hand had a lower score of 2.05.

Figure 4. 6.

Large/big vs. small/little

(a) large, big *above average in size or number or quantity or magnitude or extent "a large city" "set out for the big city" "a large sum" "a big (or large) barn" "a large family" "big businesses" "a big expenditure" "a large number of newspapers" "a big group of scientists" "large areas of the world"*

    Antonyms (2)
        From big:
            (a) small, little *limited or below average in number or quantity or magnitude or extent "a little dining room" "a little house" "a small car" "a little (or small) group"*

Note. Screenshot retrieved from en-word.net.

4. 6. *Sweet-dry*

As mentioned above, Murphy (2003) relates "sweet" to both "sour" and "bitter". In WordNet, "sweet" is the antonym of "sour" but "bitter", on the other hand, does not have a direct antonym and is a satellite. Interestingly though, none of the senses of "bitter" is related to taste. "Sweet" besides being contrasted with "sour" is also, unexpectedly, contrasted with "dry" (see Figure 4. 7.).

Figure 4. 7.

"Sweet" and "dry" as direct antonyms

(a) sweet *(used of wines) having a high residual sugar content "sweet dessert wines"*
    Antonyms (1)
        From sweet:
            (a) dry *(of liquor) having a low residual sugar content because of decomposition of sugar during fermentation "a dry white burgundy" "a dry Bordeaux"*

Note. Screenshot retrieved from en-word.net.

4. 7. *Easy-uneasy*

Kotzor (2021) mentions "easy" and "uneasy" as pseudo-antonymic but their morphology is what made some participants decide that they are antonyms in the decision task. Kotzor still acknowledges that they can be antonymous in a very specific context. It is interesting that OEWN has "easy" and "uneasy" as direct antonyms (Figure 4. 8.) and that this specific context is considered.

Figure 4. 8.

"Easy" and "uneasy" as direct antonyms

> (a) <u>easy</u> *free from worry or anxiety "knowing that I had done my best, my mind was easy" "an easy good-natured manner" "by the time the child faced the actual problem of reading she was familiar and at ease with all the elements words"*
>
> ### Antonyms (1)
> From easy:
>
> > (a) <u>uneasy</u> *lacking a sense of security or affording no ease or reassurance "farmers were uneasy until rain finally came" "uneasy about his health" "gave an uneasy laugh" "uneasy lies the head that wears the crown" "an uneasy coalition government" "an uneasy calm" "an uneasy silence fell on the group"*

Note. Screenshot retrieved from <u>en-word.net</u>.

This leads us to the conclusion that WordNet sometimes includes antonyms we would not expect, or very context-specific examples, while at other times it does not include the examples we would expect.

5. Conclusions and Recommendations for Future Research

What this thesis set out to analyze is the way adjectival antonyms were represented in OEWN2021 and whether the dumbbell model was an appropriate choice of relating adjectives. Another issue it looked at was if this wordnet includes any context information and if it could be improved with findings of the recent research on antonymy.

The case studies showed that in some instances OEWN includes context information or it has two adjectives in direct antonymy when it is not expected. On the other hand, the analysis has shown that there certainly is room for improvement. Furthermore, the dumbbell model is not entirely adequate for the representation of adjectives and antonyms. Except for relying on word association experiments, another possible explanation for this could be that WordNet was only relational in the beginning and that glosses were added in retrospect. Certain glosses include the context and the noun the adjective modifies, yet there is no cross-POS (part-of-speech) relation, the antonyms of those senses do not apply to the noun included in the gloss, or there is another one which collocates more frequently.

We can say that antonymy in WordNet is lexical in the sense that "the best" or the most canonical antonyms are direct antonyms, but even that is not always the case. It is not lexical enough in the sense that some satellites could have been paired with an antonym other than their indirect antonym. Even though they are conceptually related to their indirect antonym, they may have a better lexical pairing which was not linked to them.

The drawback of the dumbbell model for Sheinman et al. (2013) is that all satellites of a head antonym are at the same distance from it. This would mean that all the satellites have equally similar meaning to the head adjective which is not the case. Therefore, Sheinman et al. (2013) propose a reorganization of the gradable adjectives using the AdjScales method. This scale is an intensity scale which was proposed to be linked to a half of a dumbbell and it would express a different value of a gradable property. While this method may be more suitable if we need WordNet to analyze the intensity of statements or if we need sentiment analysis but if we need to understand polysemous adjectives then we also need to link its different senses to the nouns they modify.

WordNet can be improved to be more contextual and conceptual but there will always be a gap between the language use, in which any two adjectives can be contrasted in a certain context, and the lexical resource that simply cannot account for endless possibilities.

However, one of the possible improvements would be cross-POS links between nouns and adjectives. Linking adjectives to nouns would provide, at least partially, the often (or always) needed context, necessary for choosing the appropriate antonym pair. Using large corpora to analyze and quantify which antonym pairs modify which nouns can help researchers decide which pairs to link to nouns in WordNet. A similar improvement for GermanNet was suggested and demonstrated by Strakatova and Hinrichs (2019). They linked adjectives and nouns into collocations and showed how it can be done on a larger scale. Including antonymic relations among collocations and phrases might also be one of improvements, depending on how frequent or entrenched those collocations are. WordNet creators did propose linking adjectives and nouns but for the purposes of making nouns more distinct: "Where adjectival modification plays a major role in WordNet is in the formation of collocations or compounds that differentiate lexical concepts that are more specific than the basic level" (K. J. Miller, 1998, p. 41). However, we can see that the links or collocations are needed for the purposes of antonymy as well.

Adding frequency information would not only be beneficial for representing antonymy, but cross POS co-occurrences as well. We have seen that frequency information is most probably stored in our mental lexicon. Including this information would also greatly benefit second language learners.

The lexicon, together with word meanings and word-relations, is not static but with the methods available nowadays, it is easier than ever to come close to modeling word representations. With the open source methodology employed by Open English WordNet 2021 project, improvements can be easily suggested and implemented if the community decides that it is a valuable addition to WordNet and its applications.

Whether antonymy is lexical or conceptual, it is clear that we need more links between adjectives and between nouns and adjectives as collocations. This would have many advantages and applications, including language learning. After all, as a relational resource WordNet should not suffer from the lack of relations nor should they be its drawback.

This thesis only observed a small fraction of WordNet and only those nouns that were modified by a member of a pair but not by the other member. What should be researched more are the rest of the nouns and if the members of the pairs are good antonyms in the context of those nouns too. The frequency of co-occurrence and collocational information can be added with the FrAC module (Chiarcos et al., 2020) which was described in 2. 3. 3.

The following conclusions can be drawn: the current dumbbell model is not the best representation of adjectival antonymy and it can be improved with the scale of intensity

for gradable adjectives, collocational information and more relations between the nouns and adjectives so that WordNet, originally a lexical resource, can be more conceptual; WordNet does include contextual information but not consistently and sometimes where we do not expect it. Therefore, this thesis proposes a review of the glosses of the entries and the addition of the nouns the adjectives often collocate with in those senses.

By being in the repository of the Faculty of Philosophy, this thesis is also hoped to bring WordNet closer to the faculty's students and potentially inspire some students to think about a wordnet for their L1 (Bosnian, Croatian, Serbian) or another language they are studying. The technical side of wordnets, their construction which requires a large team of people, as well as its gaps, might discourage students of linguistics to pursue research in the field of computational lexicography but it is a field in which linguists are very much needed and where there is certainly room for improvement.

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