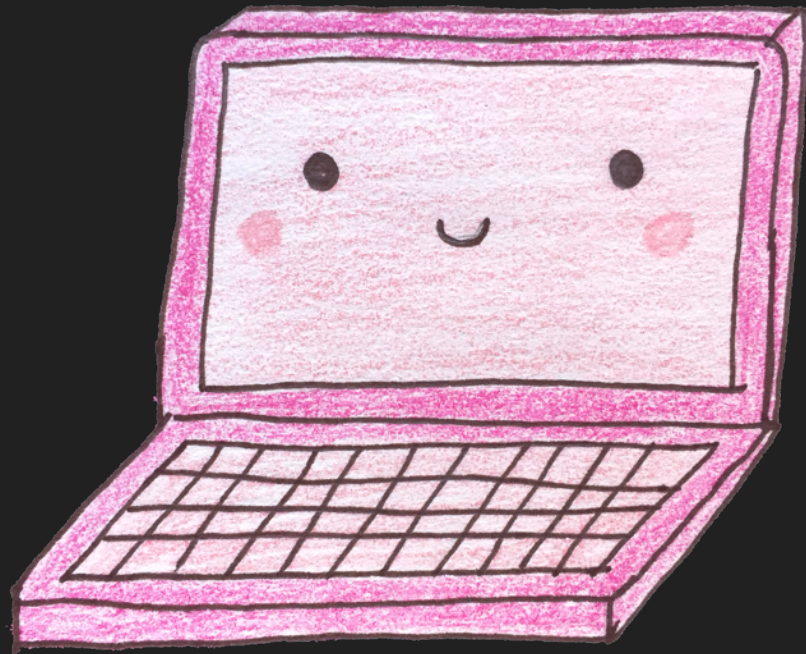
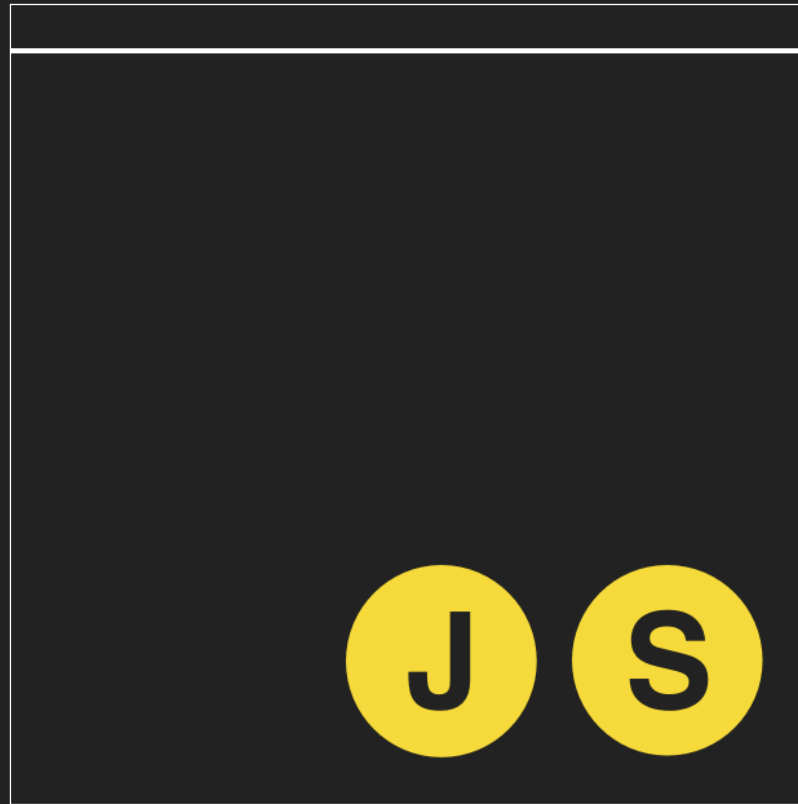


