

**Natural Language Processing**  
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**Lecture - 36**  
**Lexical Semantics**

Hello everyone. Welcome to the week eight of this course. In the last week we had started discussions on semantics and we discussed a particular method for caption semantics that were distribution semantics; so how we can use the distribution patterns of words in a corpus to extract meanings out of that. And we said that how we can compare two words to find out if they are more similar than another pair of words.

So, in this week what we will be doing, we will be taking another approach of semantics that is by using the connections that we see among items in lexicon. And that is where we will also see how to use a very important resource that is word net for extracting meaning some between words. So, topic for this week is Lexical Semantics.

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*Lexical Semantics*

*Definition*

**Lexical semantics** is concerned with the systematic meaning related connections among lexical items, and the internal meaning-related structure of individual lexical items.

To identify the semantics of lexical items, we need to focus on the notion of **lexeme**, an individual entry in the lexicon.

*What is a lexeme?*

**Lexeme** should be thought of as a pairing of a particular orthographic and phonological form with some sort of symbolic meaning representation.

- Orthographic form, and phonological form refer to the appropriate form part of a lexeme
- Sense refers to a lexeme's meaning counterpart.

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So, how can we define lexical semantics? So, as I am saying what we are doing in this topic, we will see some entries in a lexicon and we will try to identify what is the relation between these generatives. So, we will have some particular set of relations and we will try to define this relation among these entities. So, in that way we can define this field. So, lexical semantics is concerned with the systematic meaning related connections

among lexical items. So, I will have a certain lexical items in my lexicon, and I will try to find out what are the connections between any two items and we will be also see what are the internal meaning related is structure of individual lexical items.

So, what you are seeing here? We are not focusing our attention to something called a lexical item. So, what is the lexical item? So, lexical item I there is another term for that this called lexeme. So, this is nothing, but an individual entry in my lexicon. So, here I am talking about connections among different lexical items and what is the single entity it will call a lexeme and we will mostly we talking about in terms of lexemes. Now so if we try to understand intuitively, what would be there in an entry in a lexeme entry, what are the things that I need to keep in an entry? So, because I am also talking about the meaning, if a word as multiple meanings it should not be called like a single lexeme it should be called as two different lexemes.

So, when I talk about lexeme, what all things I need to have? I need to have what is the form; so how do I spell that, how do I pronounce that and also some something that says what is the meaning of this particular entry. So, these are the two important components that make like a lexeme. So, I will have. So, I can think of lexeme as a pairing of some orthographic and phonological form, that is how do you write the lexeme, how do you pronounce that and with some sort of symbolic meaning representation. Something that might be definition of the lexeme or something that explains what this it is stands for.

So, when I talk about orthographic form and phonological form, they are the form part of the lexeme and then I have a science part of the lexeme that talks about the meaning of the lexeme. So, if we have seen in various dictionaries that is all the entries are also defined.

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*Example*

**verge**<sup>1</sup> | vɜːdʒ |  
noun  
an edge or border: *they came down to the verge of the lake.*  
• an extreme limit beyond which something specified will happen: *I was on the verge of tears.*  
• (lit.) a grass edging such as that by the side of a road or path.  
• Architecture an edge of tiles projecting over a gable.

verb [no obj.] (**verge on**)  
approach (something) closely; be close or similar to (something): *despair verging on the suicidal.*

ORIGIN late Middle English: via Old French from Latin *virga* 'rod.' The current verb sense dates from the late 18th cent.

**verge**<sup>2</sup> | vɜːdʒ |  
noun  
a wand or rod carried before a bishop or dean as an emblem of office.

ORIGIN late Middle English: from Latin *virga* 'rod.'

**verge**<sup>3</sup> | vɜːdʒ |  
verb [no obj.]  
incline in a certain direction or toward a particular state: *his style verged into the art nouveau school.*

ORIGIN early 17th cent. (in the sense '*descend to the horizon*'): from Latin *vergere* 'to bend, incline.'

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So, let me take one example. So, this is example from the dictionary that comes with mac. So, you are having suggested single word like verge, but it appears size 3 different lexemes. So, we are having verge one, verge two and verge three and do I see the pair the form part in the meaning part? So, form part is giving on top for each entry. So, I have the spelling, so that is the same for all 3, then I have the pronunciation also; then there are certain descriptions about this entry that that correspond to what is the meaning of this entry.

