LING 1010

Language and Mind

Prof. Jon Sprouse

02.10.21: Lexical Access

Words are (at least) a pairing of Sound and Meaning

sound **meaning**

[k æ t]

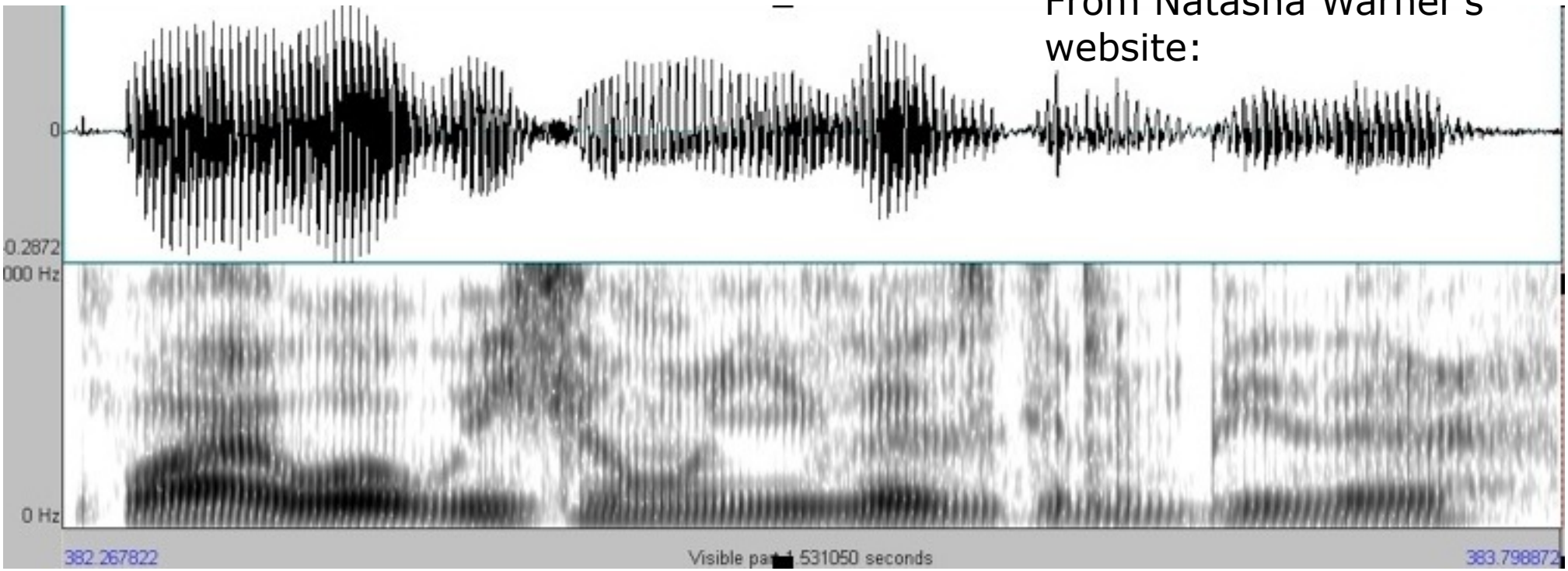
= the word "cat"

A fancier word for "meaning" is **semantics**, and when it comes to words, we call their meaning their **lexical semantics**.

Where is the meaning in the speech signal?

When you listen to speech, you certainly perceive a meaning. But where is it in the signal?

Here is a waveform of speech. Where is the meaning?



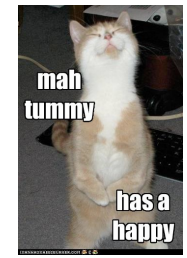
From Natasha Warner's website:

The answer is it comes from your memory!

There is no way to actually transmit meaning in an acoustic signal. Therefore it must be the case that we have the meaning stored somewhere in our memory, paired with sound, and we look up the sound in our memory to find the meaning that is paired with it!

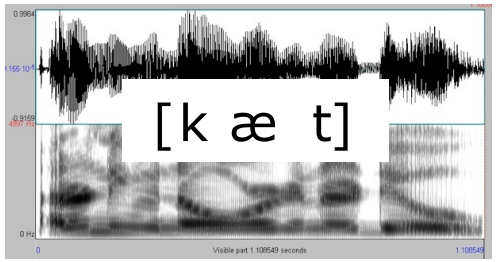
sound **meaning**

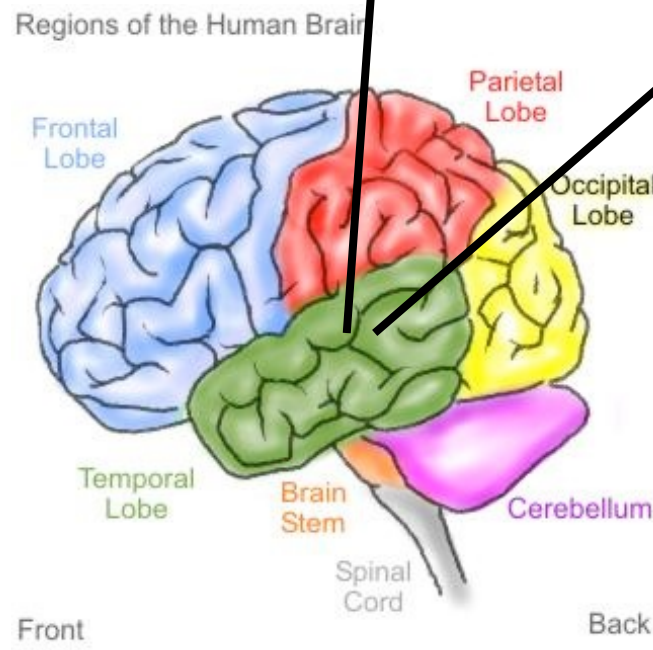
[k æ t]



The physical signal does not contain any meaning.

sound

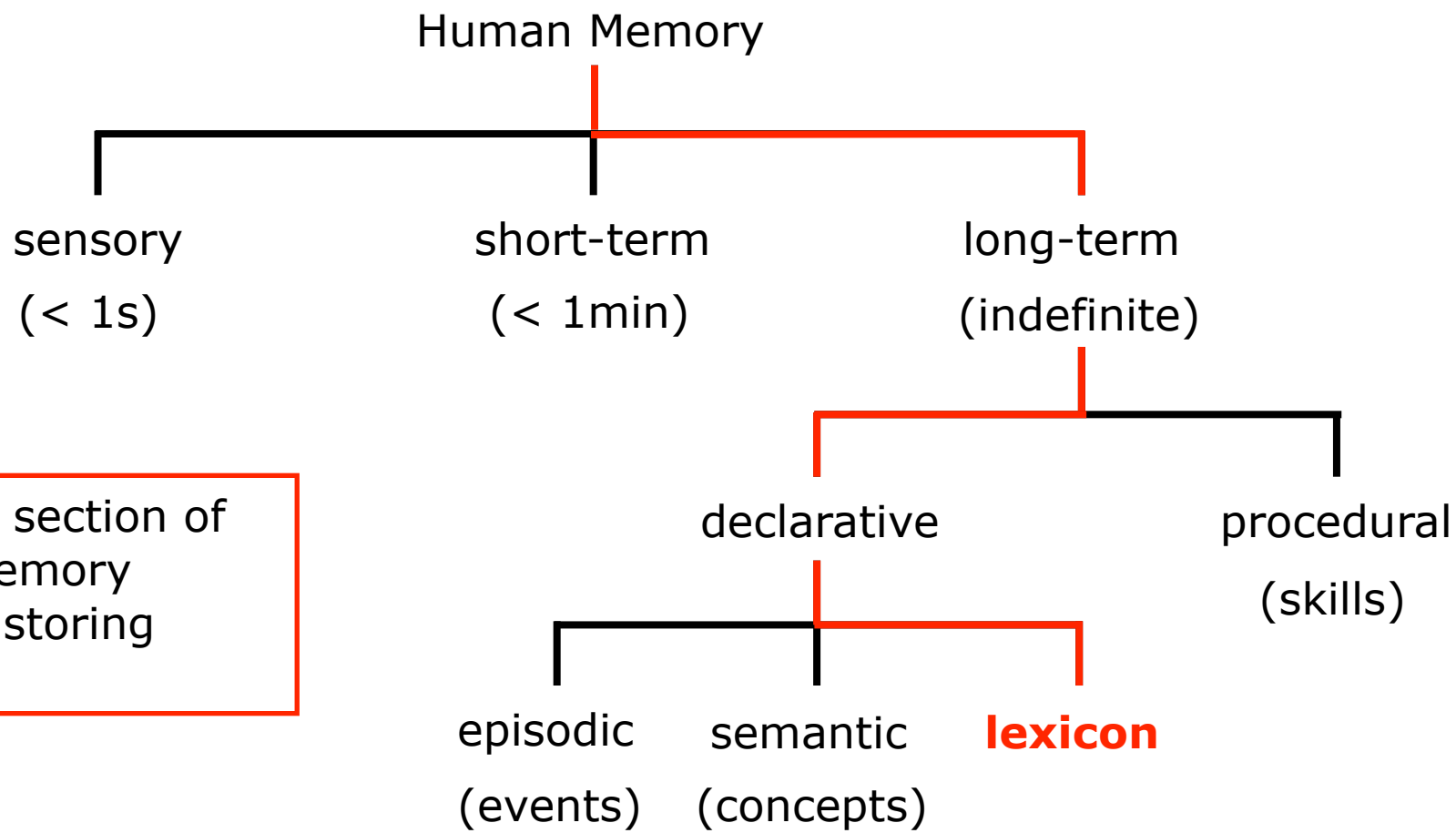




What is the organization of the words stored in our memory?

We need to store words in memory

Human memory is complex. There are multiple different components to human memory, and it is an active area of research all on its own:



lexicon: the section of long-term memory dedicated to storing words

Memory must be organized

Just like books in a library, the items stored in memory must be organized in order to be retrieved effectively.

Words are no different (they are items stored in memory). One major question for us then is **How are words organized in the lexicon?**

Thought experiment!

Imagine that you were asked to figure out the organizational system of books in the library. In other words, you need to figure out where each book is stored inside the library.

Now let’s make it difficult. Imagine that you aren’t allowed to physically go inside the library yourself.

You have to figure out how the books are organized without ever stepping foot inside!

Think about this for a moment. How can you figure out the organizational system of the library if you can’t see it for yourself?

This is exactly the problem we face when studying the lexicon

Just like the library thought experiment, we can't look inside the lexicon to see the organization of the lexical representations.

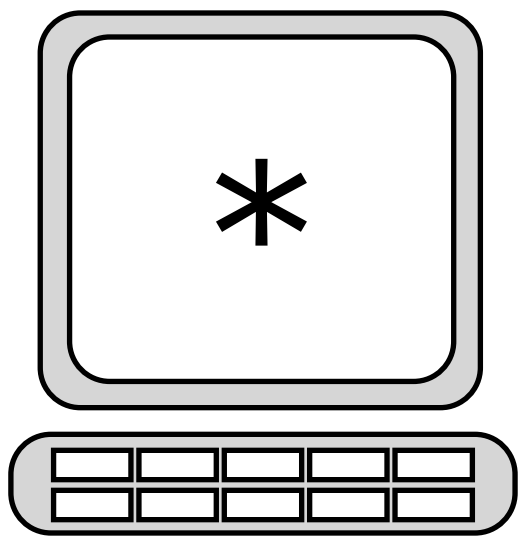
One solution you probably already thought of is to ask somebody else to go into the library for us.

If we send that person in to the library over and over again to get different books, and time how long it takes them to retrieve each book, we will get a rough idea as to the location of each book based on the time it takes to retrieve it.

Timing the retrieval of words: The Lexical Decision Task

The Lexical Decision Task

The lexical decision task: Stare at this cross. When it changes to letters, tell me whether the letters form a “word” or not.



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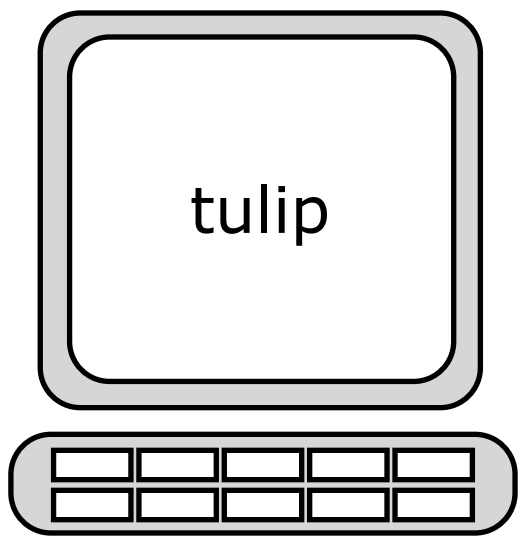

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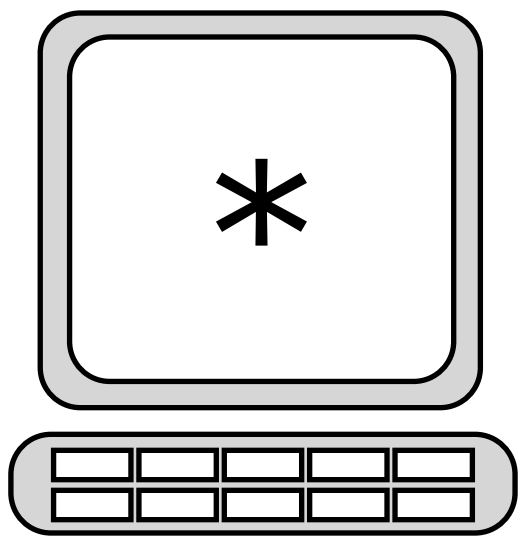

