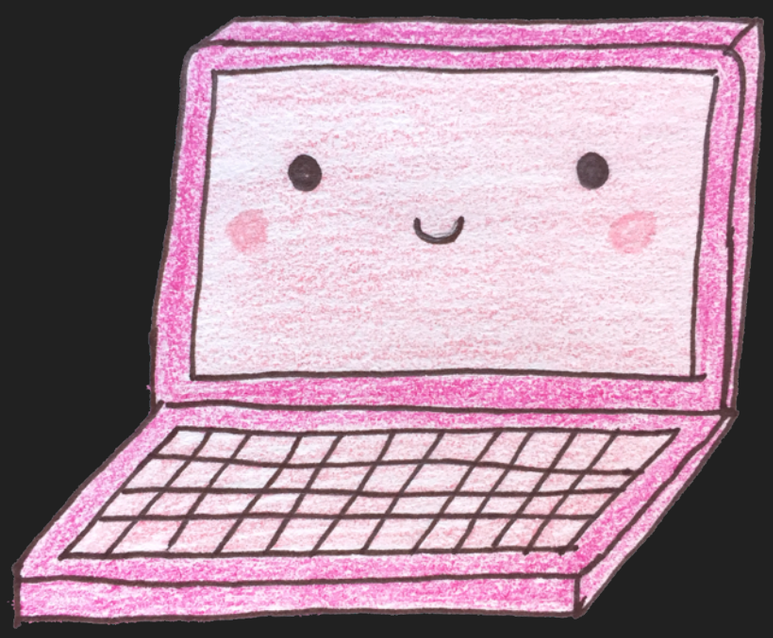
The Browser and the Brain



Jenna Zeigen • NationJS • December 1, 2017

zeigenvector

jenna.is/at-nationjs

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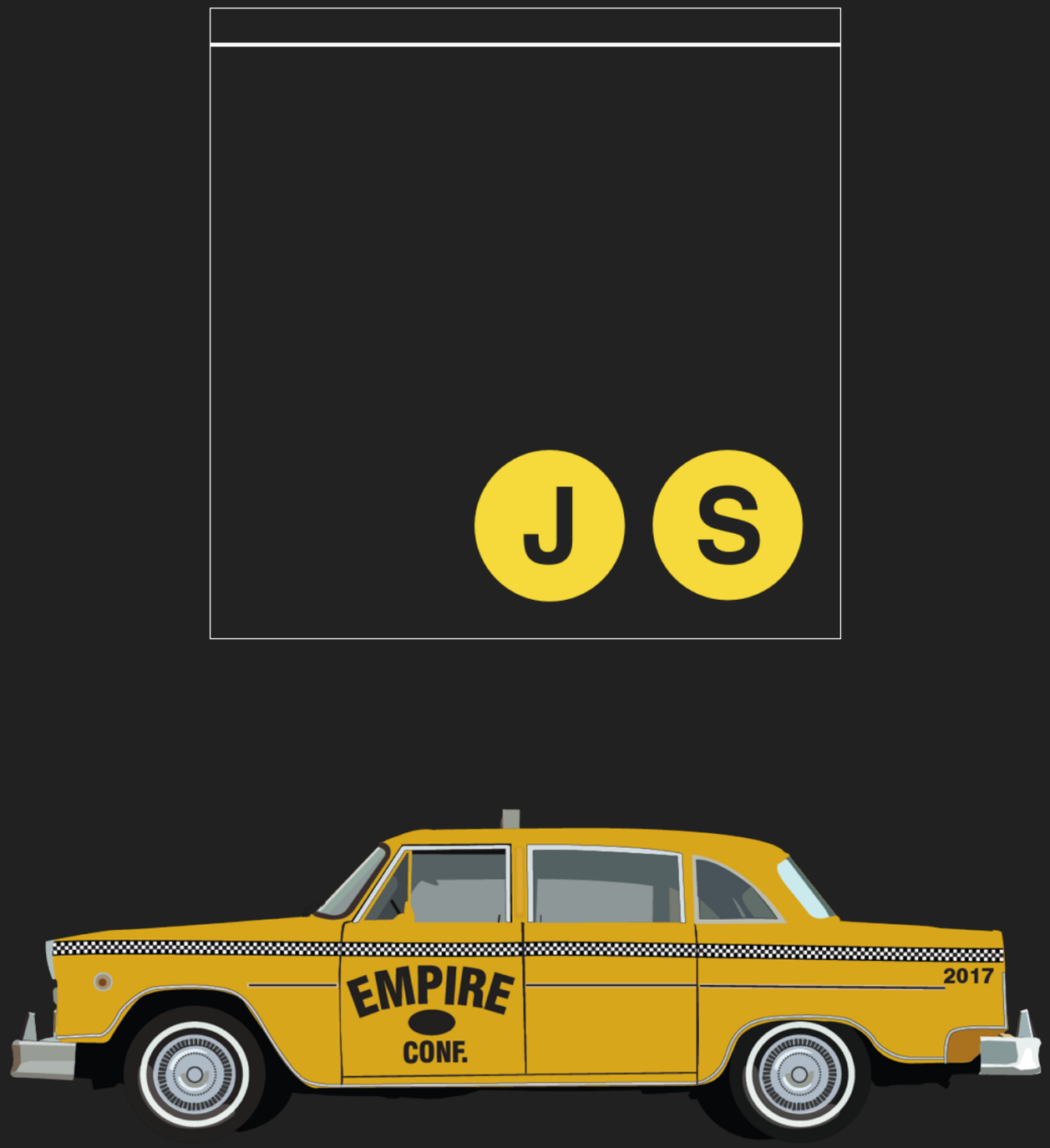

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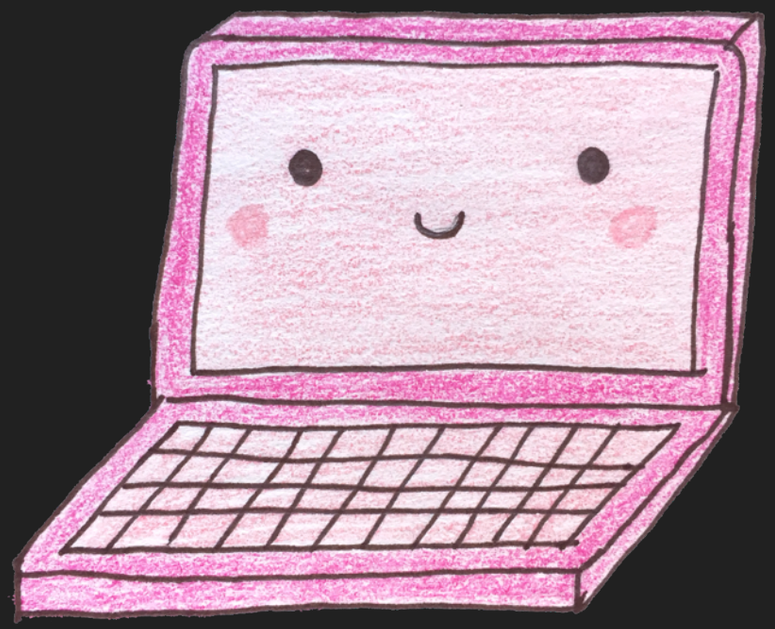
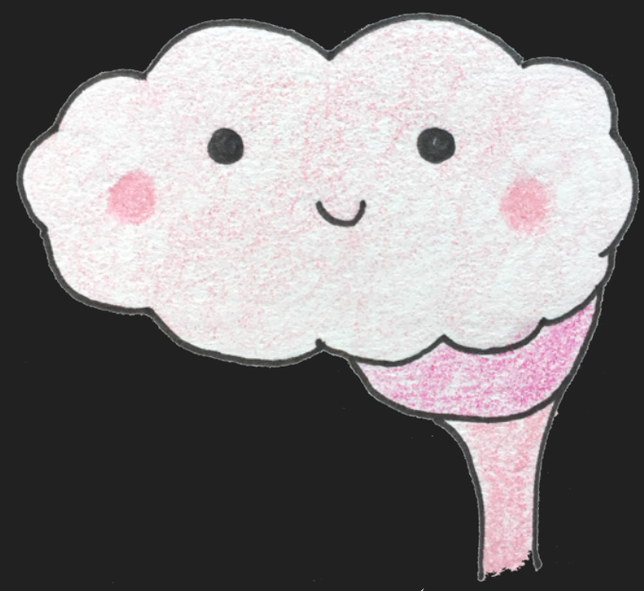
Gee, Brain. What is Jenna going to do in her talk today?

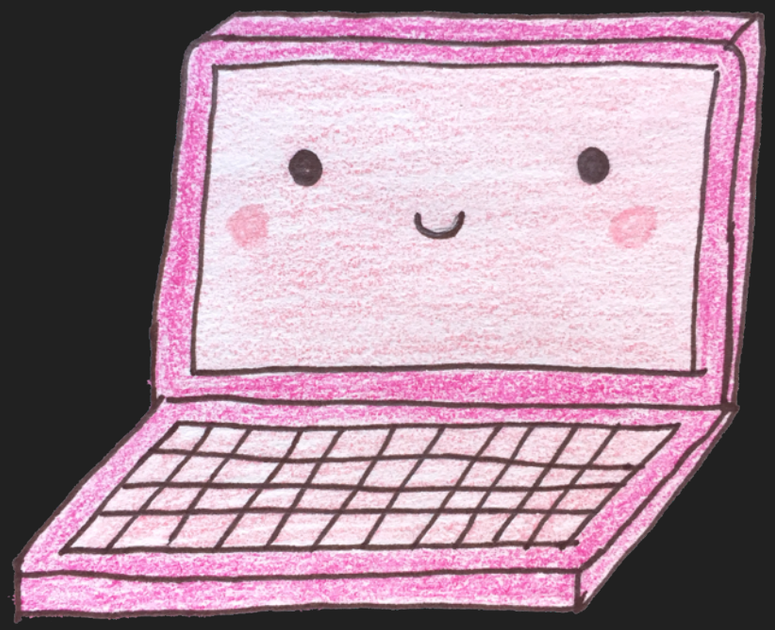


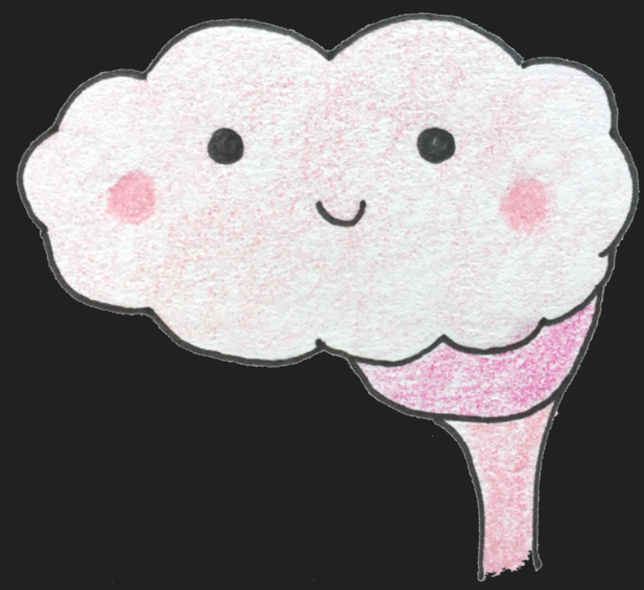


The same thing she does every time, Browser! Talk about cognition and computers!