The Browser and the Brain



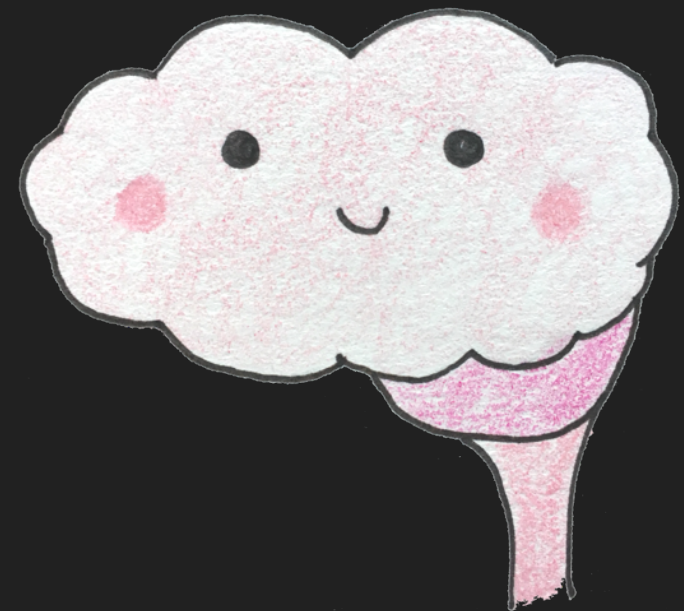
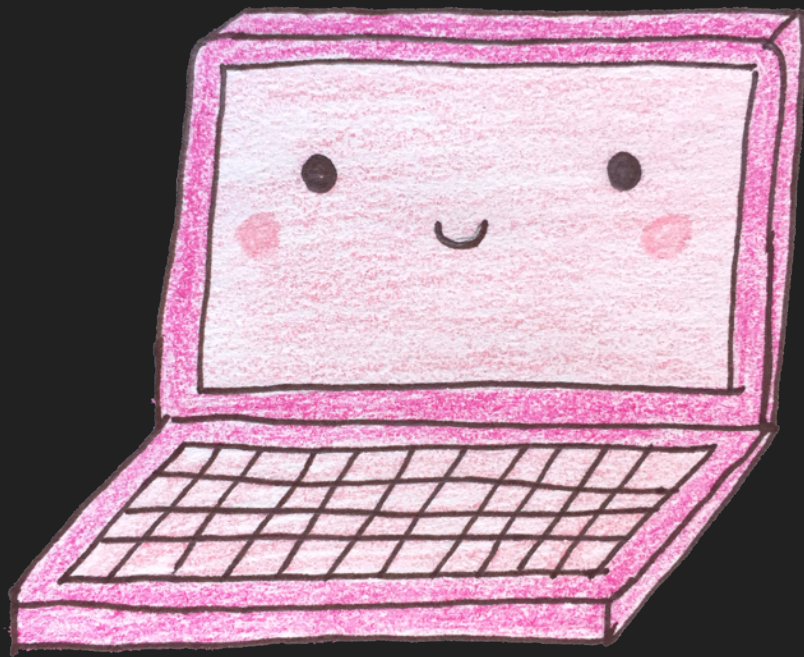
Jenna Zeigen • NationJS • December 1, 2017