For example you might have the lexical creditory of that. So, it is a noun, it is a noun, it is a verb and then there is some meaning like an edge or border they come down to the verge of the lake. So, also given an example how it is used and some history of the words also provide it. So, when I talk about lexeme that is what I need. I need a form part that can be the spelling of the lexeme plus the pronunciation, and the meaning part. Once I have done that now we can try to establish relations between various lexemes in my lexicon or each lexical item in my lexicon.

So, now what are the various meaning related facts you can extract from the, with the lexemes and defined in my dictionary.

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*Example: meaning related facts?*

*Definitions from the American Heritage Dictionary (Morris, 1985)*

- **right** *adj.* located near the right hand esp. being on the right when facing the same direction as the observer
- **left** *adj.* located near to this side of the body than the right
- **red** *n.* the color of blood or a ruby
- **blood** *n.* the red liquid that circulates in the heart, arteries and veins of animals

- The entries are description of lexemes in terms of other lexemes
- Definitions make it clear that *right* and *left* are similar kind of lexemes that stand in some kind of alternation, or opposition, to one another
- We can glean that *red* is a color, it can be applied to both *blood* and *rubies*, and that *blood* is a liquid.

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So, let us take some examples from this heritage American heritage dictionary. So, is 1985 version and what we are seeing here; we are seeing four different entities here right, left, red and blood they are 4 different lexemes in my in this dictionary and some meaning of these entities are also provided. So, for example, right is defined as located near the right hand especially being on the right when facing the same direction as the observer; and left is defined as located near to this side of the body then the right. So, this is some definitions provided to these lexemes.

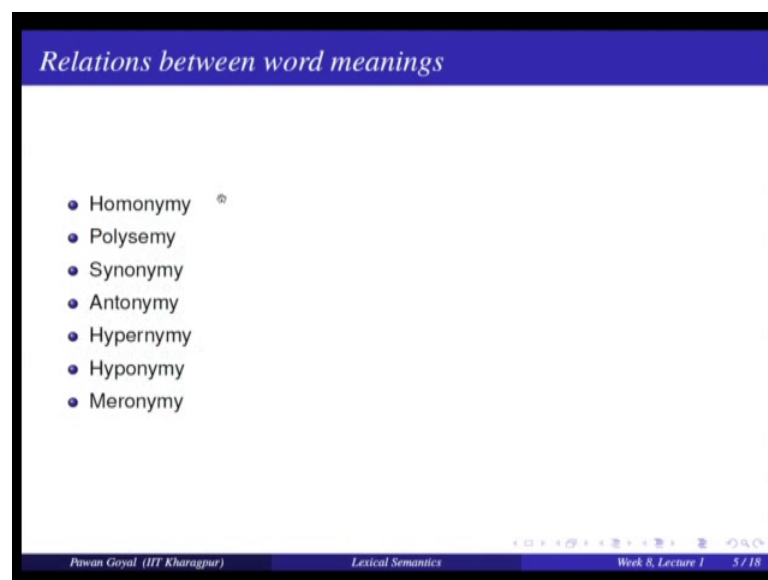
Now, what is something that you can immediately some point that you can immediately see from these definitions? So, one thing that you see is that the word right has been defined terms of right; this is some sort of circular definitions, if you say in that way and also lexemes are defined in terms of other lexemes. So, like here red the color of blood or a ruby and blood is defined the red liquid. So, blood is defined in terms of red and red is defined in terms of blood. So, we see that there is some sort of circularity involved here in the way we have defined in the lexicon.

But even if that is the case you can still extract some sort of meanings for example, if you see the definitions of right and left, you can easily find out that they are somewhat related, their meanings are very much related and you might also say that they might be in some sort of ultravation with respect to each other.

So, what do we see here? So, the entries are description of lexemes in terms of other lexemes and from the definitions I can see that right and left are some similar sort of lexemes and they are in some sort of alternation or opposition. Also from these definitions we can see that red is some sort of color and it can be apply to blood as well as ruby and blood is some liquid. So, you might extract some other facts about the lexemes also from these entries.

Now, in general; so when I am talking about identifying what is the connections of different between different entries, what are the various formal connections that have been defined, and what are the relations that we can study?