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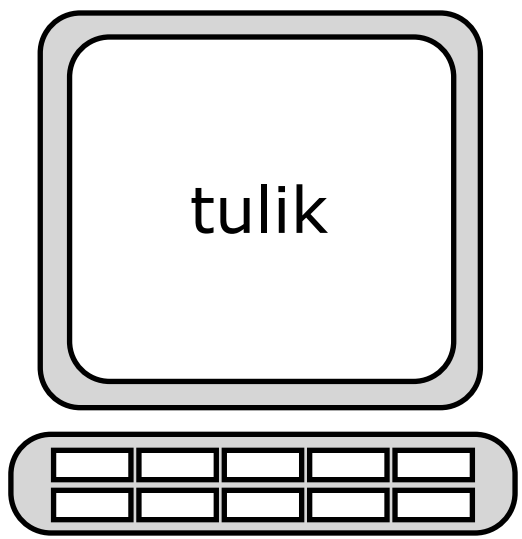

The Lexical Decision Task

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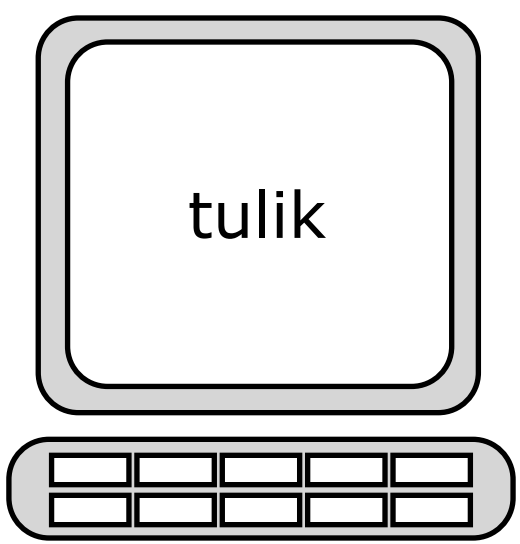
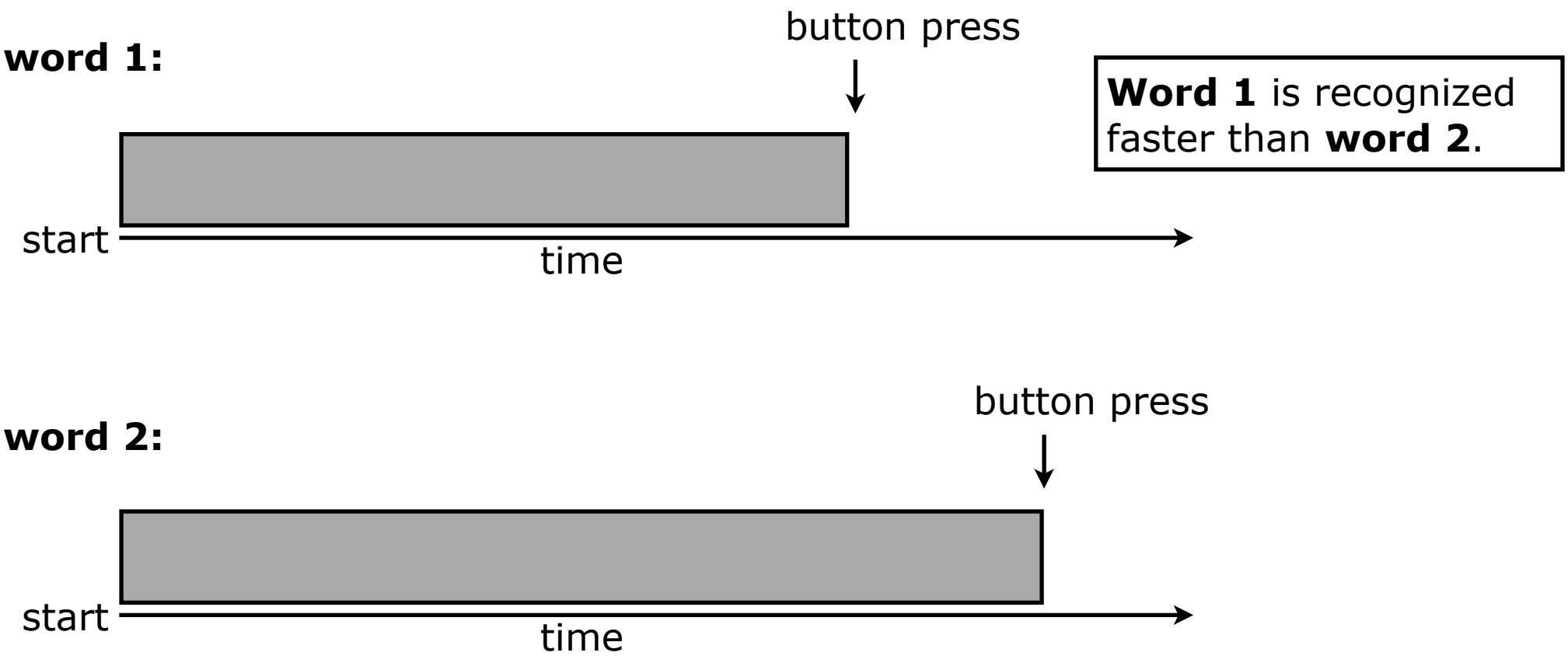
The idea behind the task: In order to say "yes" or "no", you need to access the stored word. This means that the task will engage the processes necessary for **lexical access**.

If we measure the amount of time it takes to respond to a word (the reaction time), we can use it to make inferences about the processes that occurred during lexical access.



The logic of reaction times

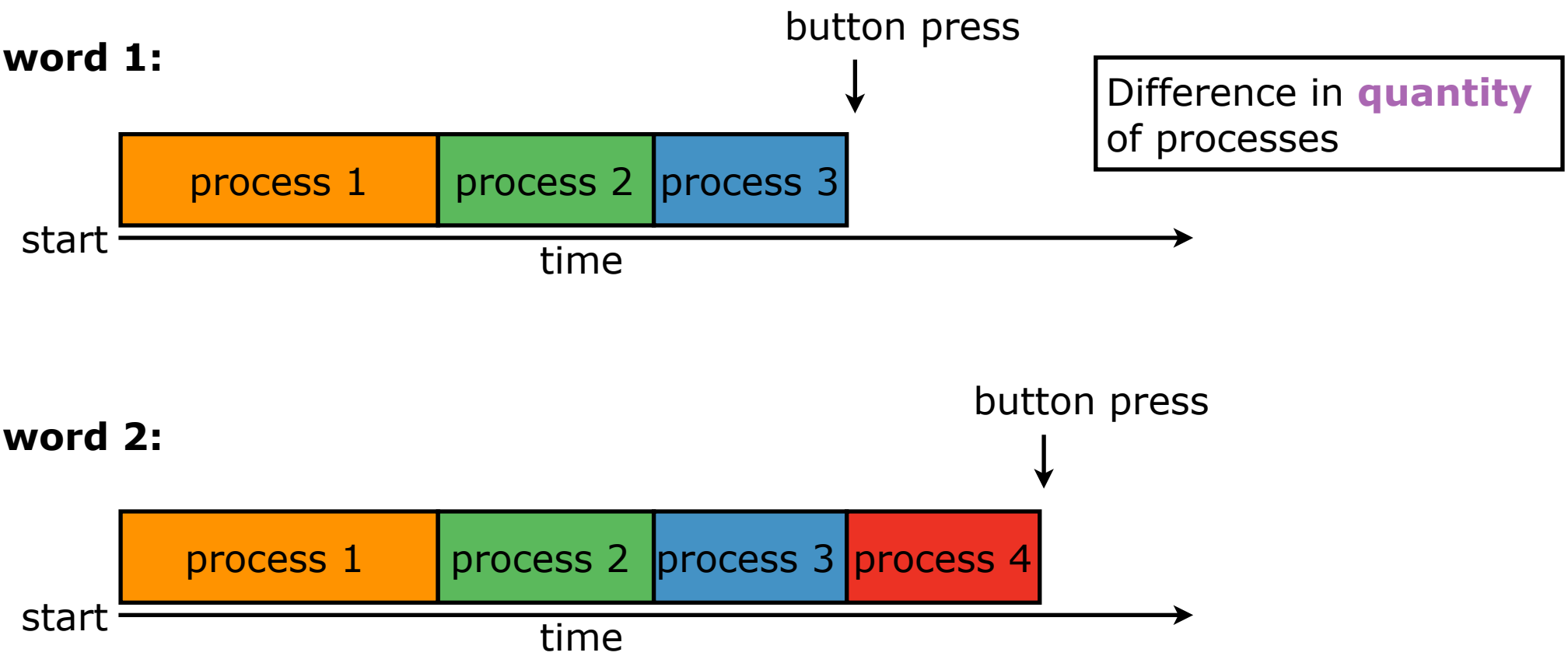
Imagine a lexical decision experiment where we compare two words. All we can measure directly is how long it takes to say "yes" to each word. In the plots below, word 1 is recognized faster than word 2.



The logic of reaction times

Even though the only thing we can directly measure is the button press, we can use **logic** to make inferences about the processes underlying the recognition of the two words.

If the two words differ in timing, then there must either be a quantitative or qualitative difference in processes.



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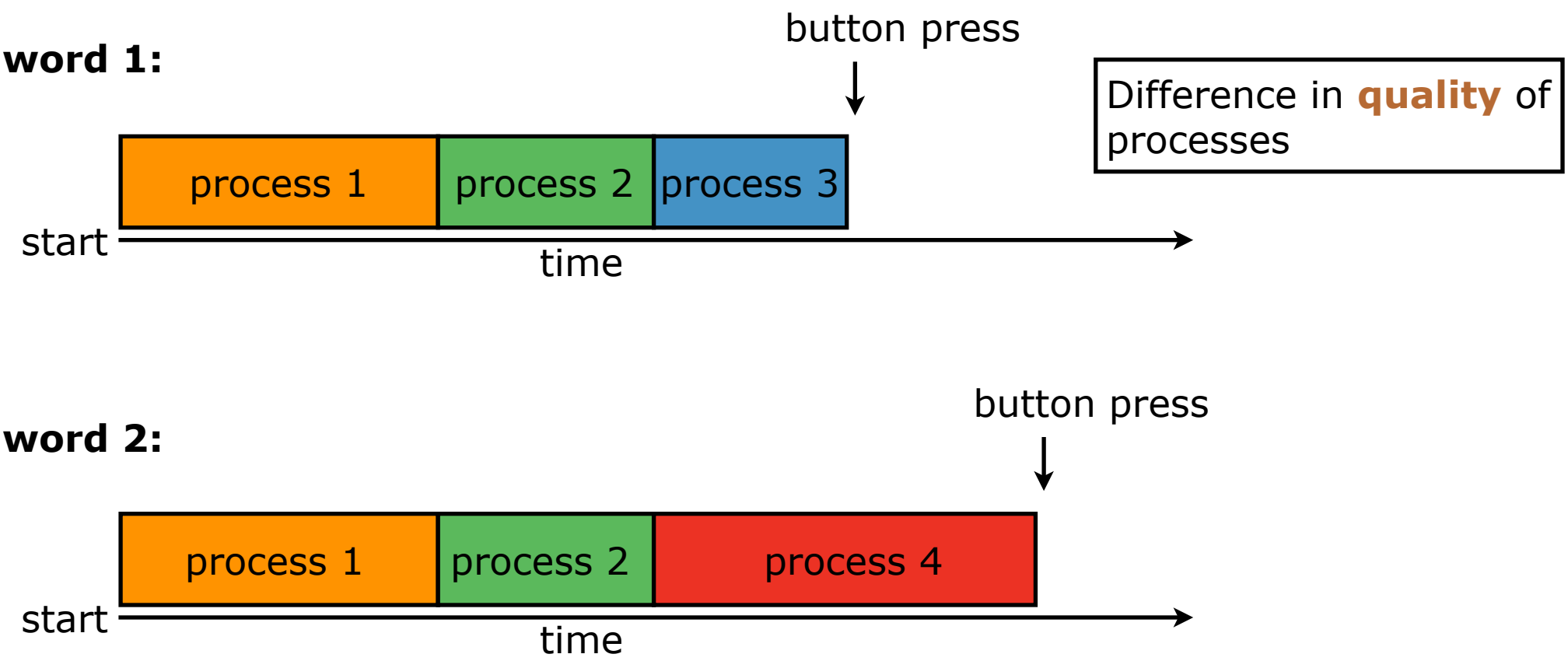


Organizational principle 1: Frequency

Word Frequency

The **frequency of occurrence** of a word is the number of times that a word occurs.

How do we calculate frequency?

A **corpus** is a collection of text that was written or spoken by people. It could be a set of phone conversations, a set of newspaper articles, or even a set of webpages.