1. Understanding
2. Visualizing
3. Task Management

Browser, are you processing the same way I'm processing?





I don't think so, Brain, but let's dig into it!

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We made computers so we know all the answers, and we do science on humans to find out the answers

Understanding

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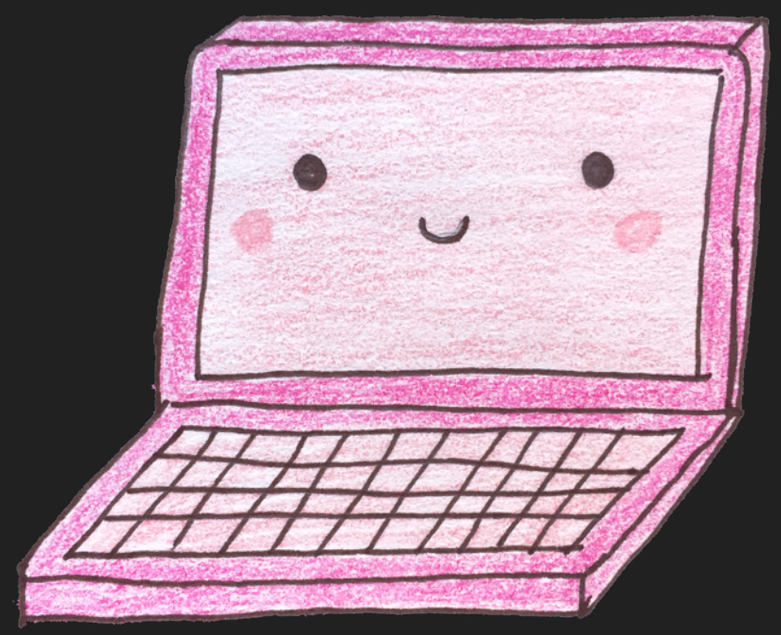
How does the browser process HTML, CSS, and JavaScript, and how does the human mind process natural languages?

HTML, CSS, & JS

Most programming languages have a vocabulary described using regular expressions and a syntax described by a context-free grammar



https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
https://en.wikipedia.org/wiki/Context-free_grammar

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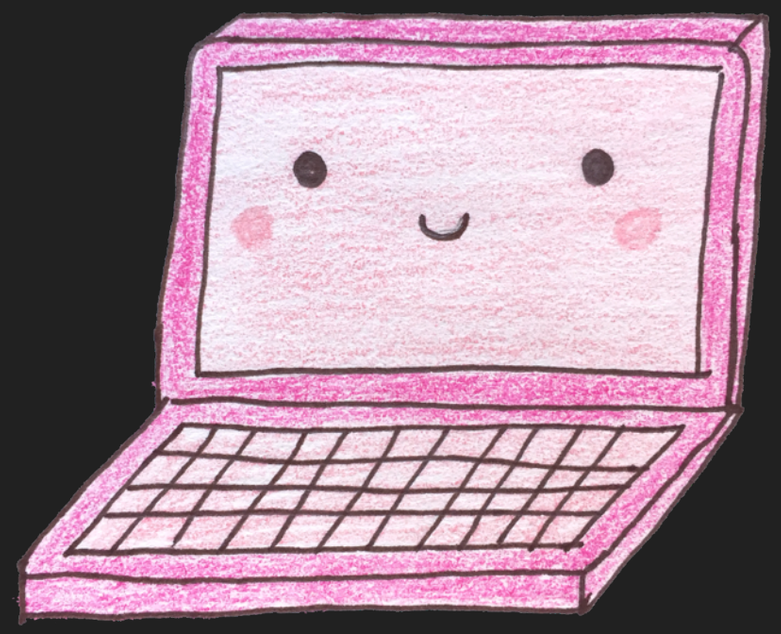
HTML, CSS, & JS

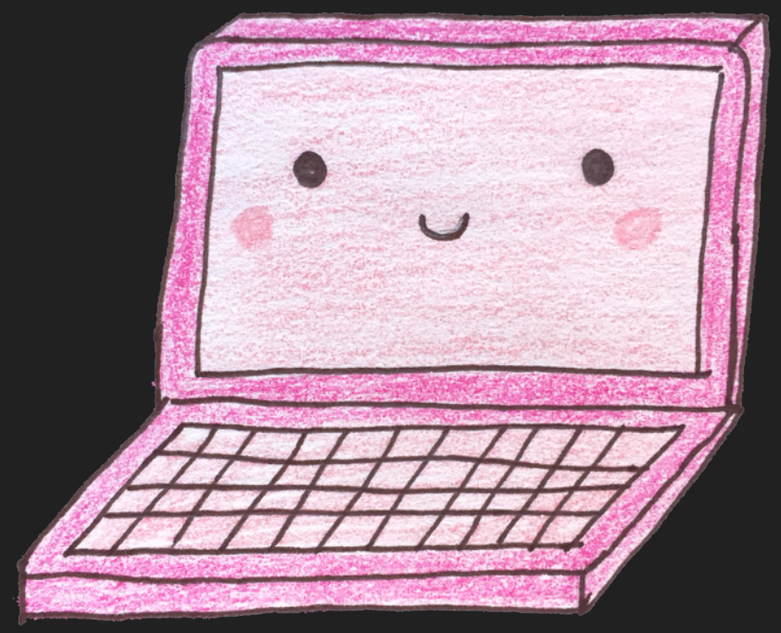
A parser's job is to take a document and break it into a structure the code can use i.e. a syntax tree



https://www.html5rocks.com/en/tutorials/internals/howbrowserswork

HTML, CSS, & JS

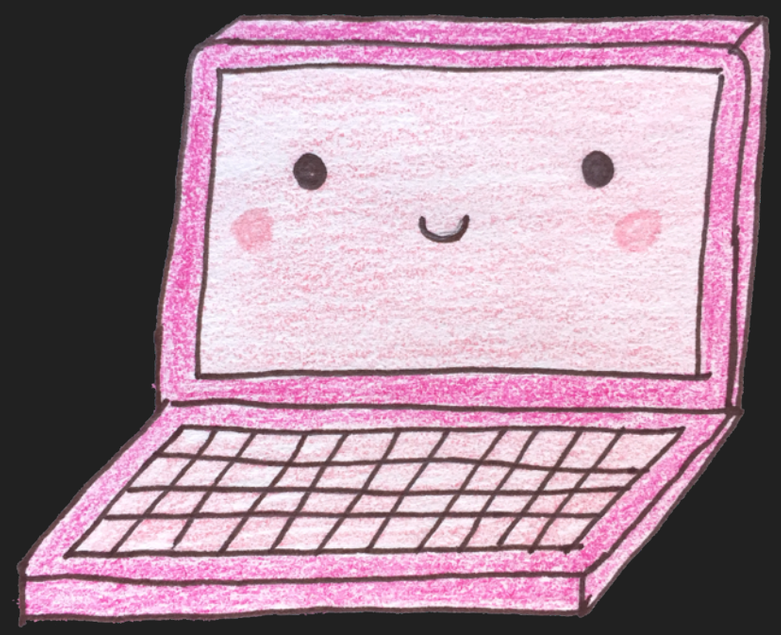
Parsing can be separated into two parts — lexical and syntactic analysis— which are performed by a lexer and parser, respectively



https://www.html5rocks.com/en/tutorials/internals/howbrowserswork

HTML, CSS, & JS

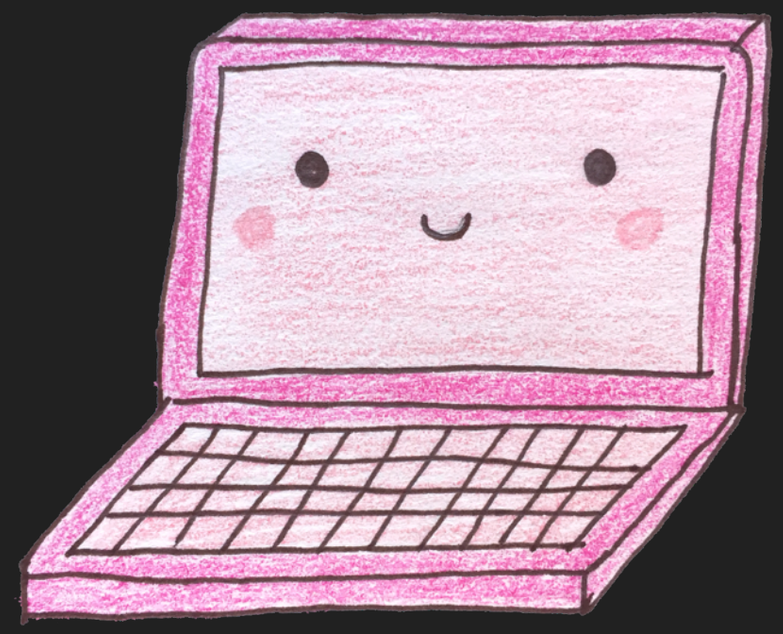
HTML isn't a context-free language, and therefore can't be parsed by a regular parser



https://www.html5rocks.com/en/tutorials/internals/howbrowserswork

HTML, CSS, & JS

CSS is context-free and therefore easier to parse.