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So, let us have a look at some of the relations. So, these are some very important relations that are established between word meanings and forms. So, like Homonymys Polysemy, Synonymy, Antonymy, Hypernymy, Hyponymy and Meronymy and you might have heard of some of the list terms like Polysemy which very very popular and similarly synonymy and Antonymy so these we might already have heard. So, let us try to formally define what are these relations and when do I say that to and it is my lexicon are connected by a participation from one of these

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**Homonymy**

*Definition*

**Homonymy** is defined as a relation that holds between words that have the same form with unrelated meanings.

*Examples*

- Bat (wooden stick-like thing) vs Bat (flying mammal thing)
- Bank (financial institution) vs Bank (riverside)

*homophones and homographs*

**homophones** are the words with the same pronunciation but different spellings.

- write vs right
- piece vs peace

**homographs** are the lexemes with the same orthographic form but different meaning. Ex: bass

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So, how do I define homonymy? So, homonymy is defined as a relation that holds between words that have the same form, but unrelated meanings. So, what is that mean? So, we have defined an individual entry in my lexicon as having a form part and a meaning part. So, now, if two entities have the same form part, but the meaning part is different then they will be called homonyms. Now can you think of an example of two such or a single word that has the same form, but two different meanings. So, a simple example might be like the word bank. Bank can be the financial institution bank or it can be some river bank. Similarly bat it can be for the cricket bat or it can be the bat as a mammal. So, what you are seeing here? They are having the same form, but different meanings.

So, these are two examples that we talked about. Now so there is one important thing that you should remember here. So, we are seeing that they have the same form, but different meanings, but we have defined form to be both orthographic form and phonological form. So, it might happen that in certain cases, the orthographic form is same and meaning is different and in some cases the phonological form is same and meaning is different; they are called homonyms, but there are specific terms for both of these and these are called homographs, if there is the same orthography and homophones if there is the same phonological form.

Let us see some example, so homophones are the words that have the same pronunciation, but different spellings, and different meanings also. So, examples here are write and right; there is the same homological form, they are written differently and their meanings are different. Same with piece and peace and homographs would be the lexemes and that the same orthographic form, then they would have may be the different pronunciation and different meaning all to gather. So for example, the two different usage of bass, one in the sense of (Refer Time: 10:28) in the sense of a guitar or music.

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*Problems for NLP applications*

*Text-to-Speech*  
Same orthographic form but different phonological form

*Information Retrieval*  
Different meaning but same orthographic form

*Speech Recognition*  
to, two, too  
Perfect homonyms are also problematic

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Now, now why do we need to worry about this homonymys? So, we will see, what are the different NLP applications, where they create a problem? So, let us take this example of text to speech. So, do you think these homon, homophones or homographs would create a problem for text to speech? So, what do we do in text to speech? In text to speech you would have a text contain written, it can be a sentence where there are multiple words together and you need to speck that out. So, why the homophones or homographs can create a problem for that now think of the same word that as the particular spelling, but it is pronounce into different ways into different meanings. So, unless you know what is the particular sense it is being implied you cannot pronounce it properly.

So, if the of orthographic form is same, but the phonological forms are different that creates a problem for text to speech. Now it can also create the problem for information

retrieval; why the problem for information retrieval? So, suppose you are looking for the term bat and by bat you implied the mammal, but suppose the system gives you cricket bat as the desired or as the page edge that that you will look for, and immediately it will not match your information need.

So, what would happen if the same word has multiple meanings, if you are searching for that word, because you are only specifying the orthographic form, it may not be clear to the search engine what is the meaning that you are looking for. So, these also create a problem for the search engines.

And it might be a problem for the speech in (Refer Time: 12:26) also for example, the perfect homonyms or homophones, where you have the same phonological form, but different way of writing that. So, suppose you are writing to suppose you are speaking to. So, it may not be clear, which of the 3 words should be the correct interpretation, whether it is to or to or two, two, two. So, these are also problematic for speech reorganization. So, these are some problems where they create a problem. Now suppose the systems have to deal with that.

So, how do they find out when I am talking about to is it to or is it two or double o and for that they have to use various information from the context in which that is spoken or something about the speaking and so on and some of the problems of this kind we will also deal in this week in the topic of word sense disambiguation, that if a word has multiple meanings how do I use the context to identify, what is the particular meaning is being used here.

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**Polysemy**

*Multiple related meanings within a single lexeme.*

- The *bank* was constructed in 1875 out of local red brick.
- I withdrew the money from the *bank*.

*Are those the same sense?*

- Sense 1: "The building belonging to a financial institution"
- Sense 2: "A financial institution"

*Another example*

- Heavy snow caused the roof of the *school* to collapse.
- The *school* hired more teachers this year than ever before.