The First Hundred

1. the	21. at	41. there	61. some	81. my
2. of	22. be	42. use	62. her	82. than
3. and	23. this	43. an	63. would	83. first
4. a	24. have	44. each	64. make	84. water
5. to	25. from	45. which	65. like	85. been
6. in	26. or	46. she	66. him	86. call
7. is	27. one	47. do	67. into	87. who
8. you	28. had	48. how	68. time	88. oil
9. that	29. by	49. their	69. has	89. its
10. it	30. word	50. if	70. look	90. now
11. he	31. but	51. will	71. two	91. find
12. was	32. not	52. up	72. more	92. long
13. for	33. what	53. other	73. write	93. down
14. on	34. all	54. about	74. go	94. day
15. are	35. were	55. out	75. see	95. did
16. as	36. we	56. many	76. number	96. get
17. with	37. when	57. then	77. no	97. come
18. his	38. your	58. them	78. way	98. made
19. they	39. can	59. these	79. could	99. may
20. I	40. said	60. so	80. people	100. part

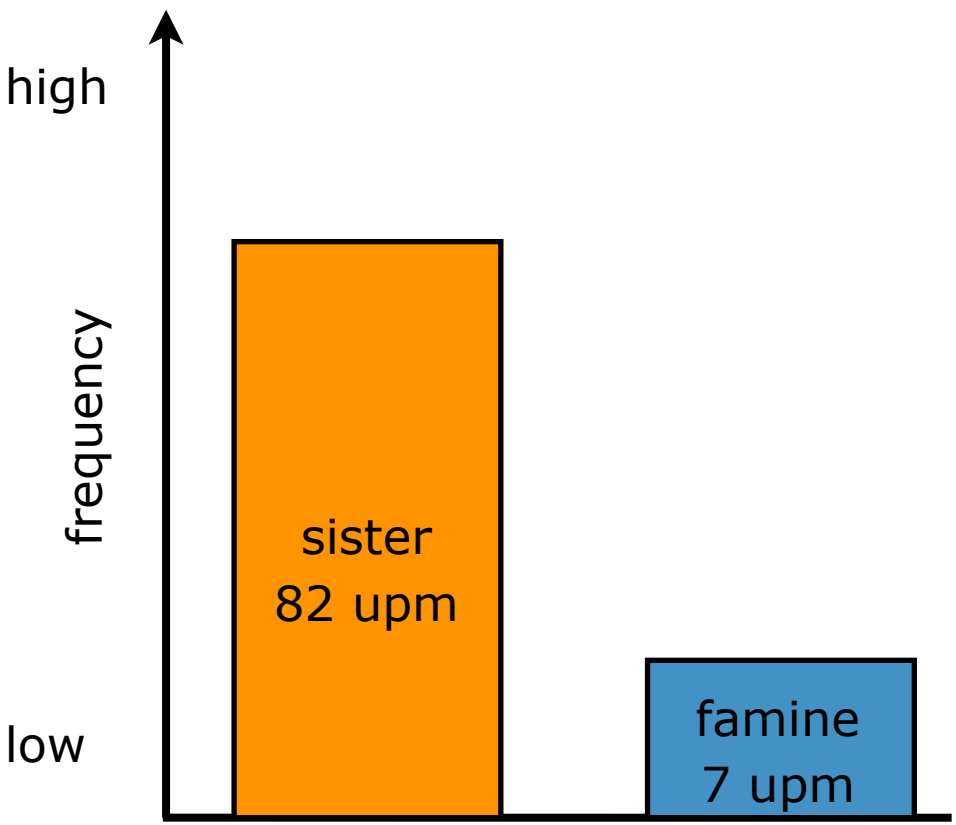
The Frequency Effect

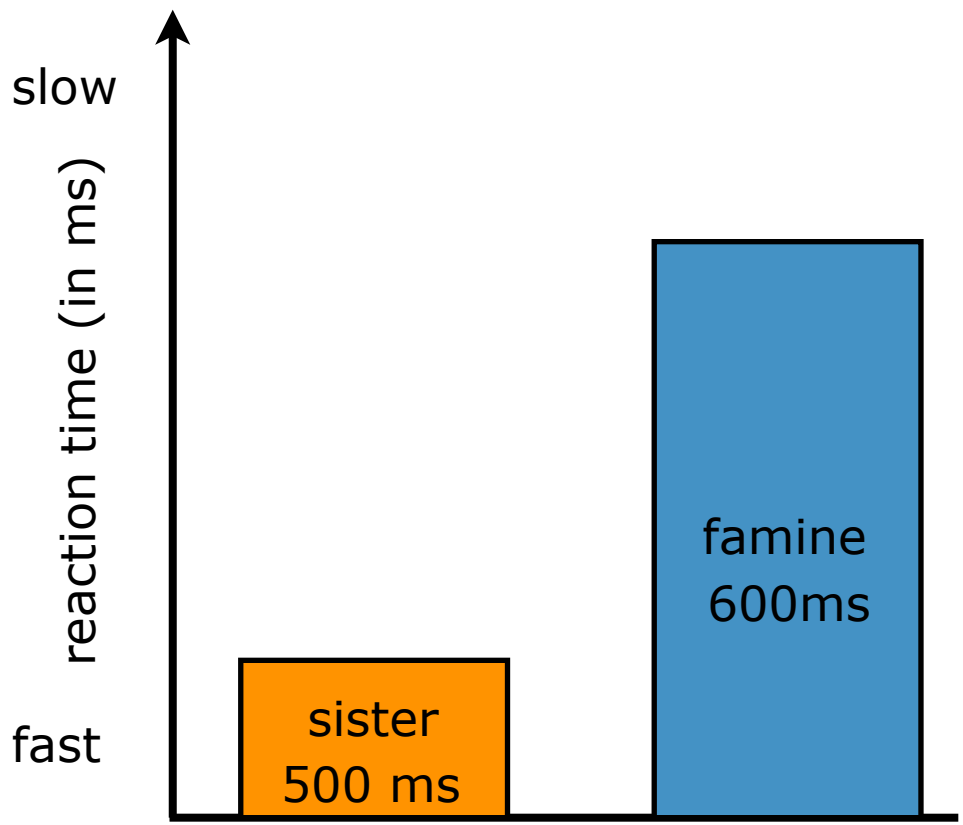
One of the earliest properties that was discovered to affect lexical access is **frequency of occurrence**: the number of times that a word appears.

The frequency effect:

High frequency words have faster lexical decision times.

Low frequency words have slower lexical decision times.



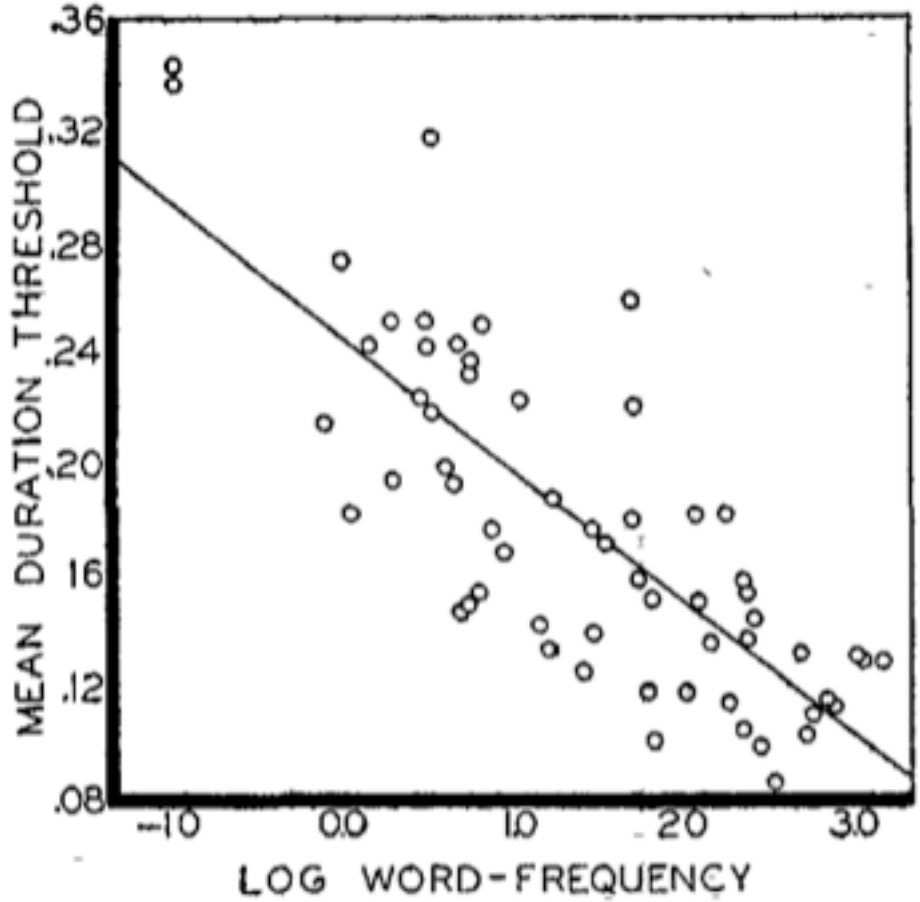


Here's another way to graph it

As the **frequency** of a word **increases** (x-axis), **recognition time decreases** (y-axis)

In other words, you are faster at recognizing higher frequency words

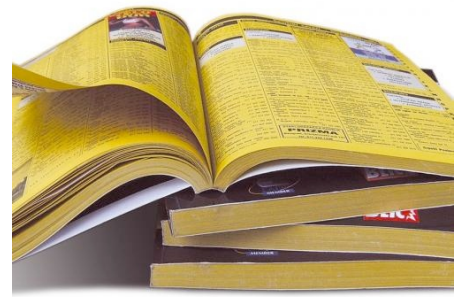
This graph is from the 1951 paper (Howes and Solomon) that first proposed frequency as a predictor of lexical decision time.



The frequency effect is robust, and seems to hold for every language. However, you have to be sure that frequency is the only property of the words that varies. If other properties vary (e.g., length), the frequency effect can be washed out.

The advantage of frequency as an organizing principle

Databases like phonebooks and dictionaries are organized alphabetically. But our personal dictionary (the lexicon) appears to be organized by frequency. Why?



It actually makes some sense. If you have to retrieve items often (e.g., words), then you will want the items that are used the most often to be the easiest to retrieve.

Phonebooks and dictionaries are created so that every entry can be accessed equally easily. But we don't need all words to be equal. There are some that we never use (e.g., defenestrate). The lexicon appears to be organized to maximize efficiency, not equality.

Organizational Principle 2: Semantics/Meaning

What's up with word-association?

Word Association Task:

I'll say a word, and you tell me the first word that pops in your head.

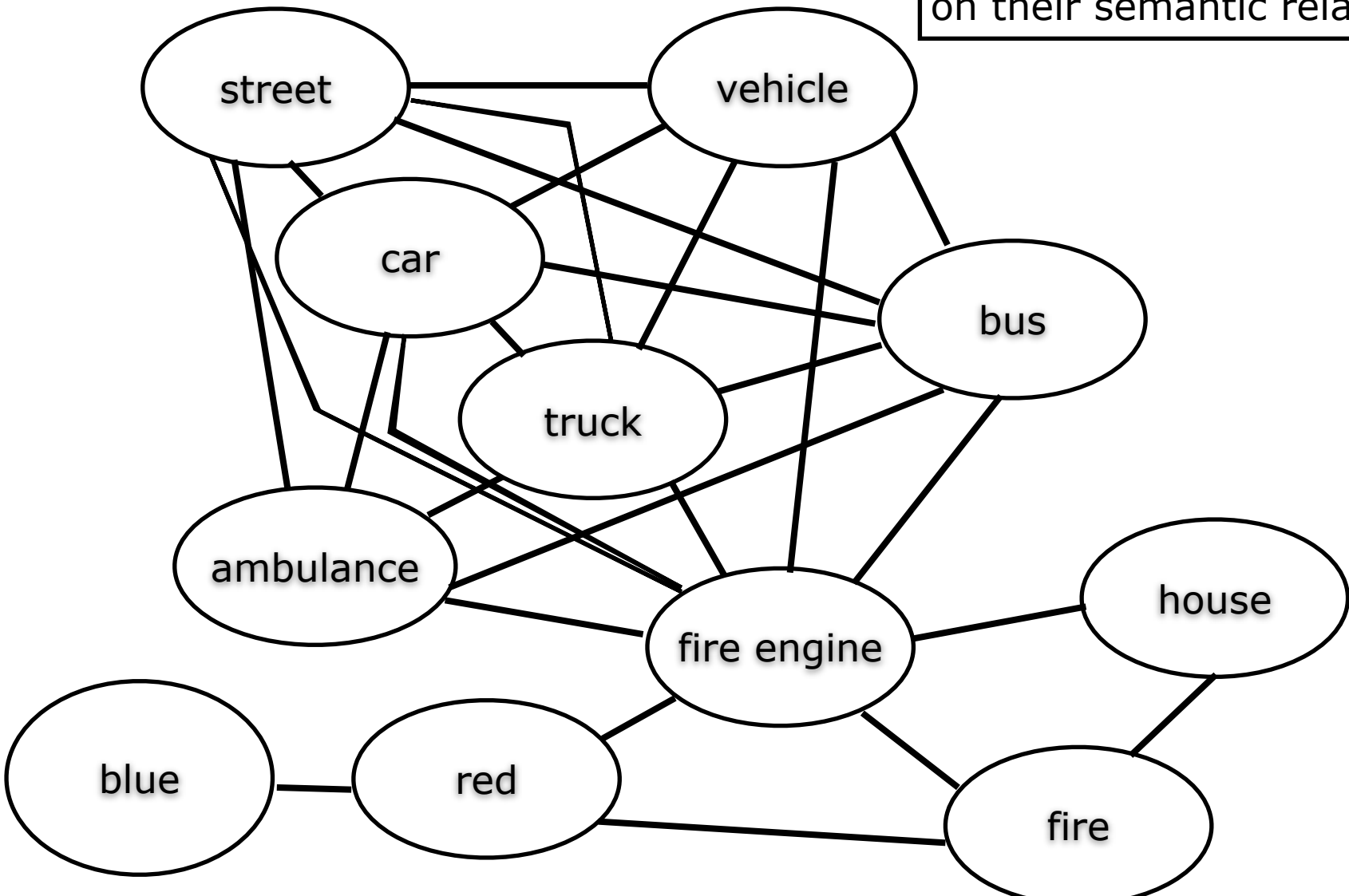
You can look this up yourself at: http://www.eat.rl.ac.uk/

What about Taboo?

https://playtaboo.com/playpage

A semantic network

A **semantic network** is simply the idea that words (or concepts) are connected based on their semantic relatedness.