https://www.html5rocks.com/en/tutorials/internals/howbrowserswork

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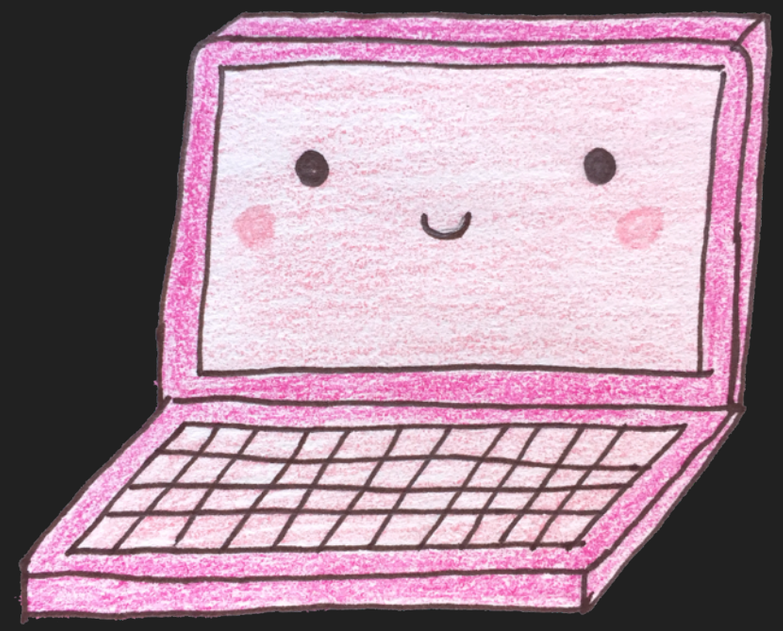
HTML, CSS, & JS

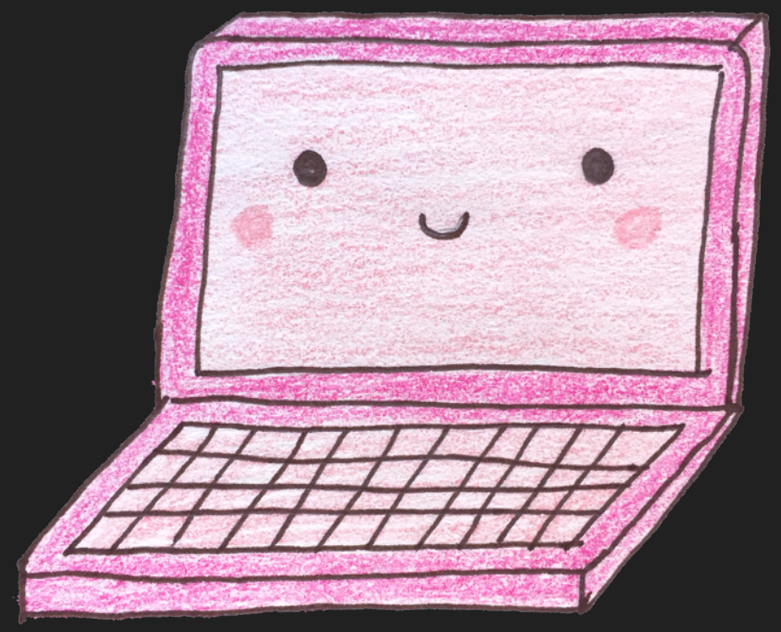
Both HTML and CSS parsers end up creating a tree representing the language it parsed, the DOM and CSSOM trees



https://www.html5rocks.com/en/tutorials/internals/howbrowserswork

HTML, CSS, & JS

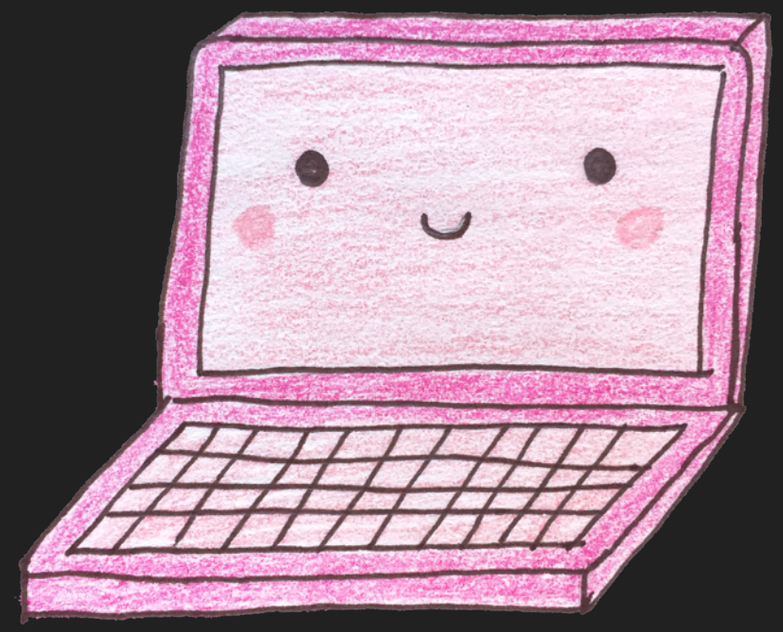
JavaScript is also context-free and can use a regular parser, but browsers complicate it in order to optimize



https://www.youtube.com/watch?v=Fg7niTmNNLg
http://www.ecma-international.org/ecma-262/#sec-notational-conventions

HTML, CSS, & JS

V8 uses two parsers—eager and lazy — to eventually create an abstract syntax tree and scope structure



https://www.youtube.com/watch?v=Fg7niTmNNLg

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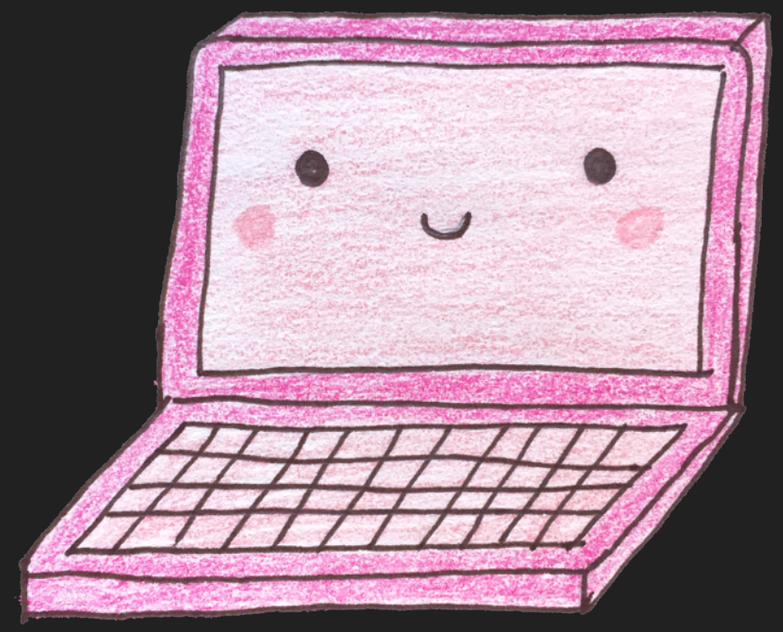
HTML, CSS, & JS

The AST and scope structures get turned into low-level code, which then gets executed



https://www.youtube.com/watch?v=Fg7niTmNNLg

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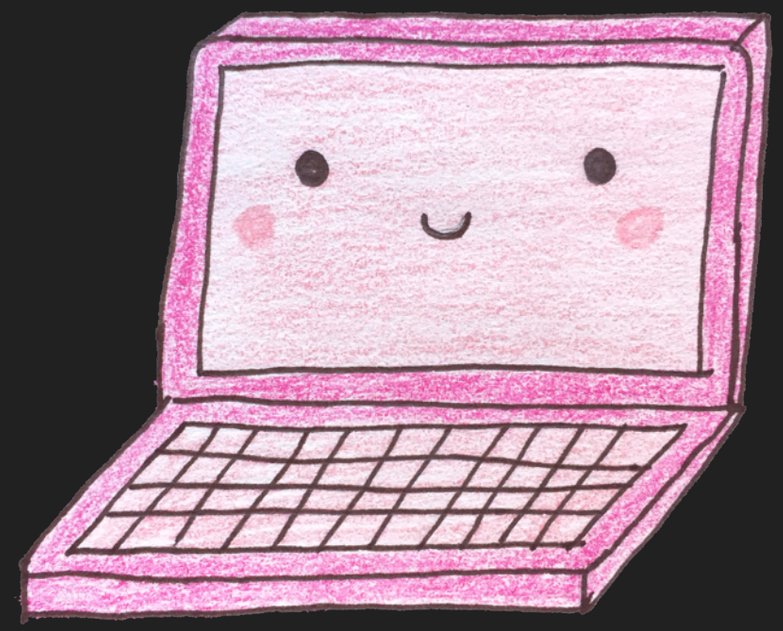
HTML, CSS, & JS

The bytecode also gets fed to the optimizing compiler which spits out machine code that then gets executed



https://www.youtube.com/watch?v=p-iiEDtpy6I

Natural Language

Human languages have a lexicon and syntax that cannot be described by a context-free grammar