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So, now coming to the second relation that is Polysemy; So, Polysemy and homonymy might be confused with a certain times. So, Polysemy is also the same sort of relation that is a word as multiple meanings, but the same form, but the difference here is these meanings are very related and not unrelated tight we had in the case of homonymys. So, in case of homonymys, 2 words have same form, but very different meanings for Polysemy they have the same form and slightly related meanings not very very similar and not very very different also.

So, what is the example? Let us focus on the Word bank here in the two sentences in the first sentence we see, the bank was constructed in 1875 out of local red brick. And second one is the sentence I withdrew the money from the bank. So, as such if you look at these sentences you may feel that. So, there the same Word bank is being used in for the same sense, but if you look closely you find there is some slightly some slight difference between the meanings of the Word bank. So, what is the difference here? In the first sentence the bank is used as some sort of building that belongs to a financial institution.

On the other end second sentence it belongs to the financial institution itself and that sort of slight gradation in meaning is there in many such words. For example, let us look at these two sentences, heavy snow caused the roof of the school to collapse and the school hired more teachers this year than ever before. So, again the same word school is being

used as they look the same sense, but again if you look closely, this refers to the building of a school and this refers to the institution a school as such or their administration.

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*Polysemy: multiple related meanings*

*Often, the relationships are systematic*  
E.g., building vs. organization  
*school, university, hospital, church, supermarket*

*More examples:*

- Author (Jane Austen wrote Emma) ↔ Works of Author (I really love Jane Austen)
- Animal (The chicken was domesticated in Asia) ↔ Meat (The chicken was overcooked)
- Tree (Plums have beautiful blossoms) ↔ Fruit (I ate a preserved plum yesterday)

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So, and these relations are called systematic. So, for example, if you look at these words school, university, hospital, church, supermarket all of these can be seen as the building as such or the institution and that is why the two meanings would be slightly related, they are not very very different and not exactly the same. There are some other examples like you can have the make the connection between the author and the works of author. So, if I say Jane Austen wrote Emma some talking about the author, on the other hand if I say I really love Jane Austen. So, what do your meaning is that? I really love the works of the author. So, author in works of author again appearing some sort of slightly different meaning side that is that is observed by this term Polysemy.

Similarly animal versus meat; so, when you (Refer Time: 16:52) chicken it can be animal or meat. Similarly sometimes it can be tree versus fruit and this kind of relation like if I say plums. So, in these sentence plums have beautiful blossoms, plums mainly refer to the tree, but here I ate a preserved plum, plum would be a fruit. So, again there are very slight distinctions between the meanings here.

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*Polysemy: multiple related meanings*

*Zeugma test*

- Which of these flights *serve* breakfast?
- Does Midwest Express *serve* Philadelphia?

*\*Does Midwest Express serve breakfast and San Jose?*

*Combine two separate uses of a lexeme into a single example using conjunction*

Since it sounds weird, we say that these are two different senses of *serve*.

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Now, in linguistics, suppose I want to distinguish identify if the same word is being is into different sentences, it is been used in slightly different meanings or is the word Polysemy somehow. So, what is one particular linguistic test that we can do and this test is called zeugma test and what is the idea? Suppose the same word has been used in two different sentences; now try to compose a single sentence where the word has been used only once and the two different usages have been captured by some sort of conjunction, and see if this sentence is making sense already is looking weird. If the sentence is making sense so probably this word as the same sense in both the sentences, but if the sentences looks weird then you (Refer Time: 18:11) there are Polysemys.

So, here is an example. So, I have the same words serve being used in two different sentences. So, which of these flights serve breakfast and does Midwest express serve Philadelphia? Now I want to find out if there is some Polysemy involved in the usage of the word self here. So, what I would do? I would combine these 2 usages together in a single sentence. So, what can be one sentence we can compose out of this? So, you can compose like does Midwest express serve, breakfast in Philadelphia and immediately we are (Refer Time: 18:48) serving breakfast in Philadelphia putting them together in the same sentence, looks weird. You can put them in to a different sentence, but putting them in same sentence looks weird then we can say that. So, these two usage of the words are Polysemys. So, here does Midwest mist west express serve breakfast and San

Jose? If you put them together, it sounds weird so we say that they are two different senses of the word serve.