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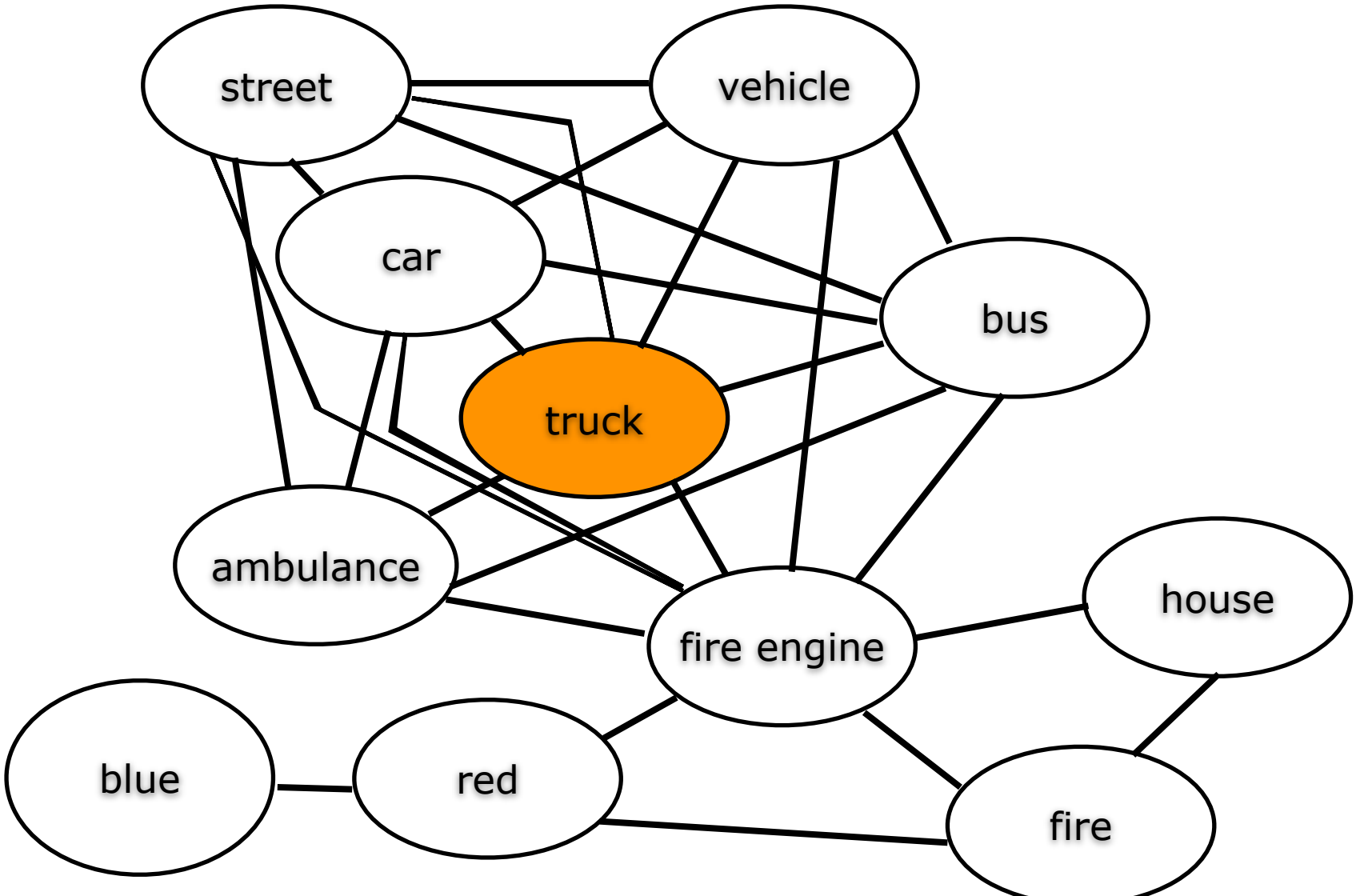

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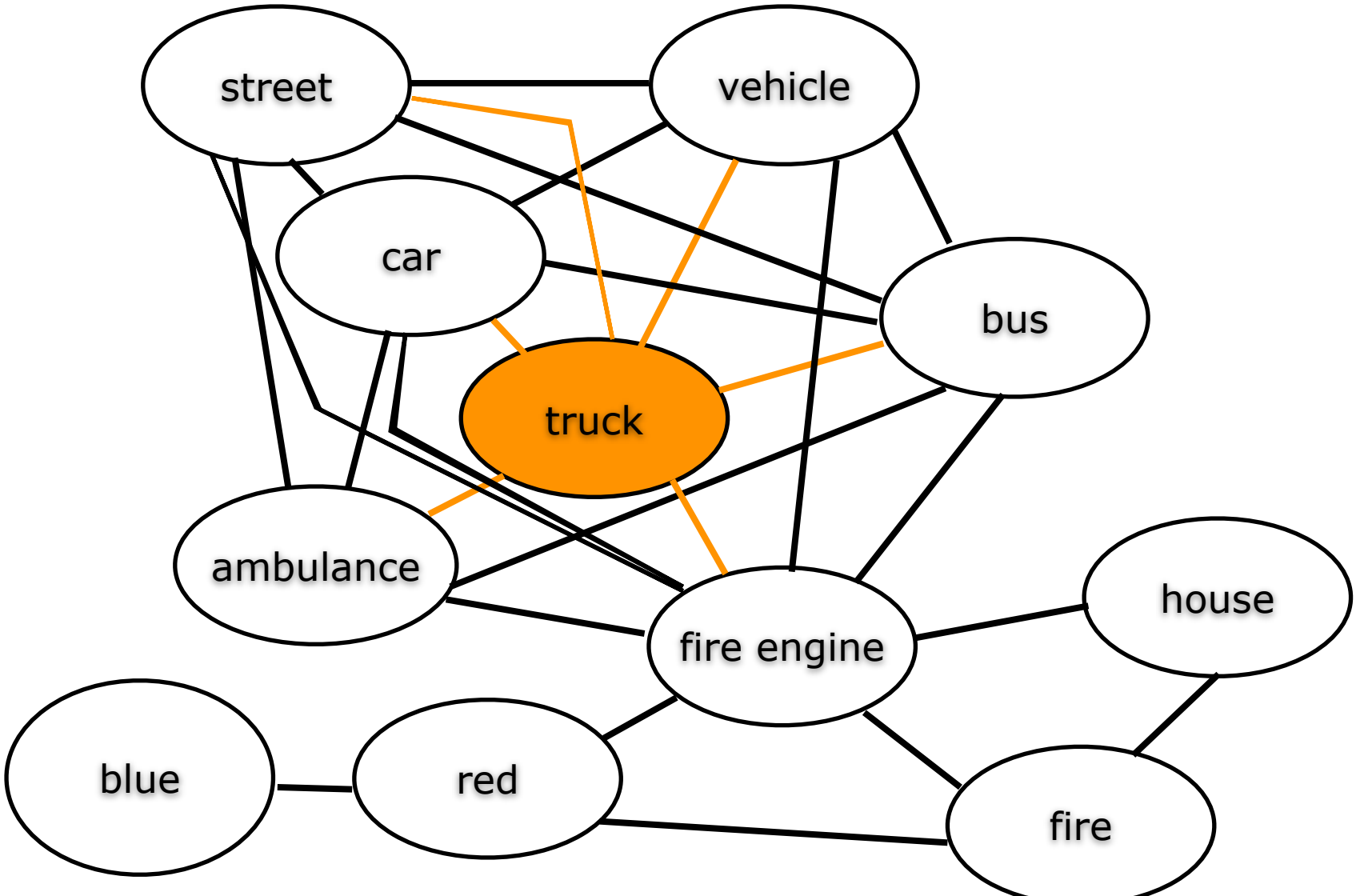

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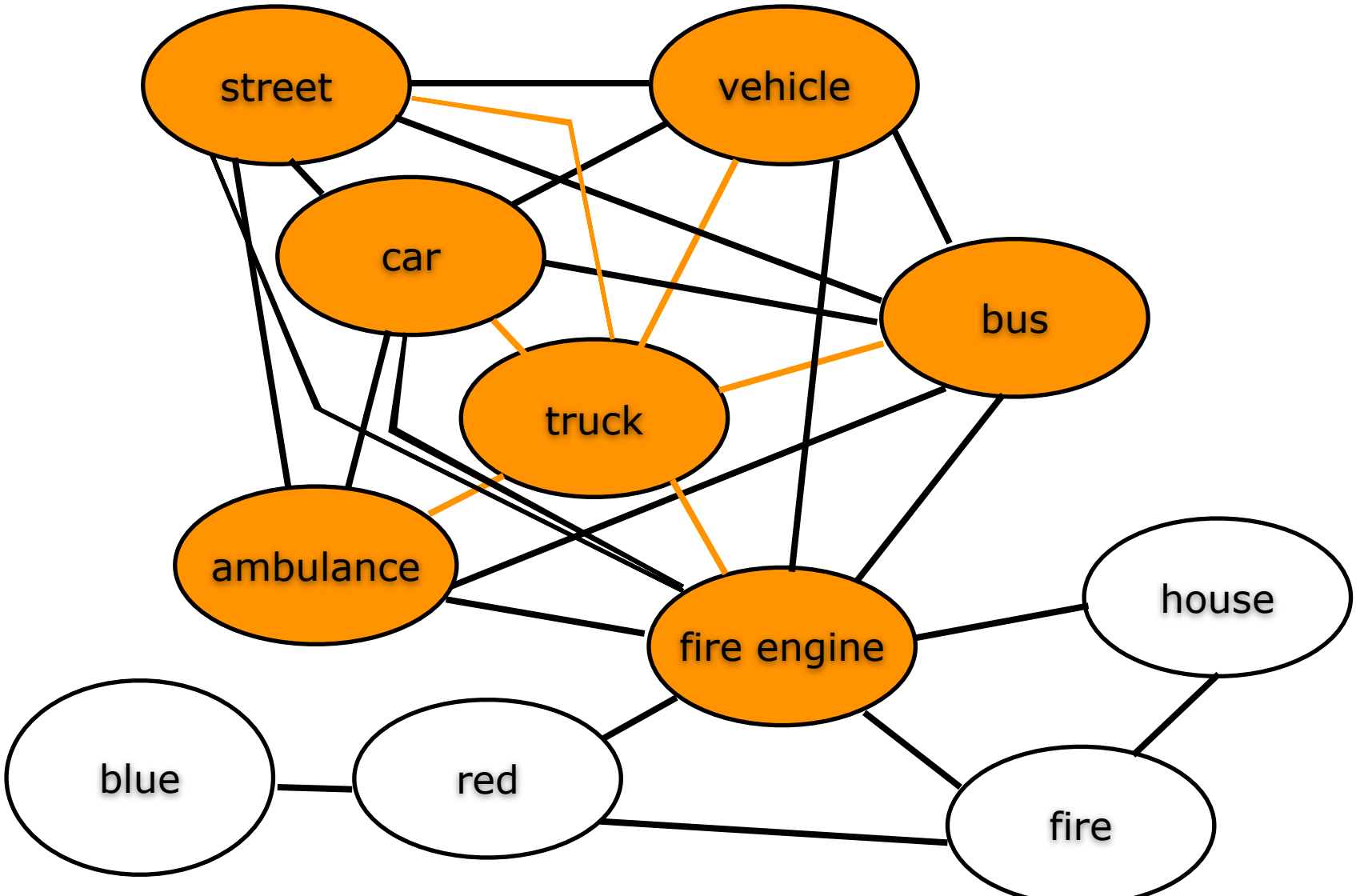

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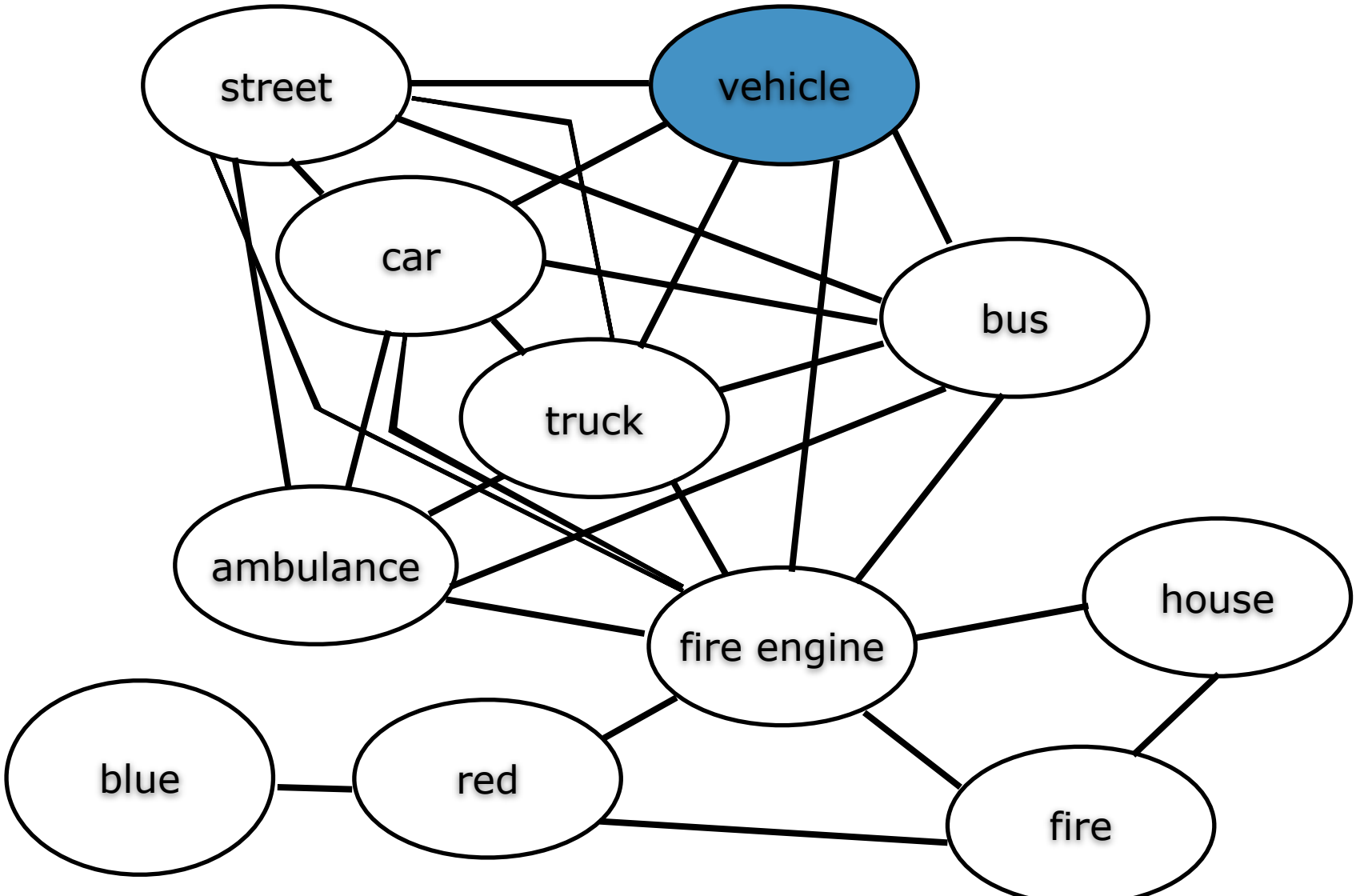