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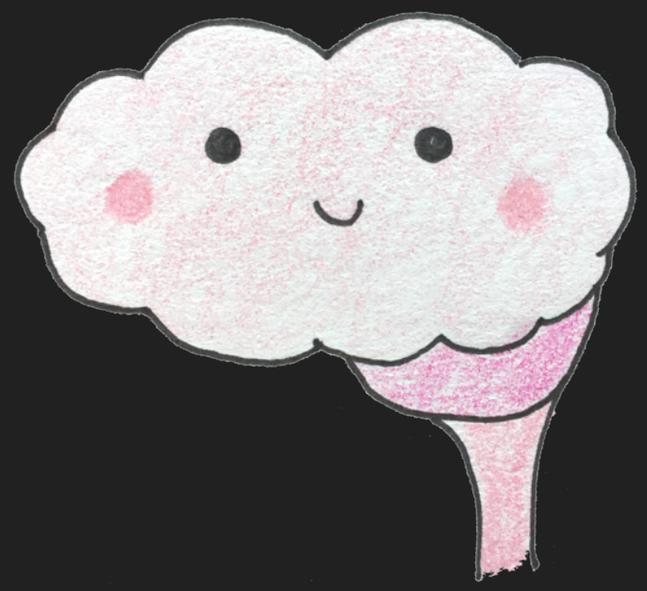
Natural Language

Humans language contains a ton of ambiguity



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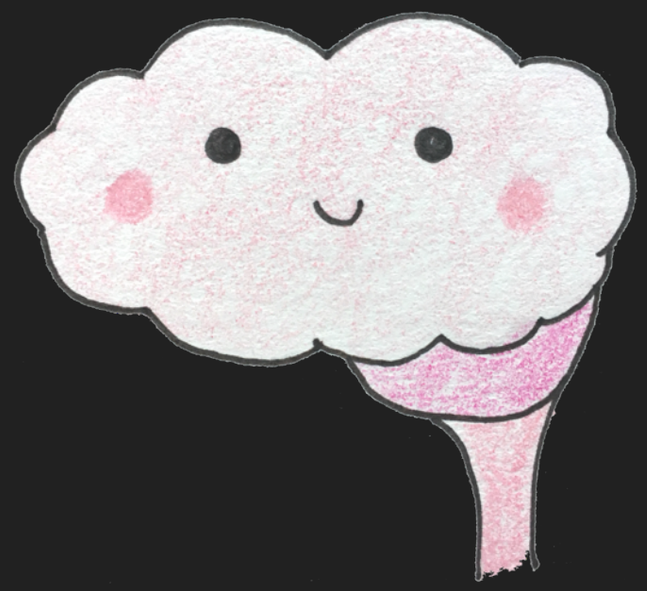
Natural Language

Step 1: To understand speech, humans break the unbroken speech stream into words



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Natural Language

Step 2: Our minds match the sounds to words in the mental lexicon

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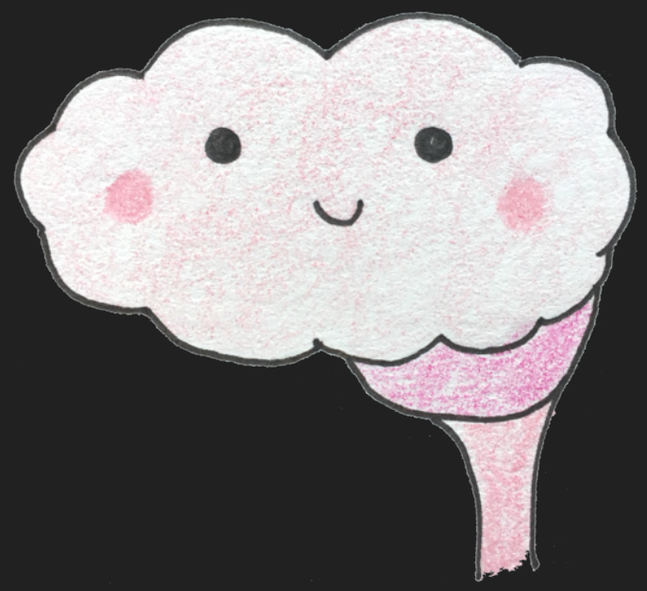
Natural Language

Step 3: Once we access a word, we have access to its meaning and its syntactic and thematic roles



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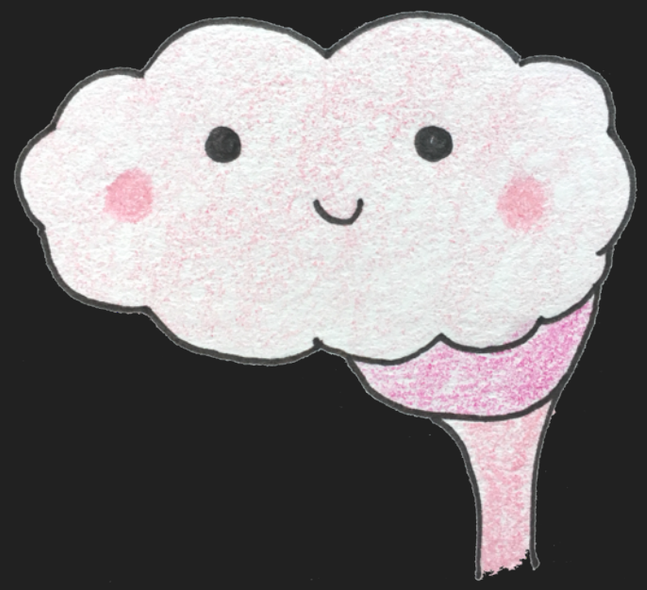
Natural Language

Step 4: We then parse the sentence.
But we're not 100% sure how...

Natural Language

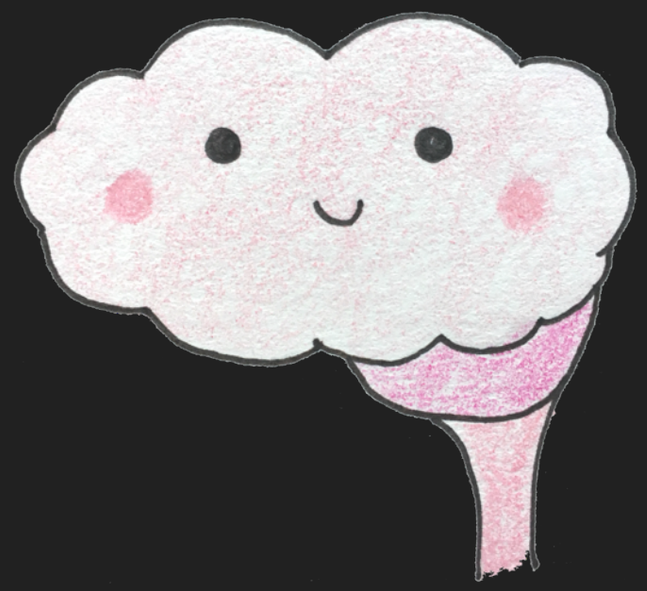
Modular View: the phases involved occur separately in different modules



https://en.wikipedia.org/wiki/Sentence_processing

Natural Language

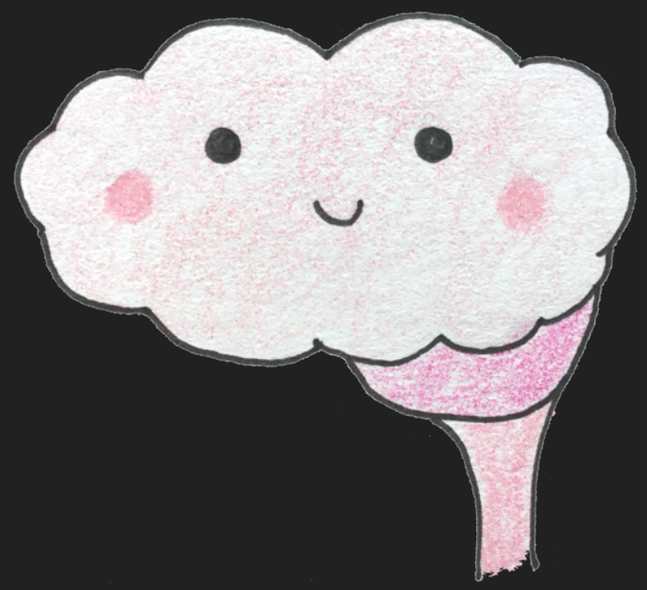
Interactive View: all available information can be used at once in parsing the sentence



https://en.wikipedia.org/wiki/Sentence_processing

Natural Language

Does this happen in serial or in parallel?



https://en.wikipedia.org/wiki/Sentence_processing

Natural Language

Humans are forgiving of syntax errors

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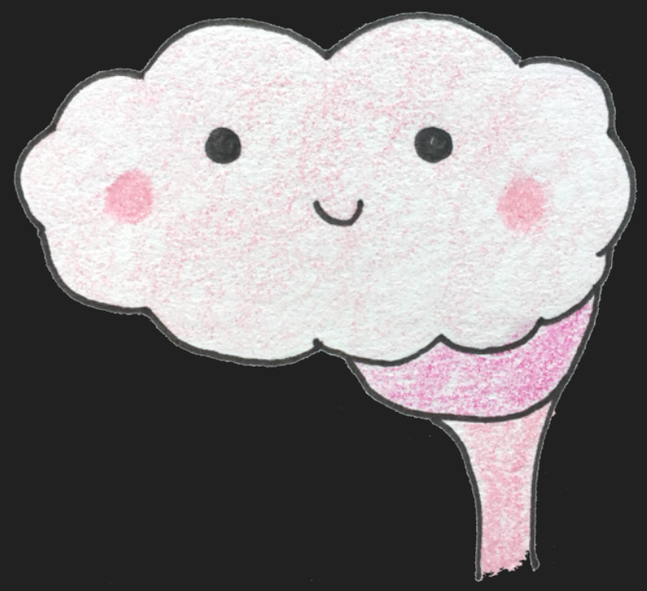
Natural Language

Receptive language processing occurs in the dominant hemisphere of the brain, in Wernicke's area.



https://en.wikipedia.org/wiki/Language_processing_in_the_brain

Visualizing

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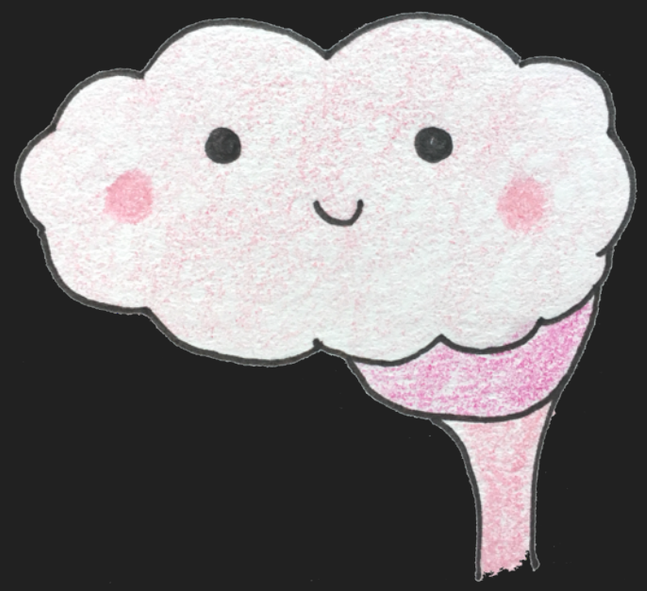
How does the human visual system paint a picture of our world, and how does the browser render pixels to the screen?