So, that is what we have covered Homonymy, Polysemy remember they are very very it may not be easy to distribution among the two; in Polysemy they are quite related, in Homonymy they are very very different. In general if you might also, you might in general you might say that word is (Refer Time: 19:38) you note that the word has multiples senses. Now the next relation that we will see is synonymy, what is synonymy; two words that have very very similar meanings but different orthographic and phonological form.

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*Synonymy*

*Words that have the same meaning in some or all contexts.*

- filbert / hazelnut
- couch / sofa
- big / large
- automobile / car
- vomit / throw up
- water /  $H_2O$

Two lexemes are synonyms if they can be successfully substituted for each other in all situations.

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So, examples are like couch and sofa; they have same meaning different words big and large, automobile car, water  $H_2O$ . So, now, what is a important here is these two words are similar meanings, but probably they are not substitutable in all the contexts. For example, in scientific context you might want to write  $H_2O$ , but not water. But when you are all talking in general terms you would use the term water crossing you to give you water, you will not ask give you  $H_2O$ . So, all though the meanings might be very very singular, depending on the context you use one word or the other.

So, as such we can call two lexemes are synonyms, if they can be successfully substituted for each other in all situations, but this not actually the case we cannot; in

general you cannot substituted them in all the places you can probably do them most to the places, but not (Refer Time: 20:58).

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*Synonymy: A relation between senses*

Consider the words *big* and *large*.

*Are they synonyms?*

- How **big** is that plane?
- Would I be flying on a **large** or small plane?

*How about here?*

- Miss Nelson, for instance, became a kind of **big** sister to Benjamin.
- \*Miss Nelson, for instance, became a kind of **large** sister to Benjamin.

*Why?*

- *big* has a sense that means being older, or grown up
- *large* lacks this sense

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So, now, let us take an example. So, I take two words big and large and let us see these sentences; how big is that plane? I can also write how large is that plane. So, would I be flying on a large or small plane? So, with word plane I can use the word either big or large and both are substitutable here.

So, in that sense they look like perfect synonymys, but can I always replace big for large or large for big in all the contexts. Let us see this example; suppose I have the sentence Miss Nelson, for instance became a kind of big sister to Benjamin and suppose I replace big by large here, and the sentence comes out to be Miss Nelson for instance became a kind of large sister to Benjamin and immediately you can see that this usage of word large, immediately it starts looking weird and why is that the case? So that means, we cannot substitute large for big, big here and why is that?

So, because you would see that big has a very very specific sense that is being grown up or elder and that sense never applies to the word large. So, big has a sense of being older or grown up, but large as such lacks this sense, it does not have this sense.

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*Synonyms*

*Shades of meaning*

- What is the cheapest first class *fare*?
- \*What is the cheapest first class *price*?

*Collocational constraints*

- We frustrate 'em and frustrate 'em, and pretty soon they make a *big* mistake.
- \*We frustrate 'em and frustrate 'em, and pretty soon they make a *large* mistake.

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Sometimes they are very shades of meaning and some sort some words of being preferred to use them other words, like when you are talking about what is the cheapest first class fare? We will talk about you will prefer to say fare then price. Sometimes there are Collocational constraints. So, with some particular words only one word goes not the other one, even if they have very very similar meanings.

For example before mistake; would you like big mistake or large mistake, generally big mistake is preferred. So, here this is the sentence. So, we frustrate em and frustrate e m and pretty soon they make a big mistake and we would not substitute large here. So, large mistake is not Collocational, but big mistake is Collocational. So, because of language usage also some words are preferred to be used then others. So, they cannot be substituted at all places probably in some places.

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**Antonyms**

- Senses that are opposites with respect to one feature of their meaning
- Otherwise, they are similar!
  - dark / light
  - short / long
  - hot / cold
  - up / down
  - in / out

*More formally: antonyms can*

- define a binary opposition or at opposite ends of a scale (*long/short, fast/slow*)
- Be **reversives**: *rise/fall*

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Now, coming to the next relation that is antonyms; so here I say that; so, what is the general notational the general definition of antonyms two words if they are entirely opposite to each other they are opposite to each other; but this is something interesting about antonyms. So, two words antonyms if they are completely; so we said that they are having very very opposite meanings, but in general if you look closely, they will have very very related meanings, but they are opposites only in word particular aspects. So, let us take one example, see like hot and cold. So, do you call them are they related or are they very very different. So, as such they are related, they both talk about temperature yes, but they are at the opposite ends of the history extreme. So, we will say it is cold one extreme and hot is the other extreme, but as such both talk about temperature.