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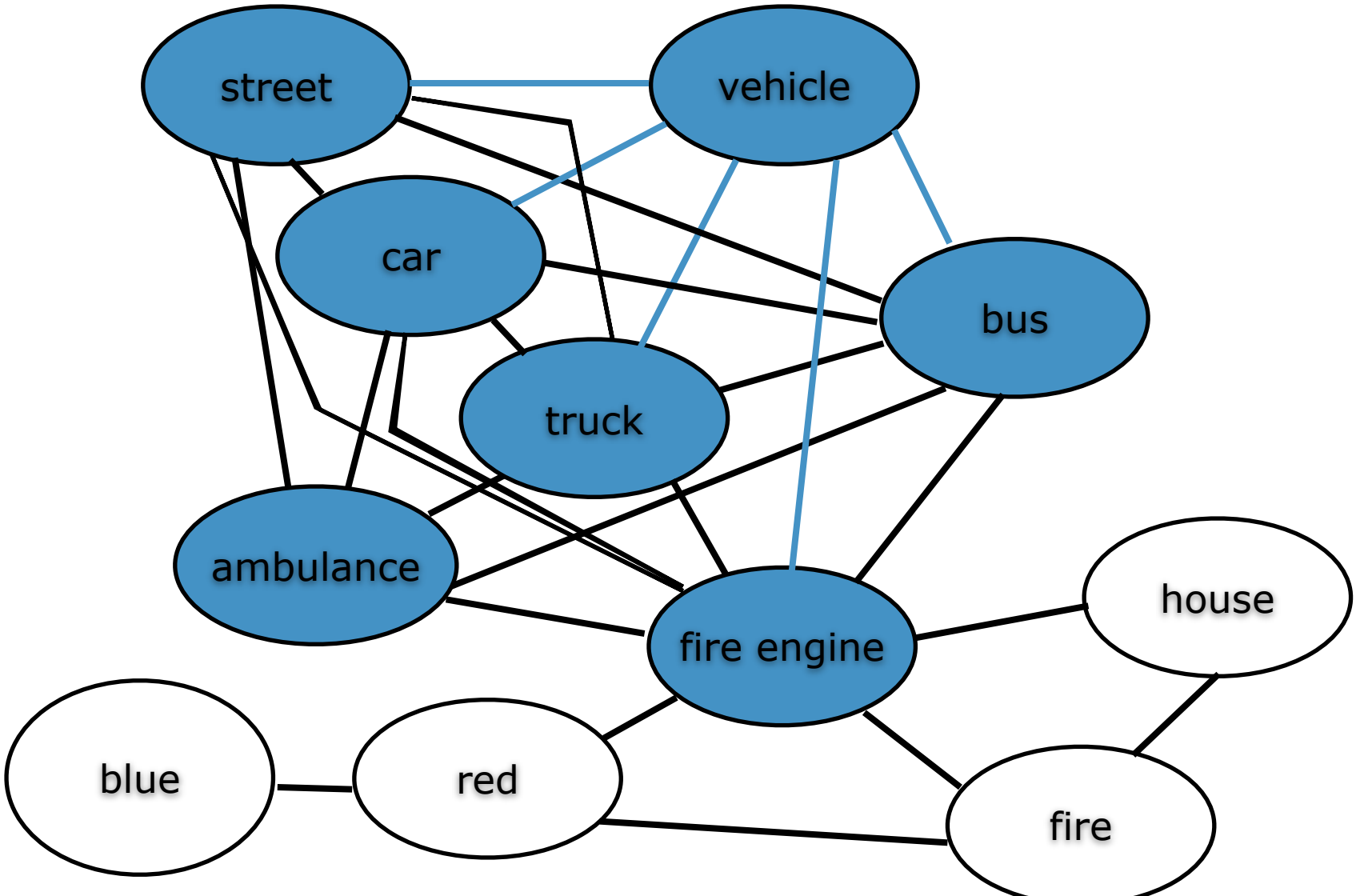

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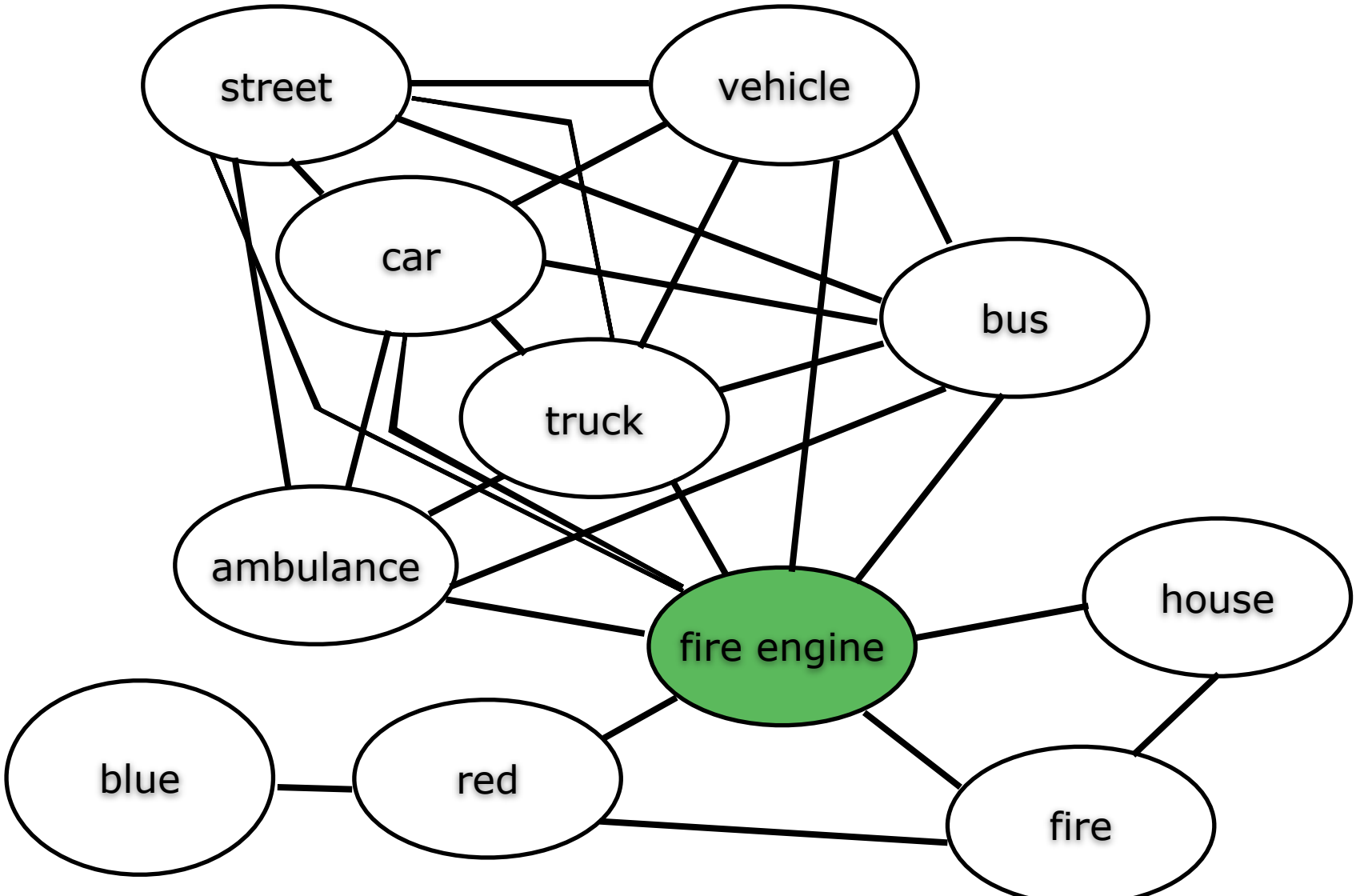

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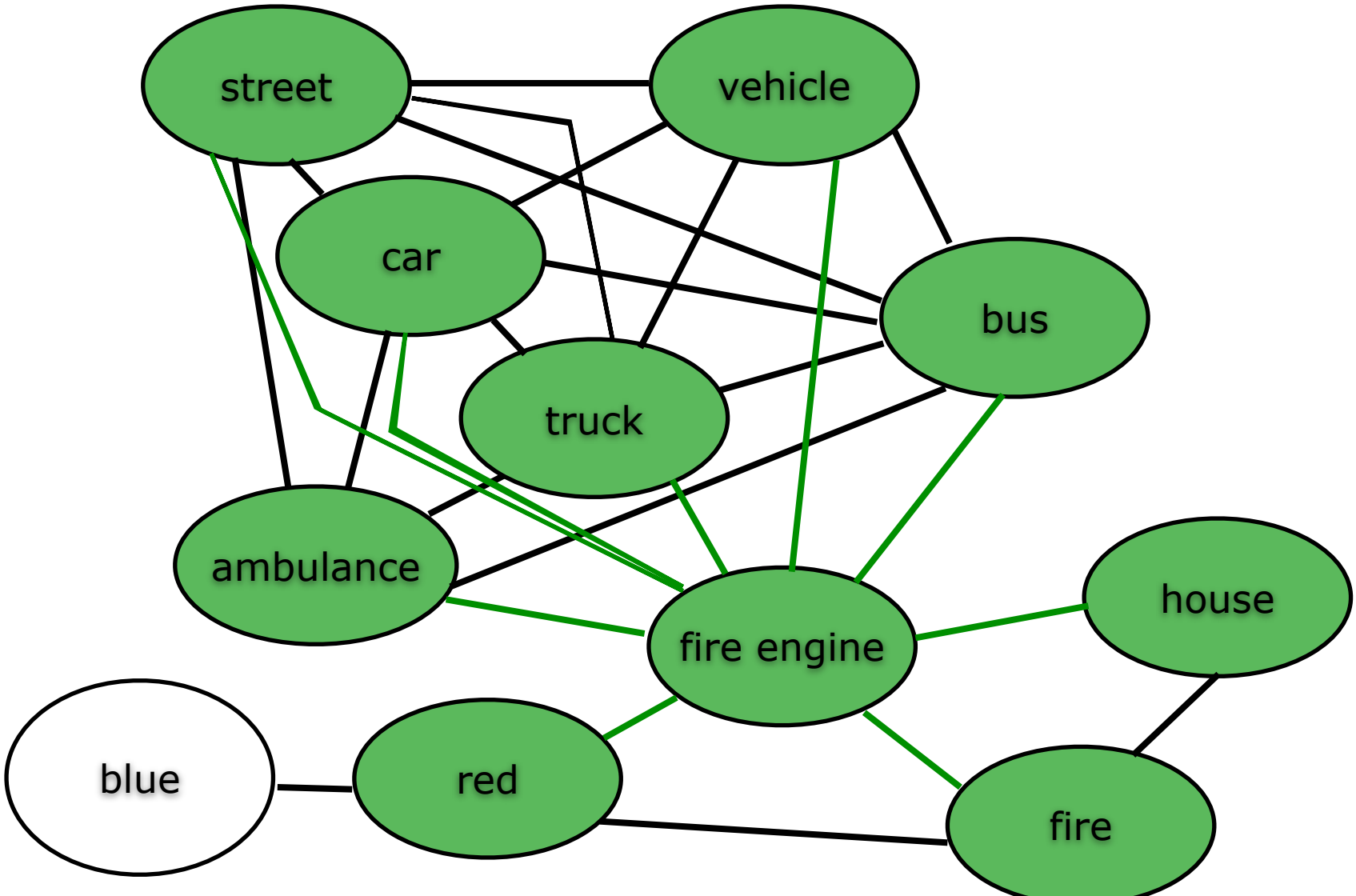

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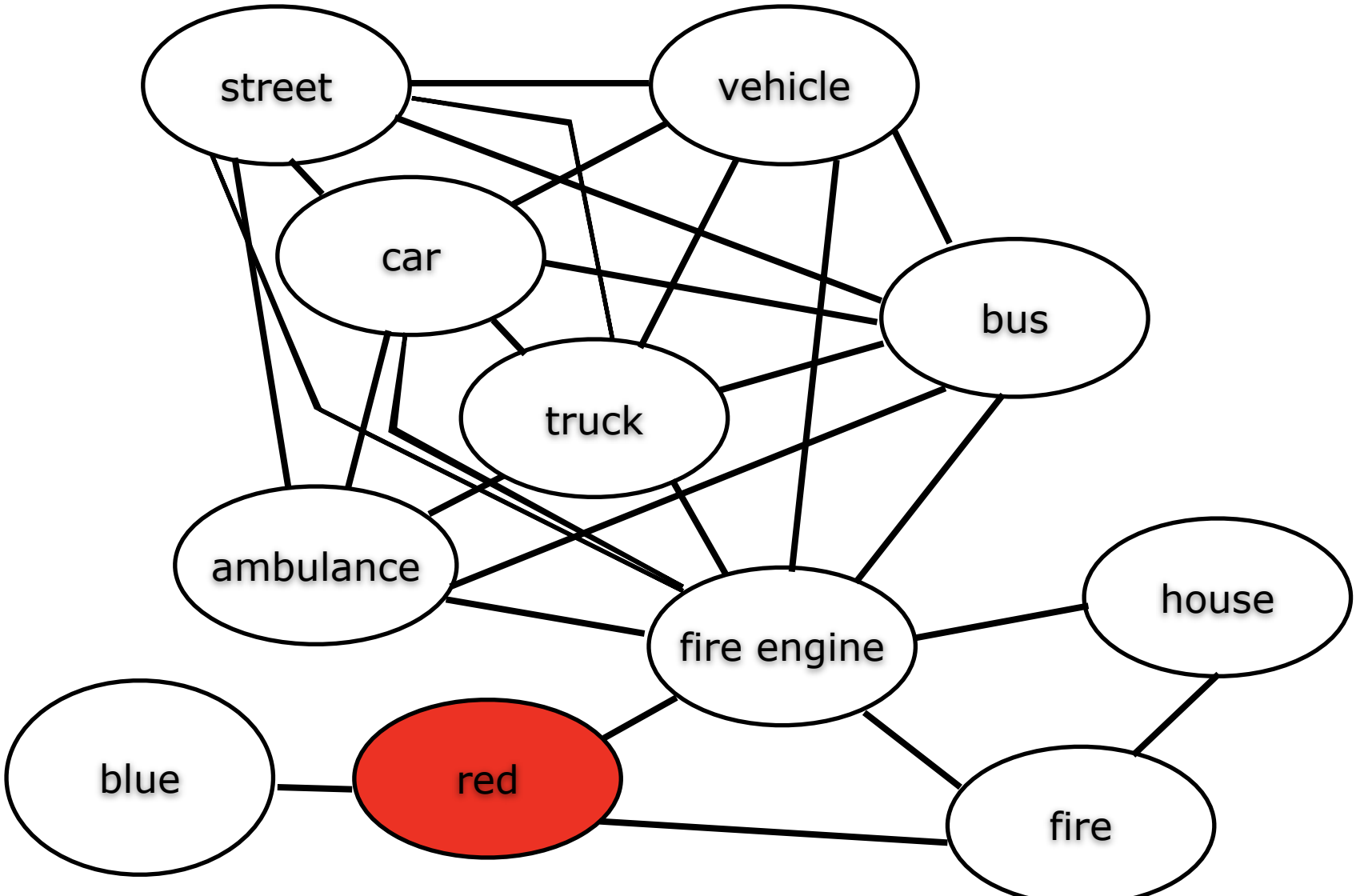