Human Vision

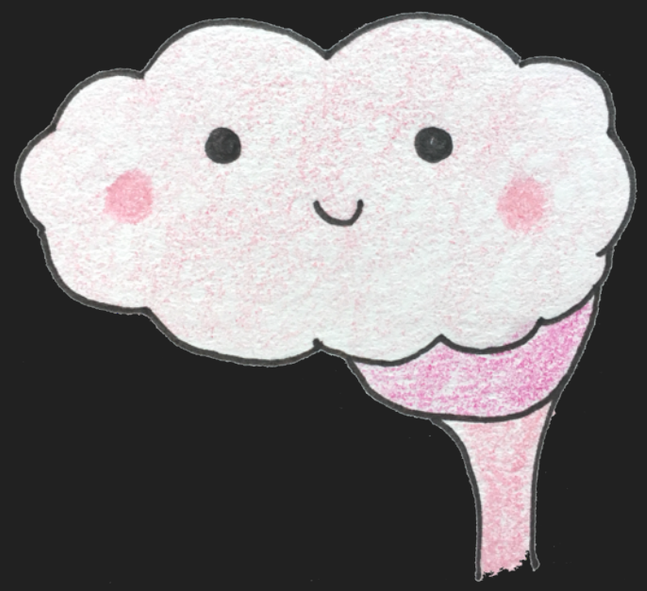
Step 1: Light goes into the eye via the cornea and lens



https://en.wikipedia.org/wiki/Visual_system

Human Vision

Step 2: The retina turns the light into neural signals using rods and cones



https://en.wikipedia.org/wiki/Visual_system
https://en.wikipedia.org/wiki/Flicker_fusion_threshold

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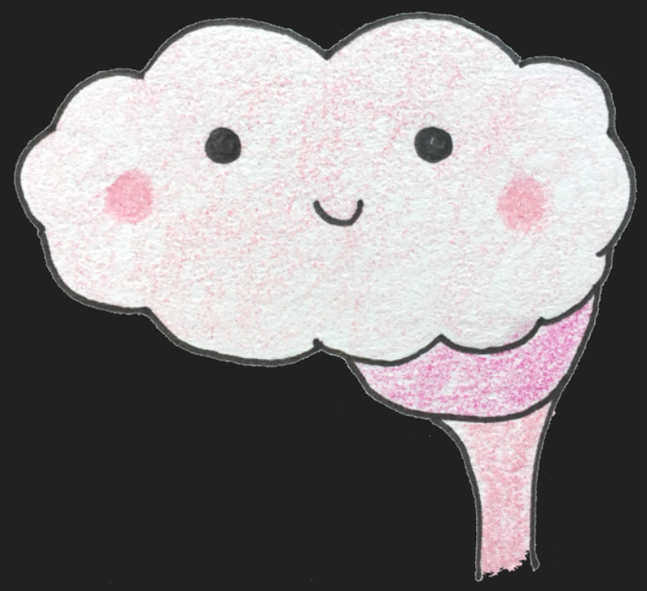
Human Vision

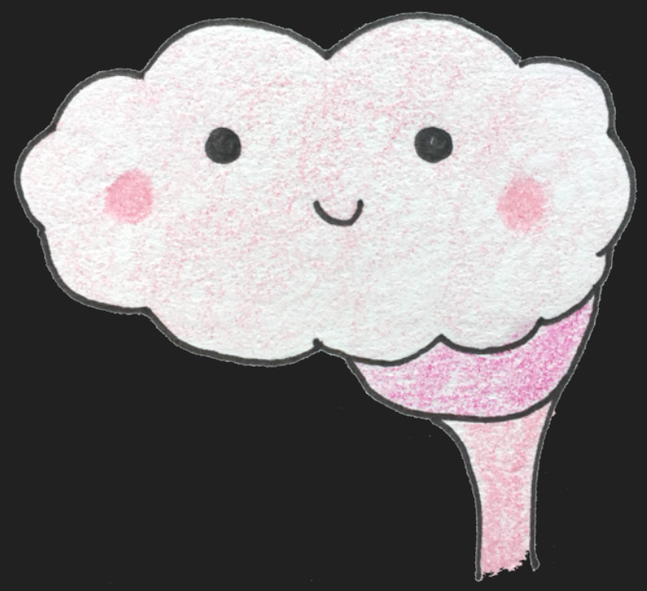
Step 3: The neural signals get sent via the optic nerve to the brain



https://en.wikipedia.org/wiki/Visual_system

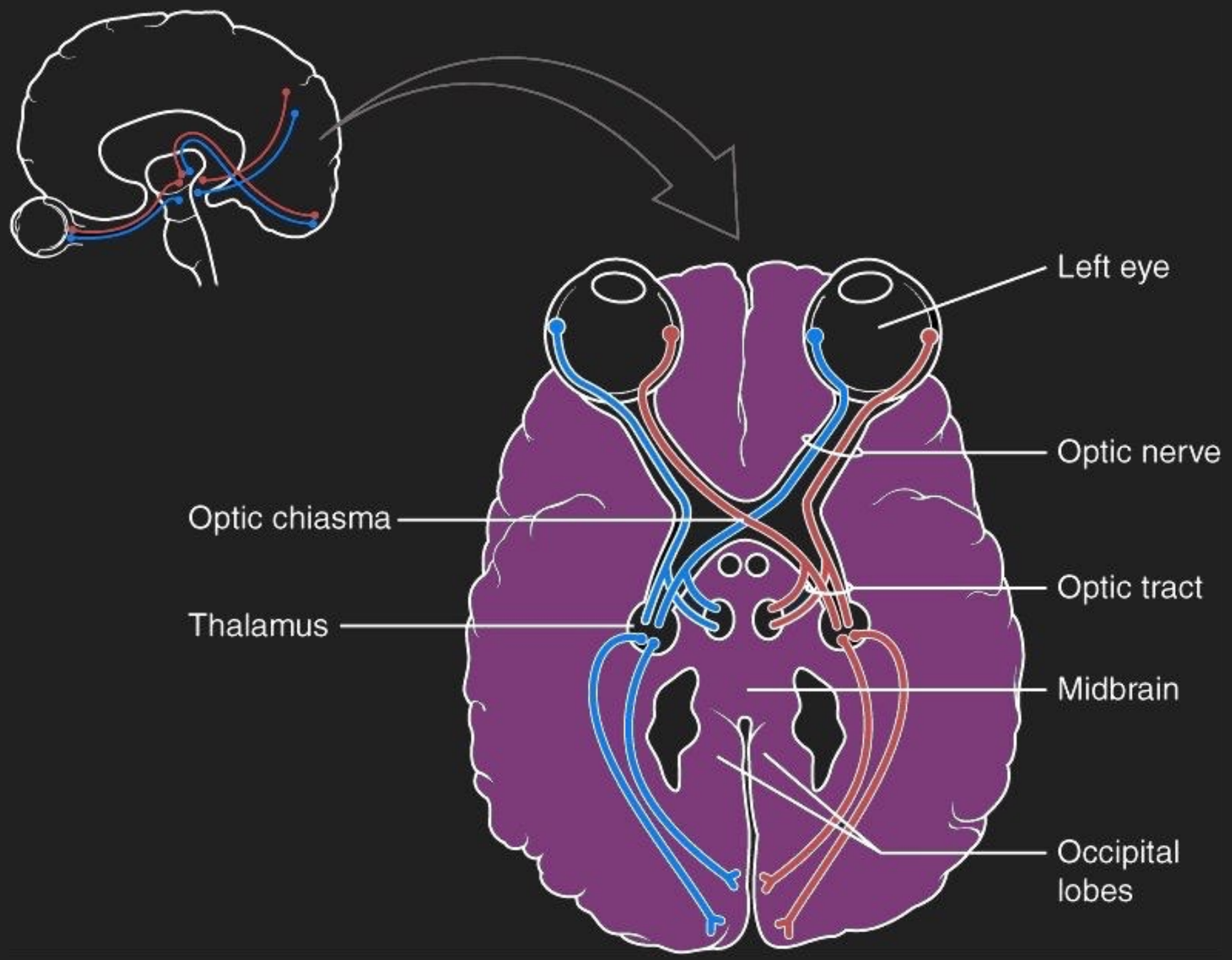
Human Vision

Step 4: Signals from both eyes reach the optic chiasm, are combined, split by visual field, and sent to the opposite side of the brain



https://en.wikipedia.org/wiki/Visual_system

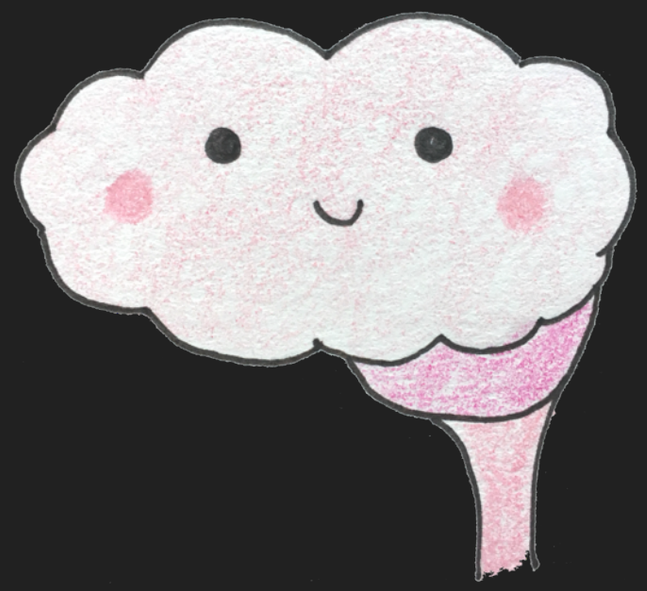
Human Vision



https://en.wikipedia.org/wiki/Visual_system
https://commons.wikimedia.org/wiki/File:1204_Optic_Nerve_vs_Optic_Tract.jpg