And suppose you try to use the distribution semantic method that we tried in the last week, to capture if two words are antonyms. It might become very very difficult, because we would occur in very very similar contexts yes. So, hot and cold occur with words like weather yes temperature and so on. So, what we are saying in antonyms, they are having very very similar meaning, but they are opposite only in one aspect of the meaning. So, like dark and light, short and long, hot and cold, up and down, in and out; they are opposite only in one aspect otherwise they are similar.

So, more formally we can say that antonyms can define some sort of binary opposition or at opposite ends of a scale. So, like long and short, hot and cold, fast and slow, and be reversives it is like rise and fall.

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**Hyponymy and Hypernymy**

**Hyponymy**  
One sense is a hyponym of another if the first sense is more specific, denoting a subclass of the other

- *car* is a hyponym of *vehicle*
- *dog* is a hyponym of *animal*
- *mango* is a hyponym of *fruit*

**Hypernymy**  
Conversely

- *vehicle* is a hypernym/superordinate of *car*
- *animal* is a hypernym of *dog*
- *fruit* is a hypernym of *mango*

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Now, coming to another important relation that is Hyponymys and Hypernymys; now what are Hyponymys and Hypernymys? So, they are relations between a subclass and a super class. So, formally we say one sense is a hyponym of another, if the first senses more specific and a denotes a subclass of the other. So, example here is like car, car is a subclass of vehicle, so we can say that car is a hyponym of vehicle. Similarly dog is a class of animal, so we say dog is a hyponymy of animal and mango is a hyponymy of fruit, because mango is a type of fruit.

Now, just the other way round the relation would be called hyponymy. So, I say mango is a type of fruit, so fruit is a. So, fruit is a super class. So, mango is a hyponymy of fruit and fruit is a hyponymy of mango. So, conversely we can define the hypernymy relation also. So, vehicle is a hypernym of car, and animal is a hypernymy of dog, and fruit is a hypernymy of mango and these are of some of the relations that we will see very very closely what is. So, how do we use hypernymy relation for extracting various meaning related facts among entities?

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*Hyponymy more formally*

*Entailment*  
Sense *A* is a hyponym of sense *B* if being an *A* entails being a *B*.  
Ex: dog, animal

*Transitivity*  
*A* hypo *B* and *B* hypo *C* entails *A* hypo *C*

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So, with hyponymys we can also defined some formal criteria. So, for example, entailment; if I say that sense is A hyponymy of sense B; that means, being an A entails being a and B. For example, as a dog is a hyponymy of animal dog is subclass, animal is super class. So, being a dog entails being an animal; as it is some entities dog, it is an animal. So, it will have all the characteristics of animal also impose on that and, but you cannot say the other way round, that is some if someone something is a dog animal, it is also called dog this is not valid.

So, if a is A hyponymy of B. I will say being an A entails being a B. You can also define the transitivity relation that is if A is hyponymy of B, B is a hyponymy of C then A is also hyponymy of C; that is also very very trivial condition on hyponymys; so entailment in transitivity.

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*Meronyms and holonyms*

*Definition*

**Meronymy:** an asymmetric, transitive relation between senses.  
X is a **meronym** of Y if it denotes a part of Y.  
The inverse relation is **holonymy**.

meronym	holonym
porch	house
wheel	car
leg	chair
nose	face

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Now, we can also define other relations like Meronymys and Holonyms. So, Meronymy is some sort of asymmetric, but transitive relation between senses what is that? So, I will say X is a meronym of Y, if X denotes a part of Y. So, it is not symmetric; so example is. So, here porch is a part of house or wheel is a part of car. So, to define the part of relation I say wheel is a meronym of car, leg is a meronym of chair, nose is a meronym of face, and the other where round relation is called Holonym that is face is a holonym of nose, car is a holonym of wheel and so on.

So now; so we saw what is the different relation that we can defined among lexical entities. So now, what are the different lexical sources? Where these relations are nicely captured? So, where you can find out what entries are related by the relation of hyponymy, hypernymy and meronymy and use for different tasks or application that you want to bit. And that is what we will see in the next lecture, then we will have a discussions on what is the structure of word net, and how are all these relations defined in word net and how can you can use that to capture various semantics like whether these two words are related or not and to word degree. That will be the topic for the next lecture.

Thank you.