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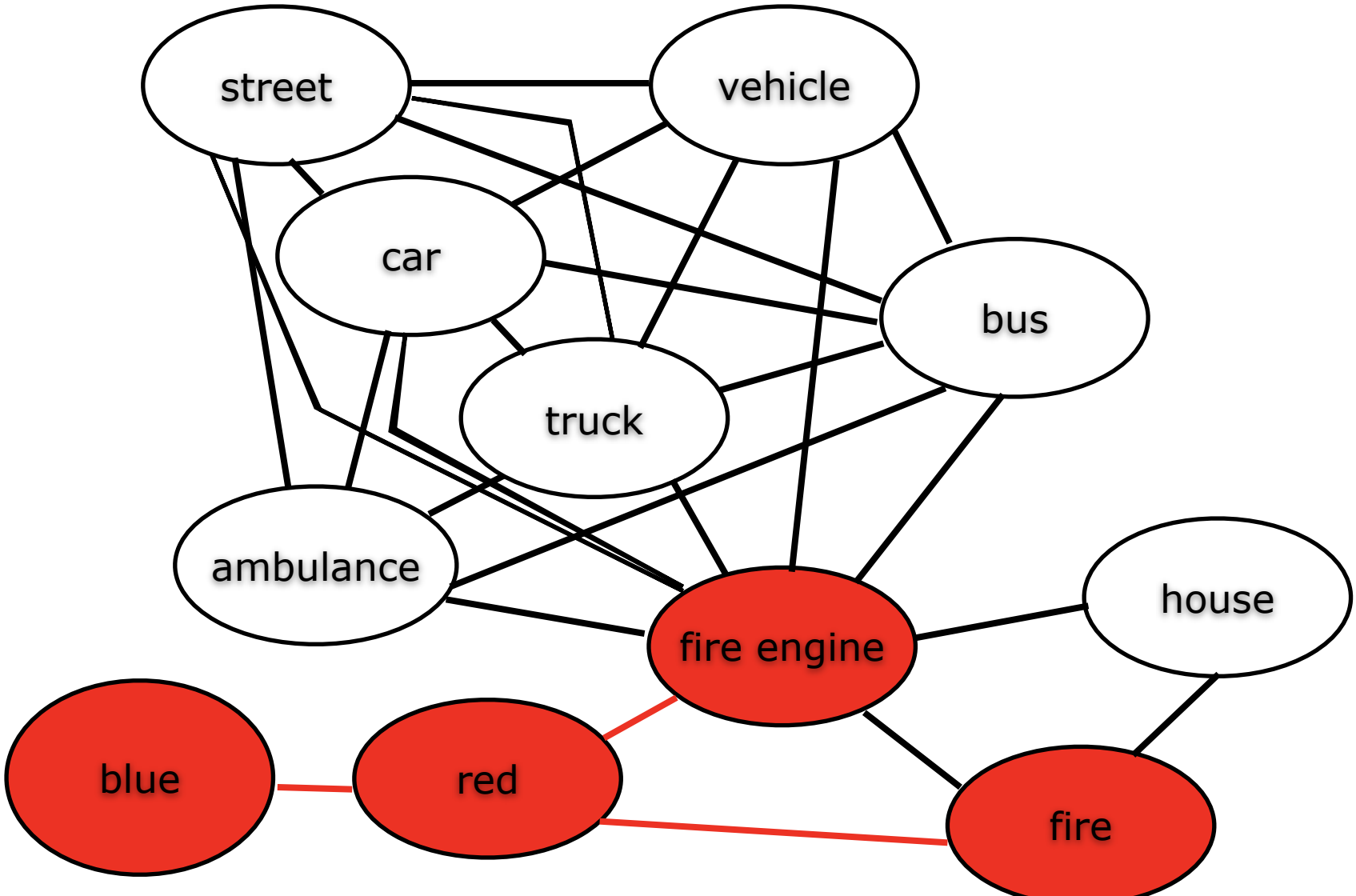
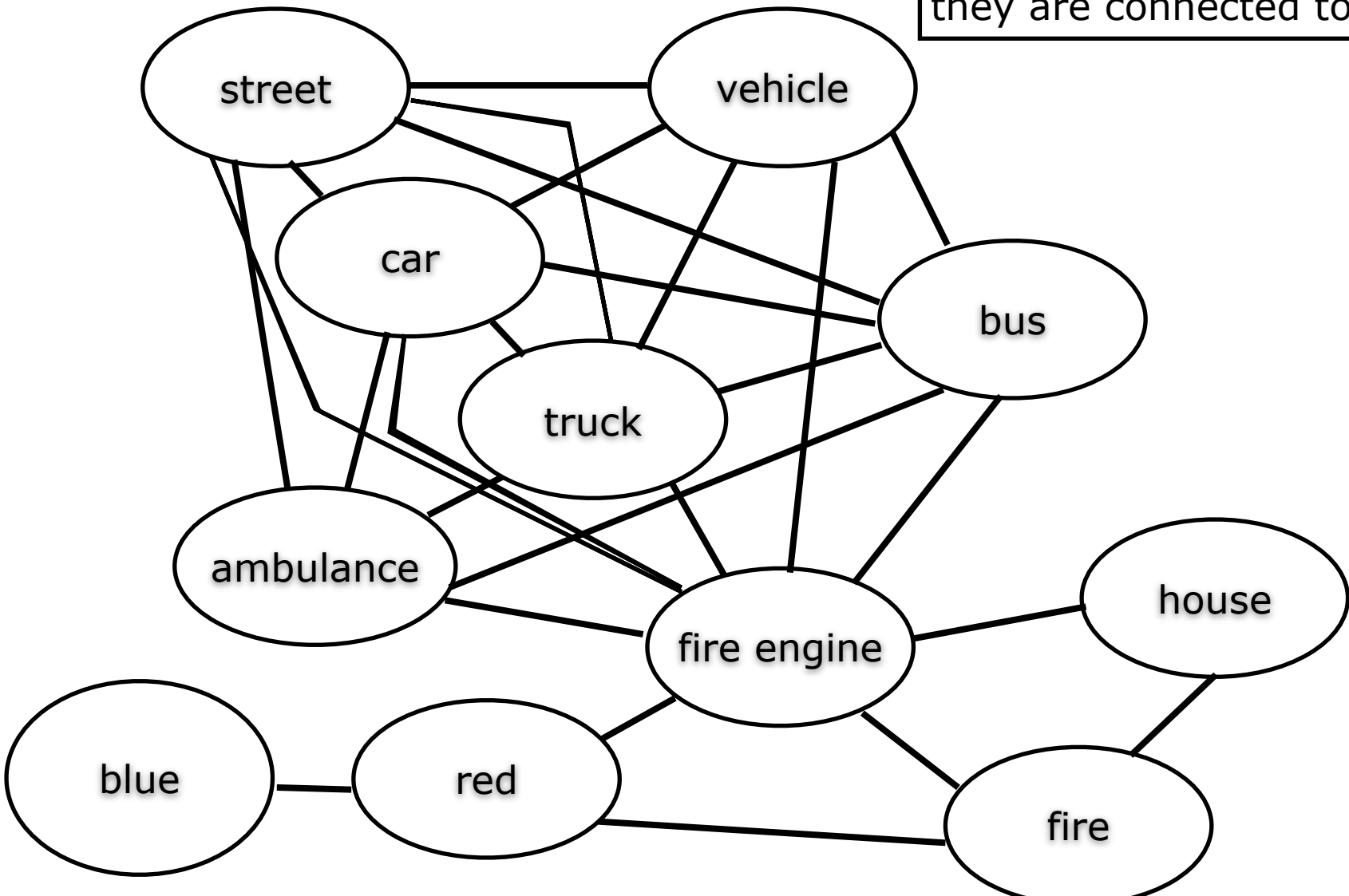


Spreading Activation

Spreading activation is a process by which nodes in the network activate nodes that they are connected to.



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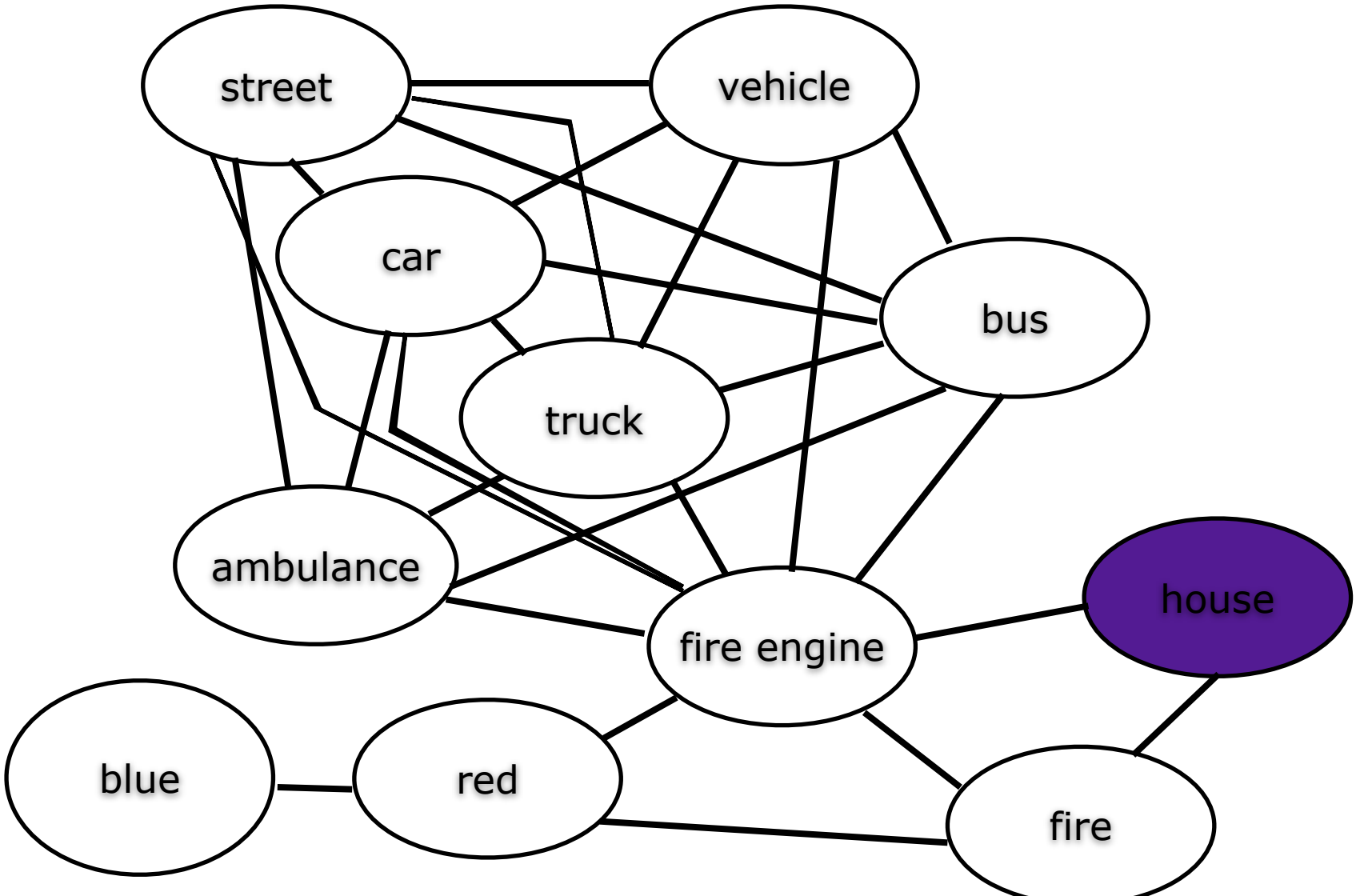
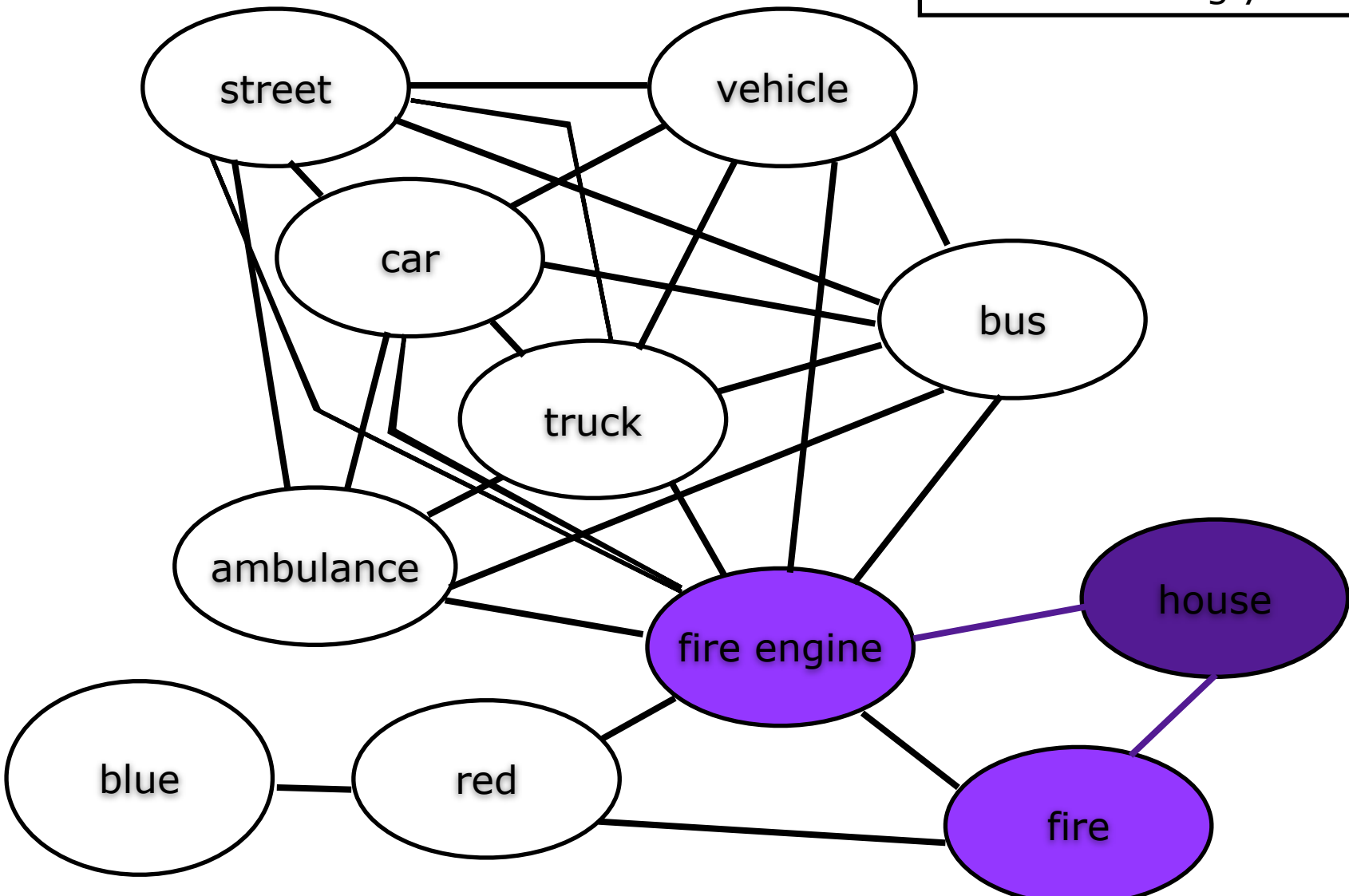