Human Vision

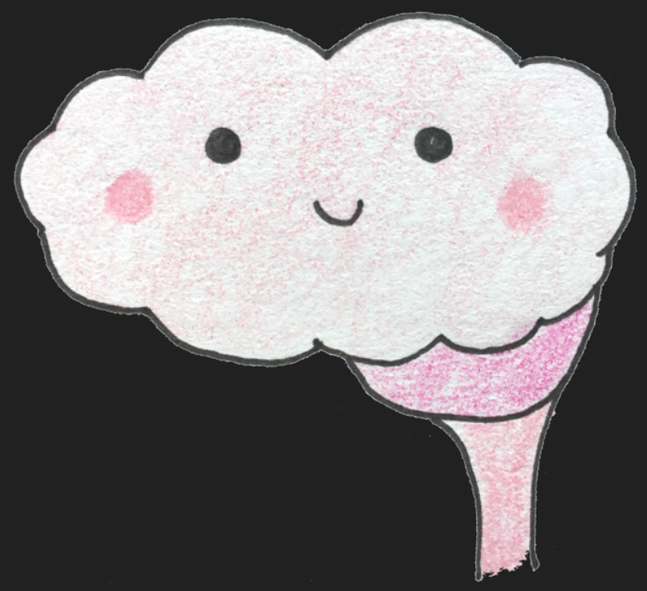
Step 5: Most signals get sent to the lateral geniculate nuclei



Blake, R., & Sekuler, R. (2006)

Human Vision

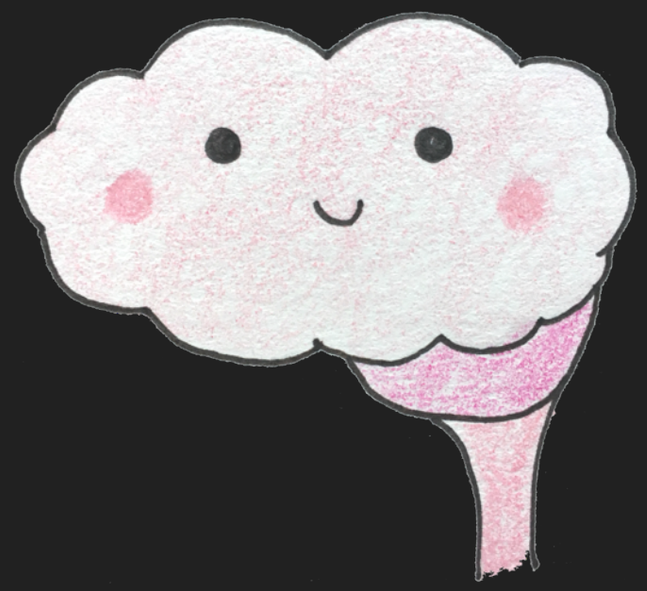
Step 6: Signals then get sent to the primary visual cortex



Blake, R., & Sekuler, R. (2006)

Human Vision

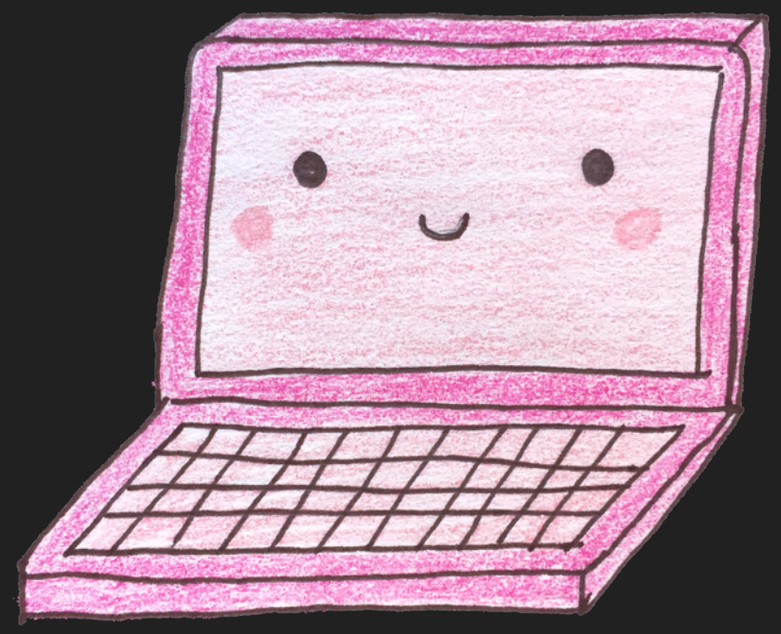
Step 7: Signals gets sent to higher visual processing centers that help us actually perceive what we are seeing



Blake, R., & Sekuler, R. (2006)

Rendering

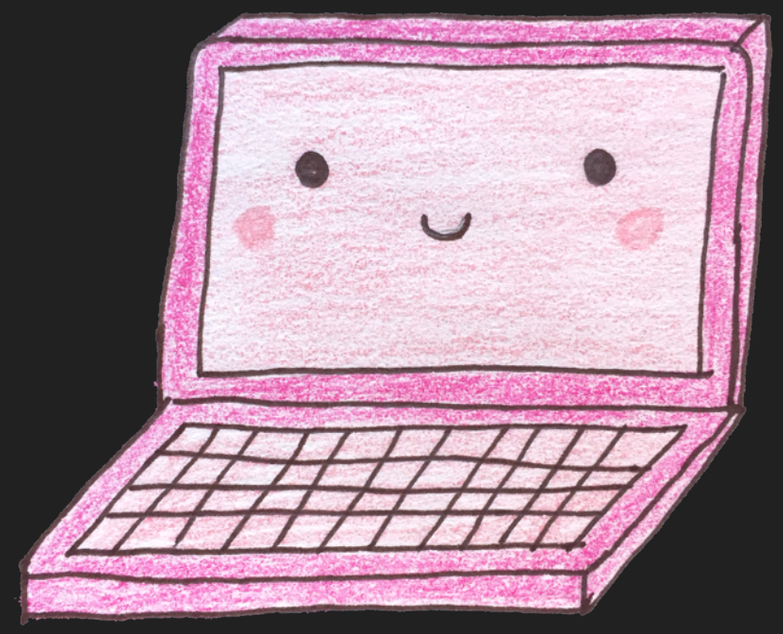
Step 1: HTML and CSS are parsed into DOM and CSSOM trees, respectively



https://developers.google.com/web/fundamentals/performance/critical-rendering-path/render-tree-construction

Rendering

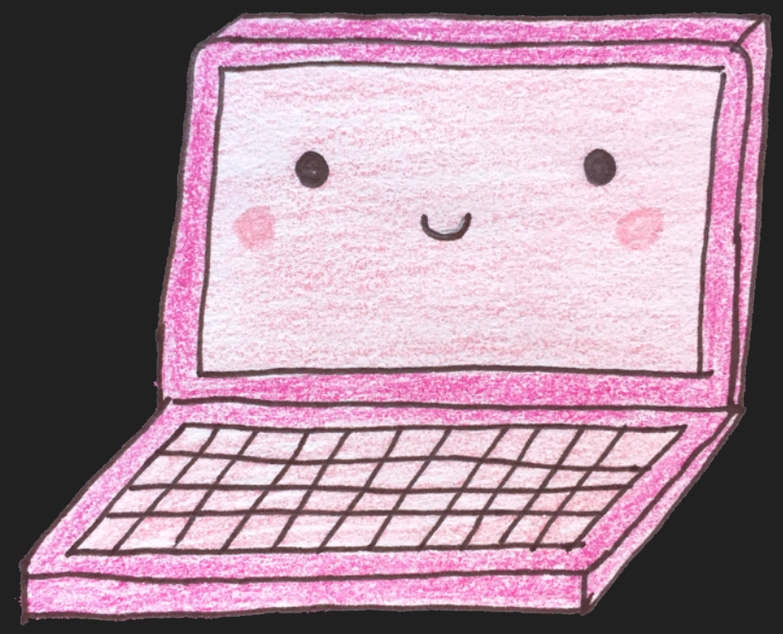
Step 2: The DOM and CSSOM trees are combined to form the render tree



https://developers.google.com/web/fundamentals/performance/critical-rendering-path/render-tree-construction

Rendering

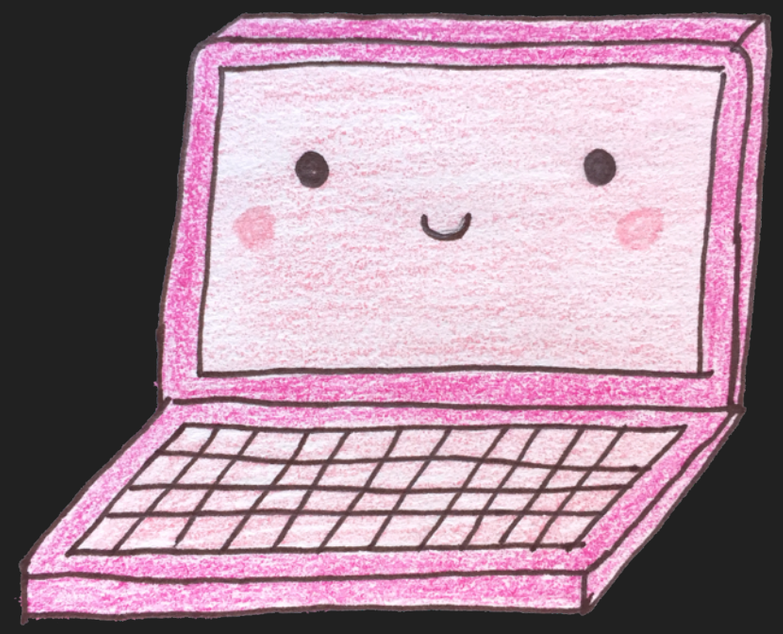
Step 3: The browser traverses the render tree, calculating the location and size of all elements



https://developers.google.com/web/fundamentals/performance/critical-rendering-path/render-tree-construction

Rendering

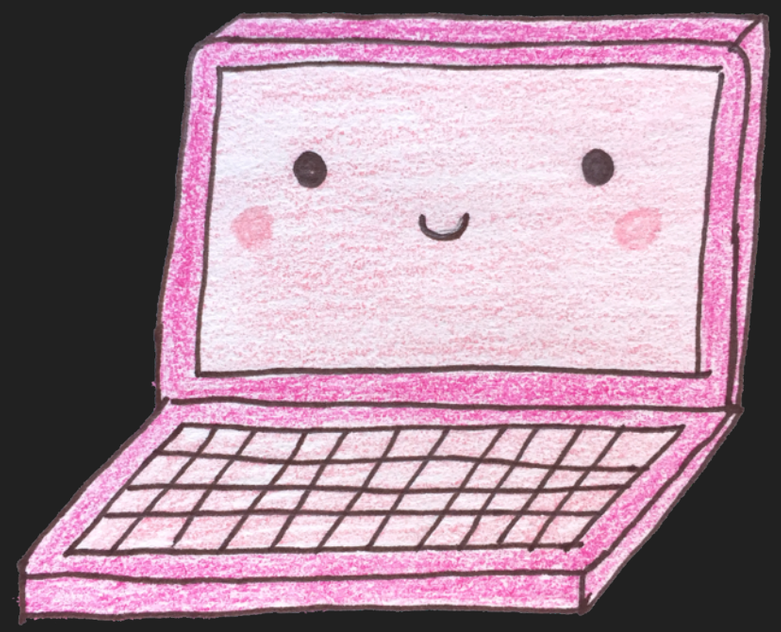
Step 4: The browser again traverses the render tree, creating bitmaps for each layer



https://www.youtube.com/watch?v=gqc88qWuiI4

Rendering

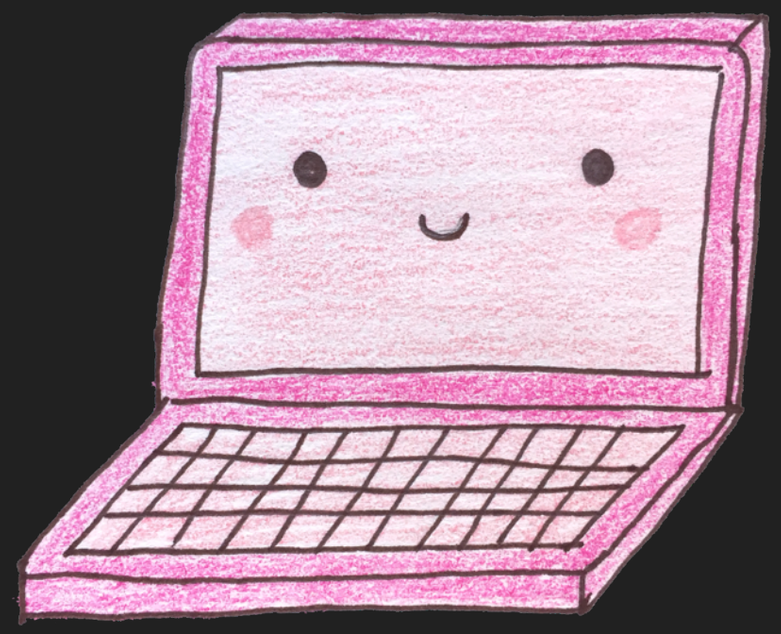
Step 5: Bitmaps are sent to the GPU for compositing



https://www.youtube.com/watch?v=gqc88qWuiI4
https://www.html5rocks.com/en/tutorials/speed/layers/

Rendering

Step 6: Do it all again, maybe 60 times a second



https://www.html5rocks.com/en/tutorials/speed/layers/

Task Management

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Can the human mind multitask? Can the browser?

Human Attention

- attention as a filter
- attention as a spotlight
- attention as control

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Human Attention

BLUE PURPLE RED

GREEN PURPLE

GREEN

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Human Attention

Human Attention

BLUE PURPLE RED
GREEN PURPLE
GREEN

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Human Attention

BLUE PURPLE RED

GREEN PURPLE

GREEN

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Human Attention

- attention as a filter
- attention as a spotlight
- attention as control

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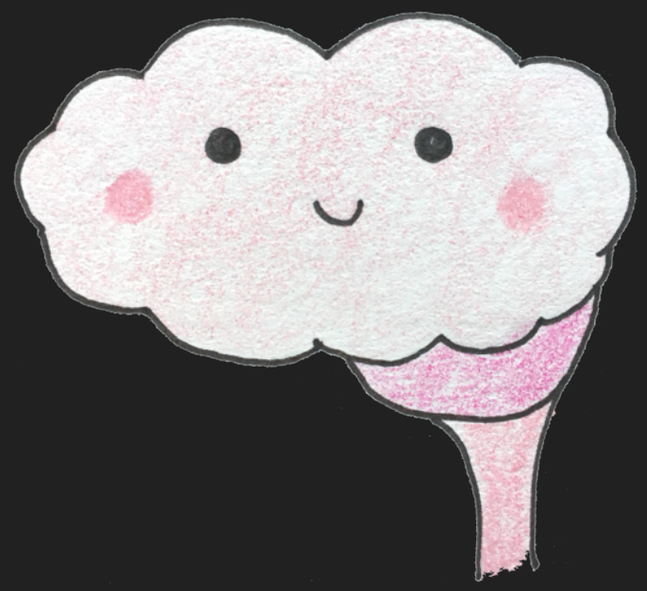
Human Attention

- attention as a filter
- attention as a spotlight
- attention as control
- attention as threads!



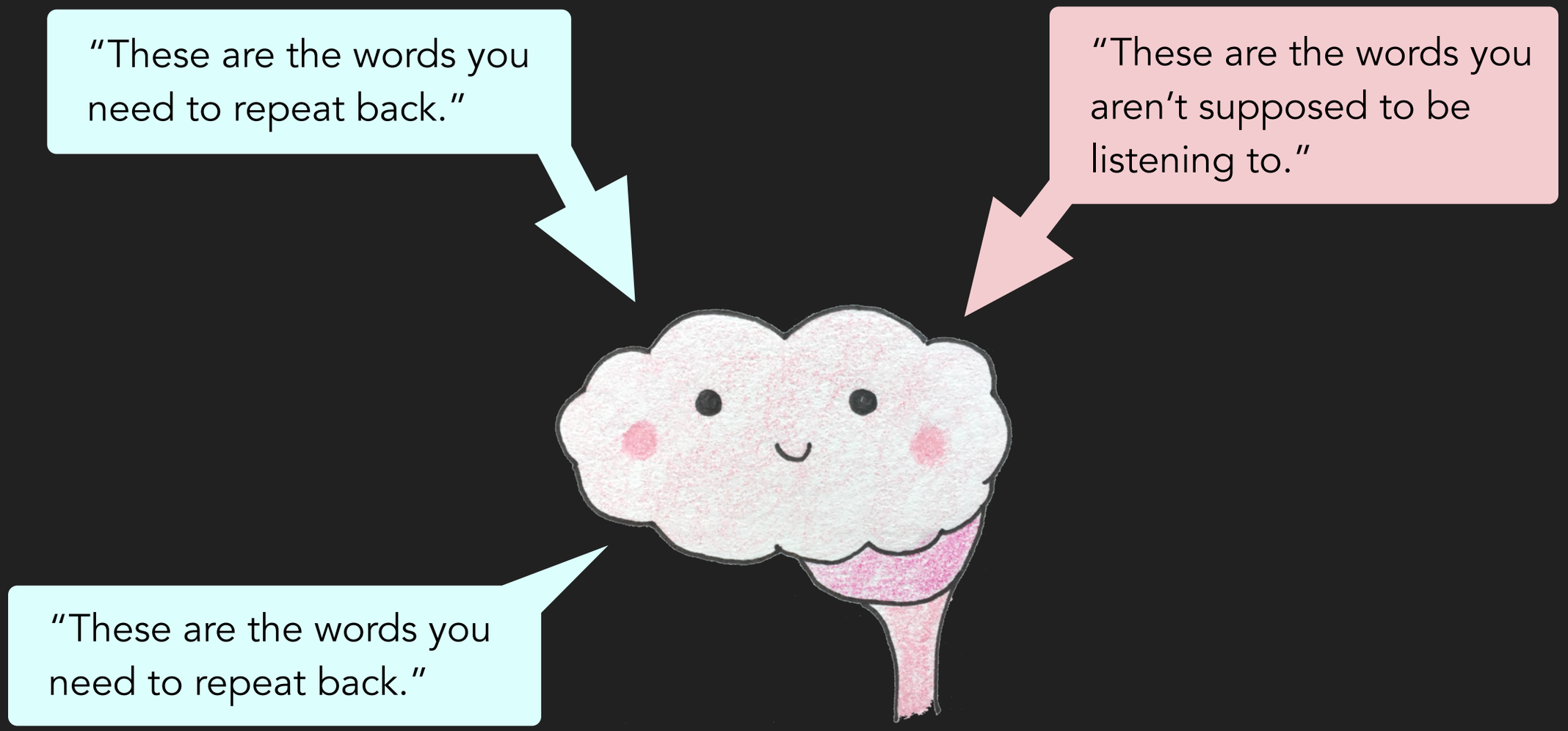
Human Attention

Humans are pretty bad at multitasking:

- inattentional blindness
- dichotic listening task
- shadowing

(Simons, 1999; Cherry, 1953; Treisman, 1964; Allport et al., 1972)

Human Attention



(Simons, 1999; Cherry, 1953; Triesman, 1964; Allport et al., 1972)

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Human Attention

"These are the words you need to repeat back."