Spreading Activation

At each step, the activation decreases, because the concept is not as strongly associated



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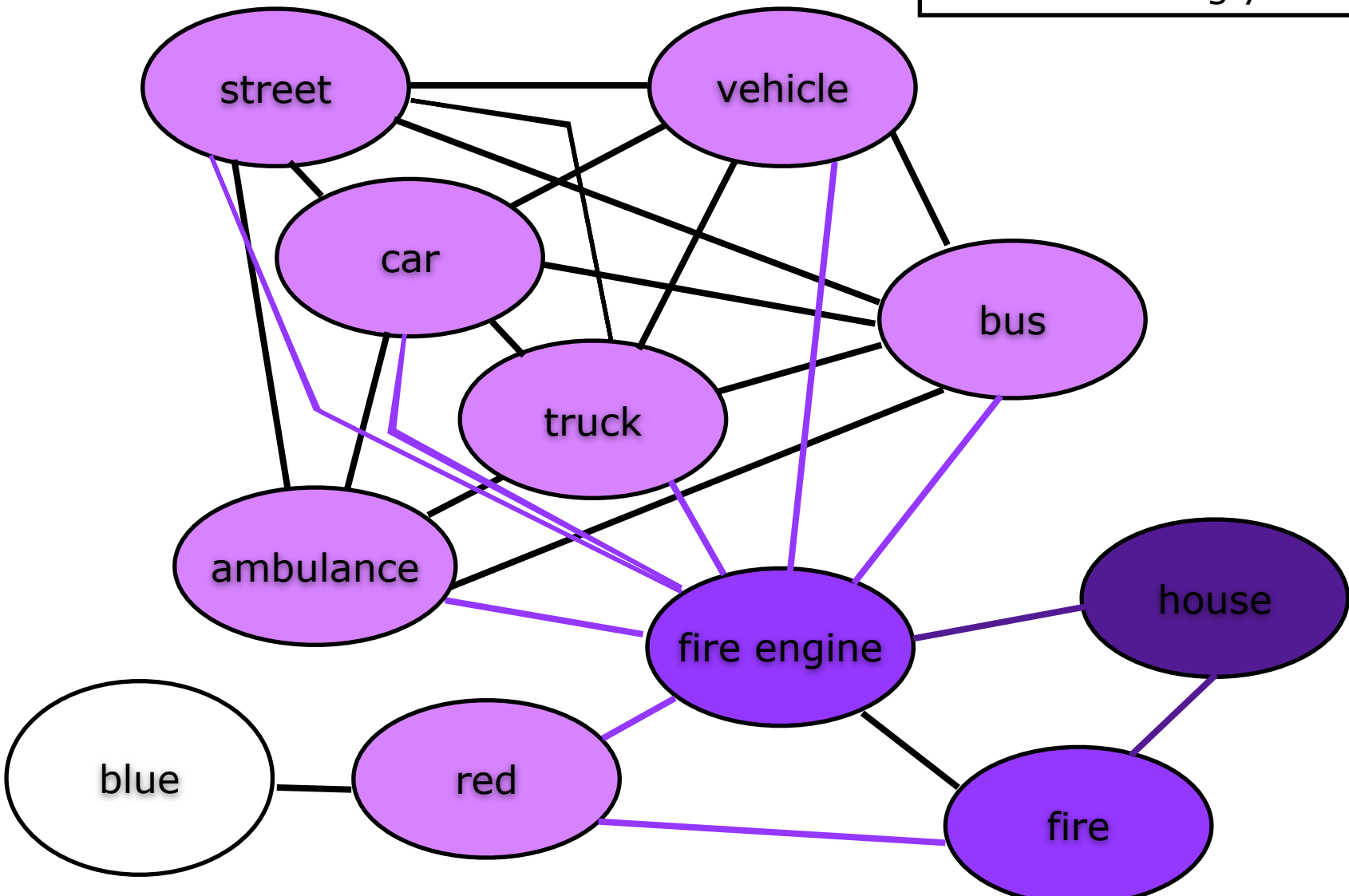

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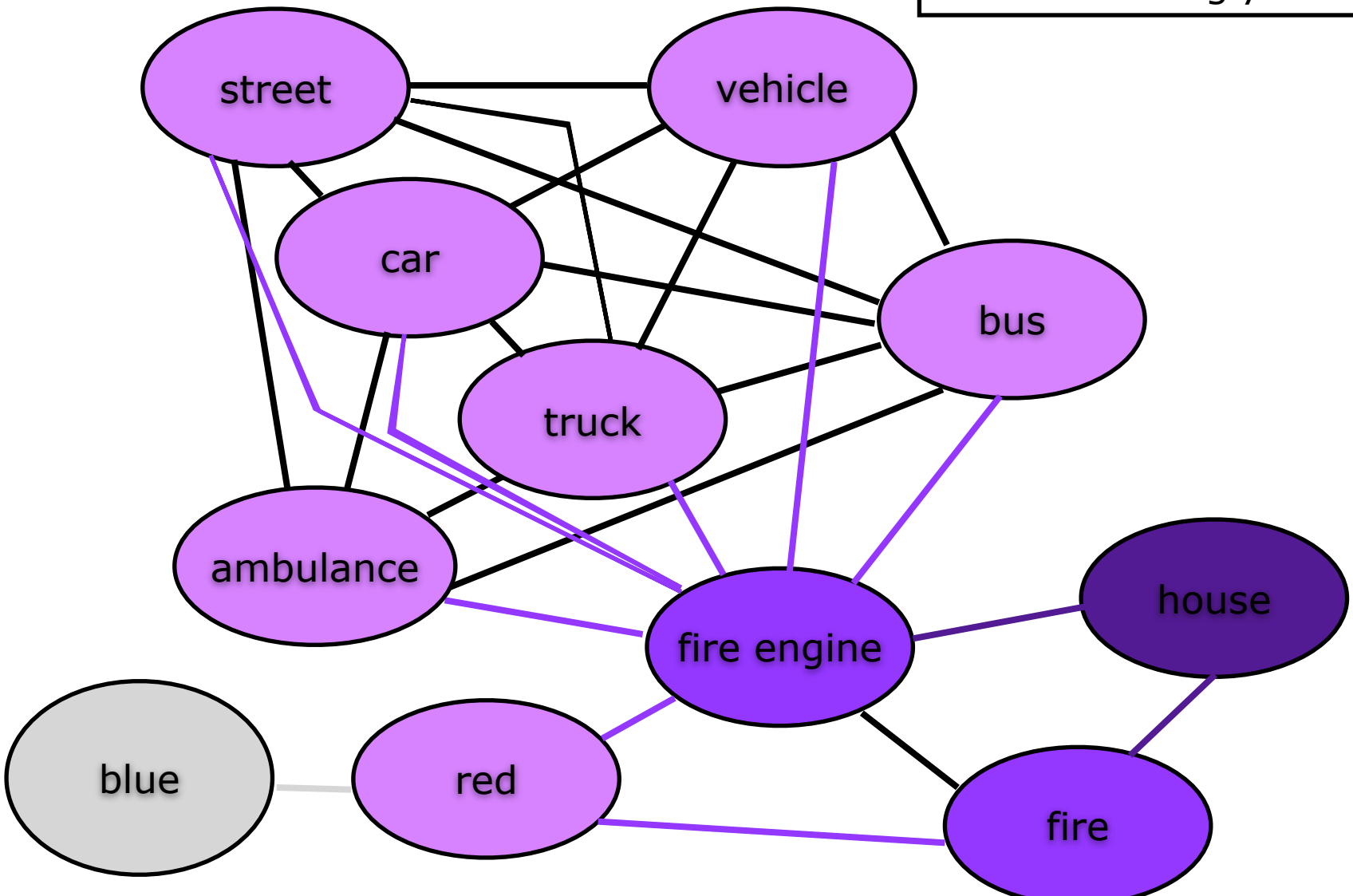
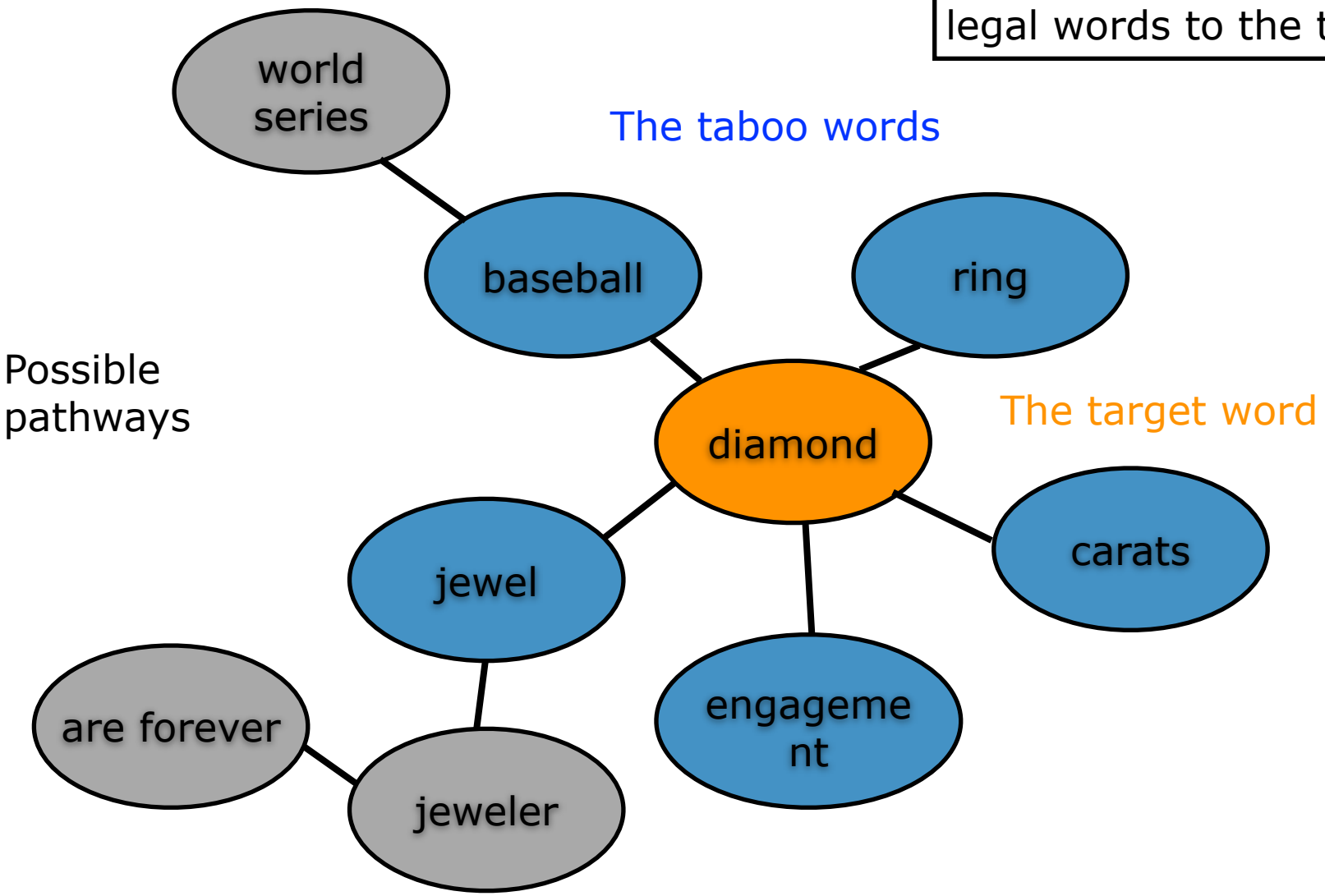