"Words these are the aren't supposed to you be to listening."

"These are the words you need to repeat back."

(Simons, 1999; Cherry, 1953; Triesman, 1964; Allport et al., 1972)

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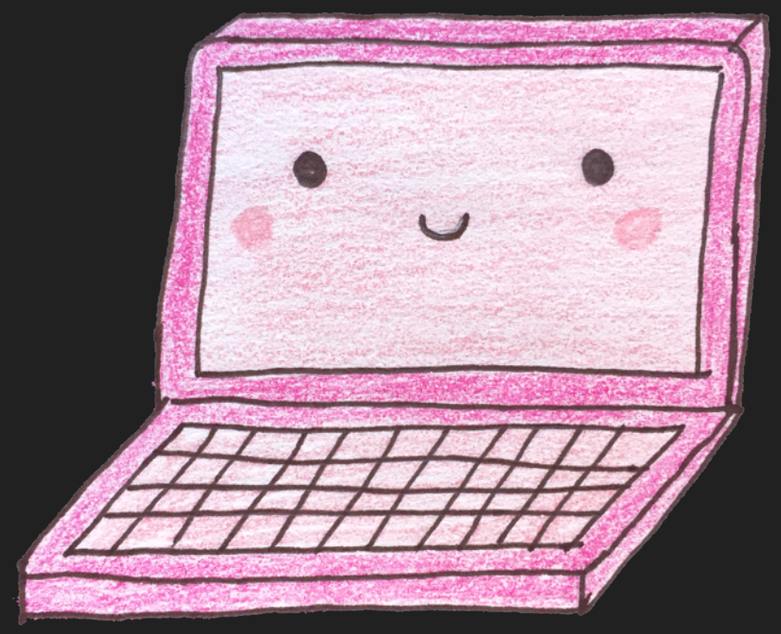
Browser "Attention"

JavaScript itself doesn't multitask.

- single-threaded
- non-blocking
- asynchronous



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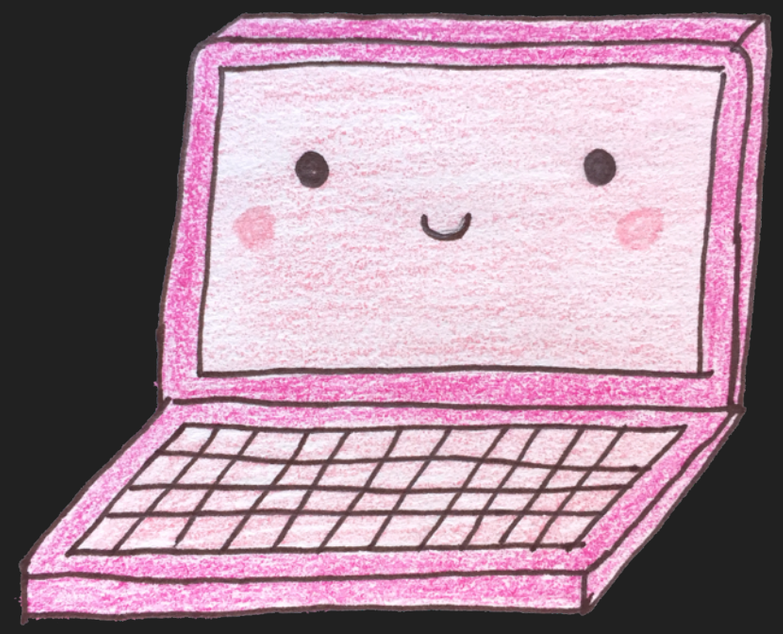
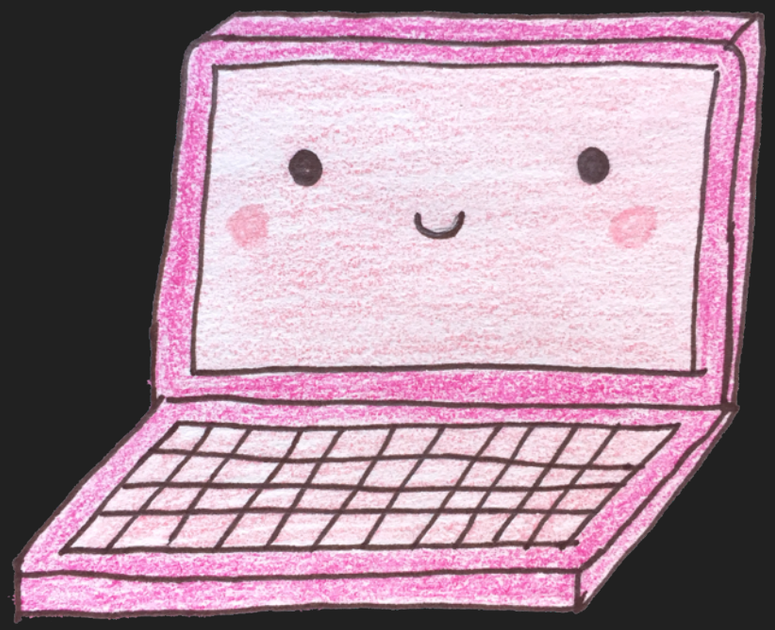
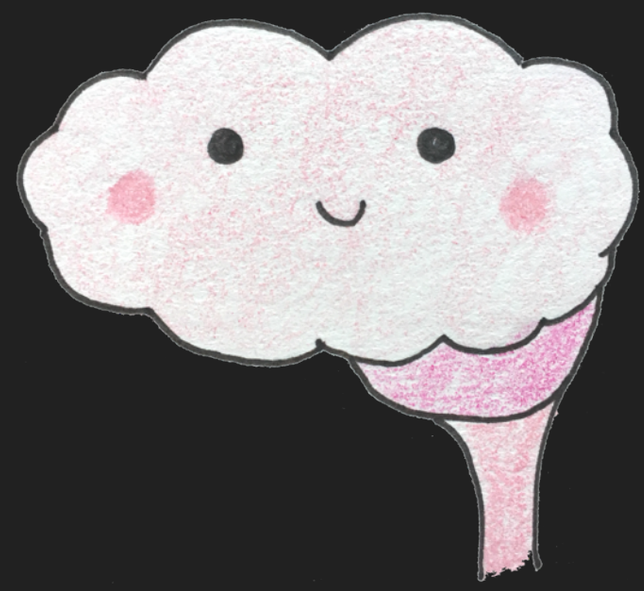
Browser "Attention"

Within the browser, JavaScript can call out to APIs, making the browser itself able to effectively multitask!



Browser, are you processing the same way I'm processing?





Guess not, Brain! But I hope you learned something!

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Resources

Books

- Blake, R., & Sekuler, R. & (2006). *Perception (5th ed.)*. Boston: McGraw-Hill.
- Harley, T. A. (2008). *Psychology of Language: From Data to Theory (3rd ed.)*. New York: Psychology Press.
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Websites

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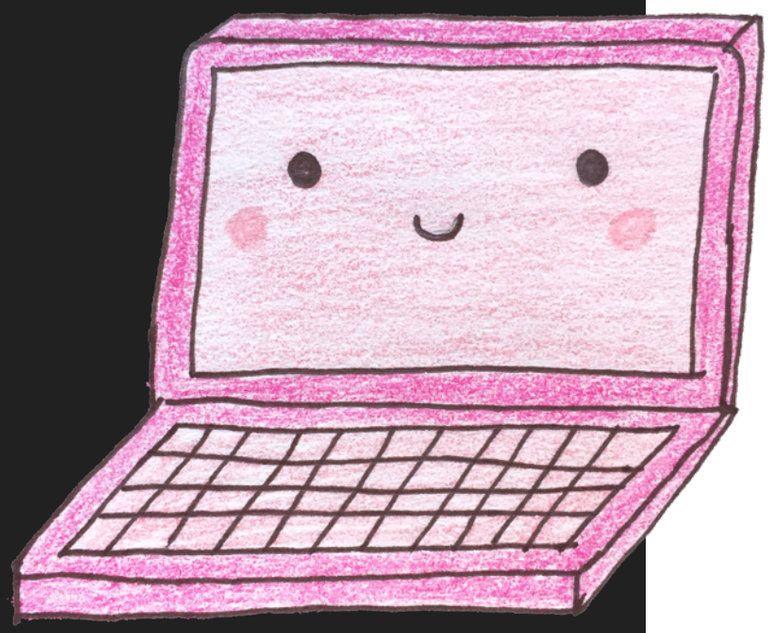
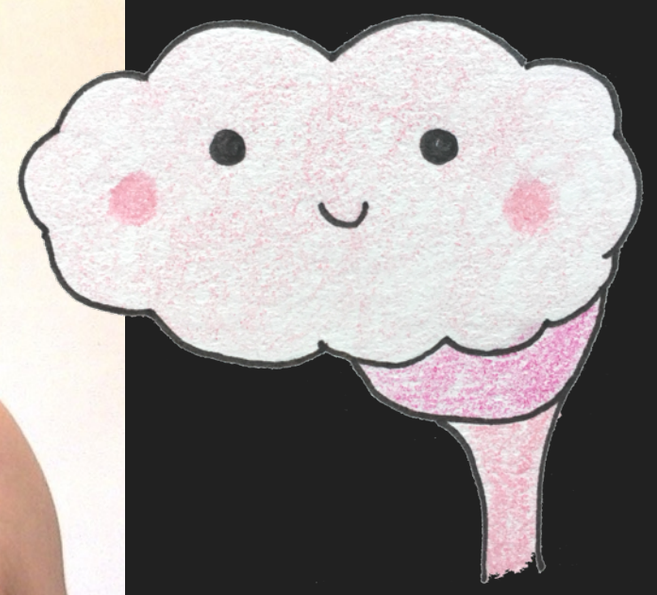
Thanks!

jenna.is/at-nationjs





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