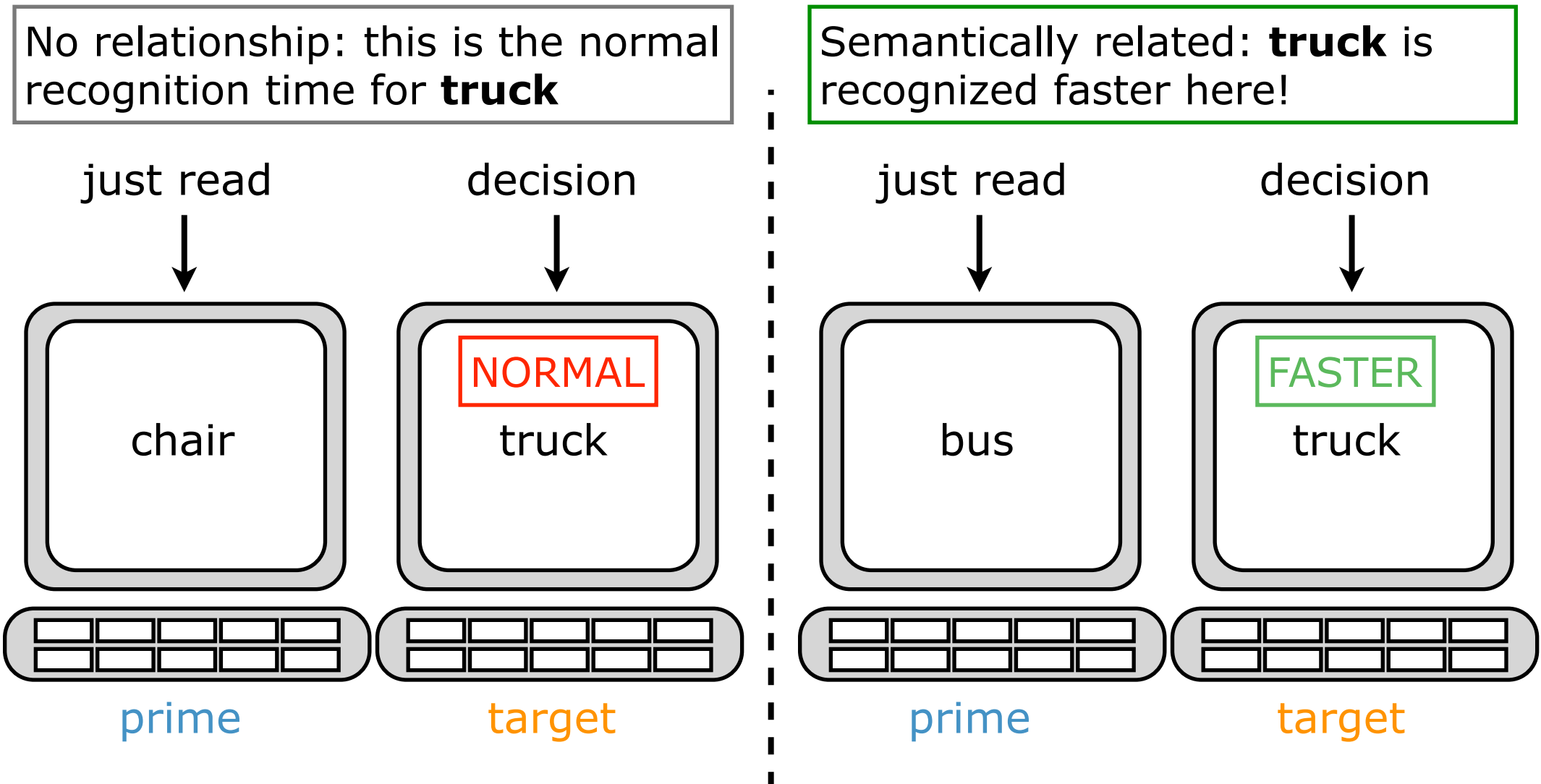
Explaining Taboo with Semantic Networks and Spreading Activation

The difficulty lies in the number of steps necessary to get from legal words to the target word!



We can show this formally with Semantic Priming

Semantic Priming: Words that are semantically related to each other make each other faster during lexical decision!



A demonstration of priming

These are links to online experimental software implementing two priming experiments.

Here is a typical priming experiment - the prime word is fast, but you can consciously read it:

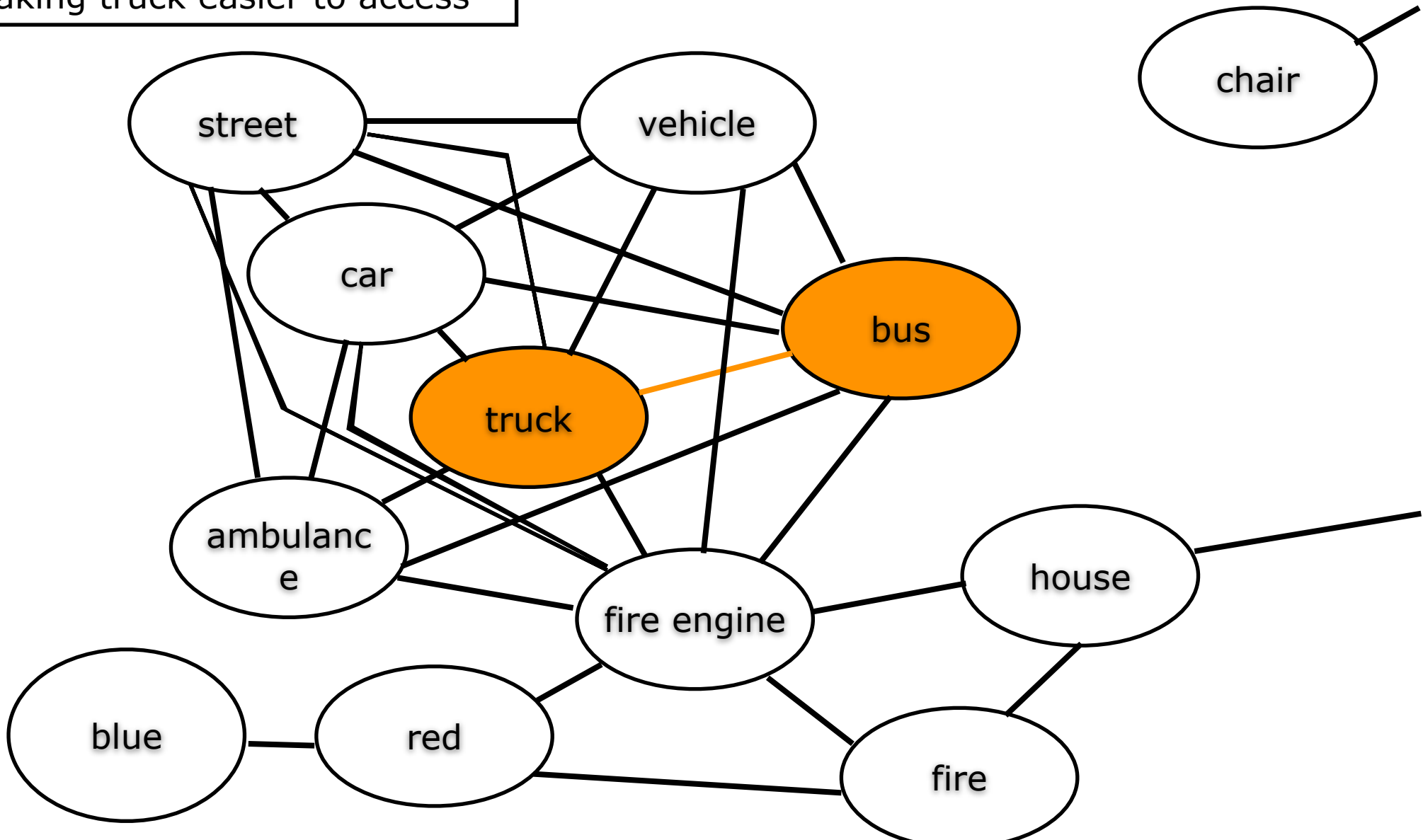
https://farm.pcibex.net/p/jcacSO/

And here is something we call “masked” priming - the prime word is too fast to consciously read, so mostly you just see the hash marks before it, which are called a mask:

https://farm.pcibex.net/p/WwWBIB/

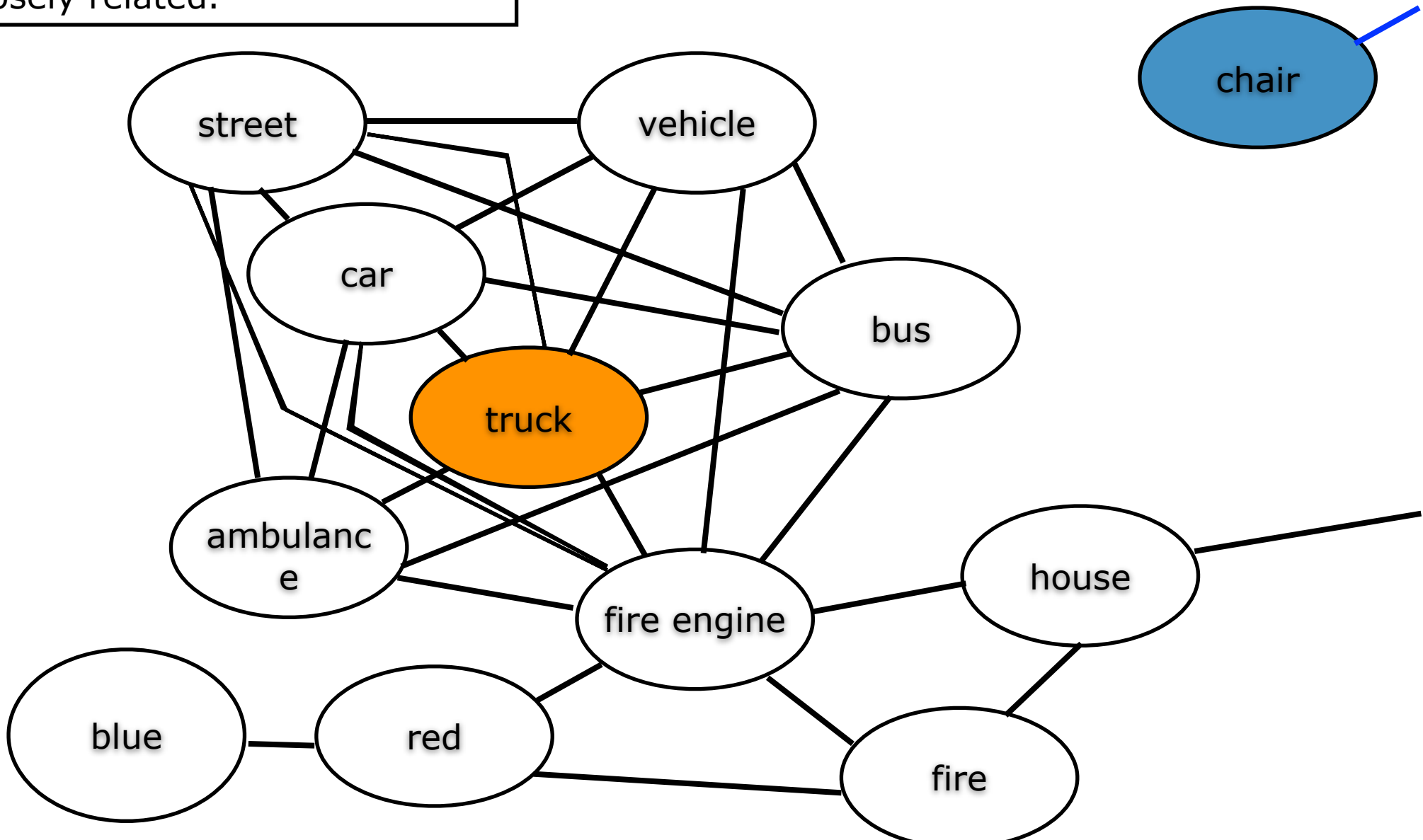
Semantic Priming

Bus primes truck, because accessing bus activates truck, making truck easier to access



Semantic Priming

Chair does not prime truck, because truck and chair are not closely related.

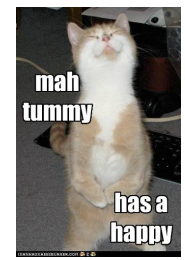


Some Conclusions

Words are (at least) a pairing of sound and meaning.

The speech signal only contains sound, so the sound/meaning pair must be stored in your memory!

sound **meaning**

[k æ t] 

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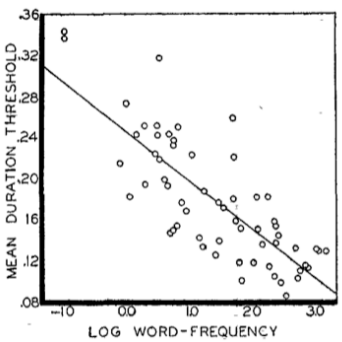
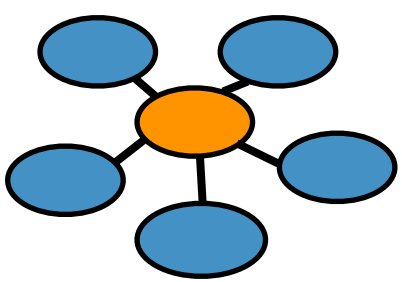


Organizational Principle 1: The frequency effect suggests that the lexicon is organized according to the frequency of words



Organizational Principle 2: Semantic priming suggests that the lexicon is organized according to the semantics/ meaning of words.