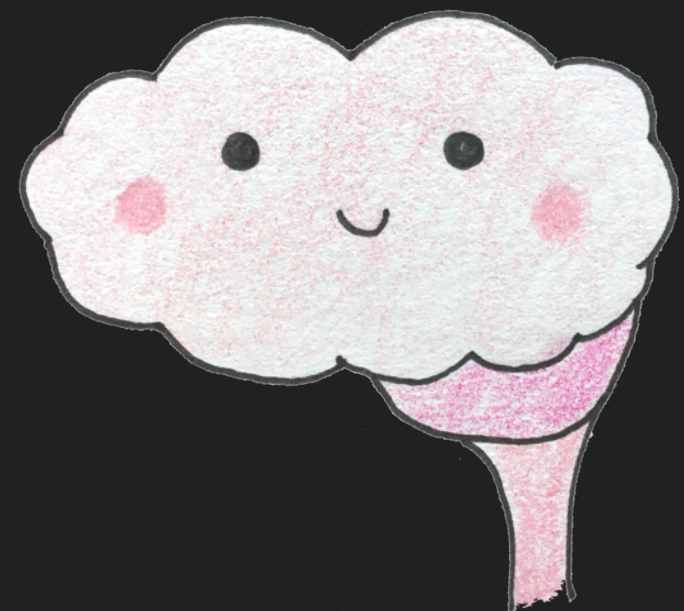
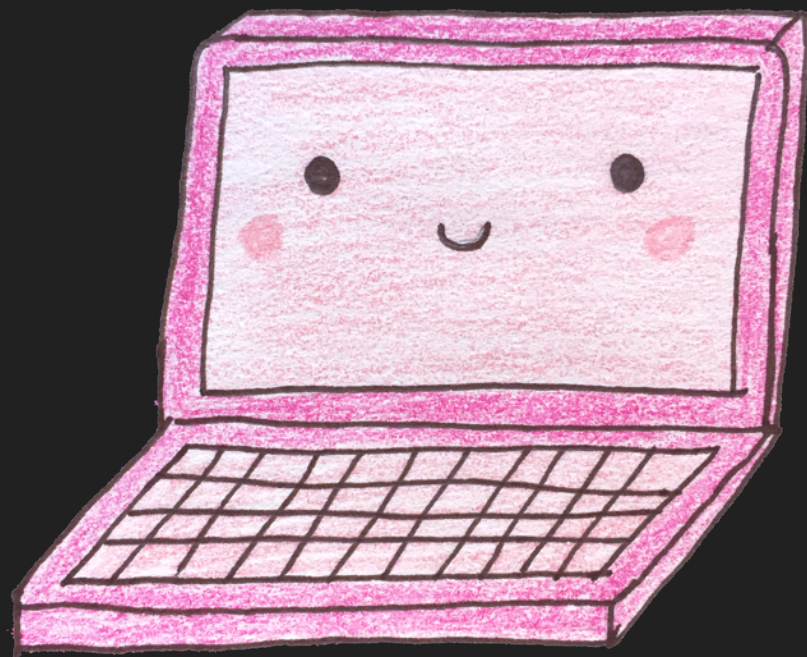


jenna.is/at-nationjs

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

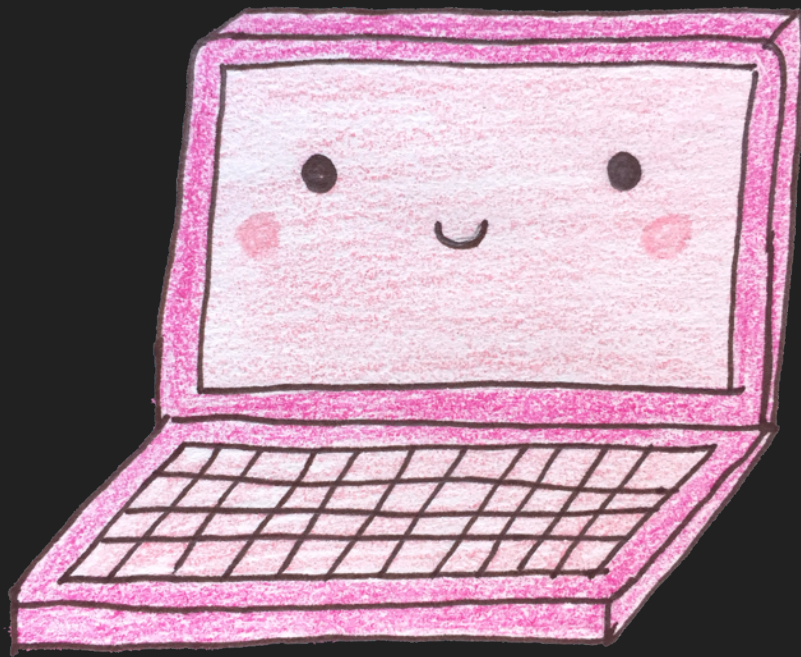


The same thing she does every time, Browser. Talk about cognition and computers!



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!

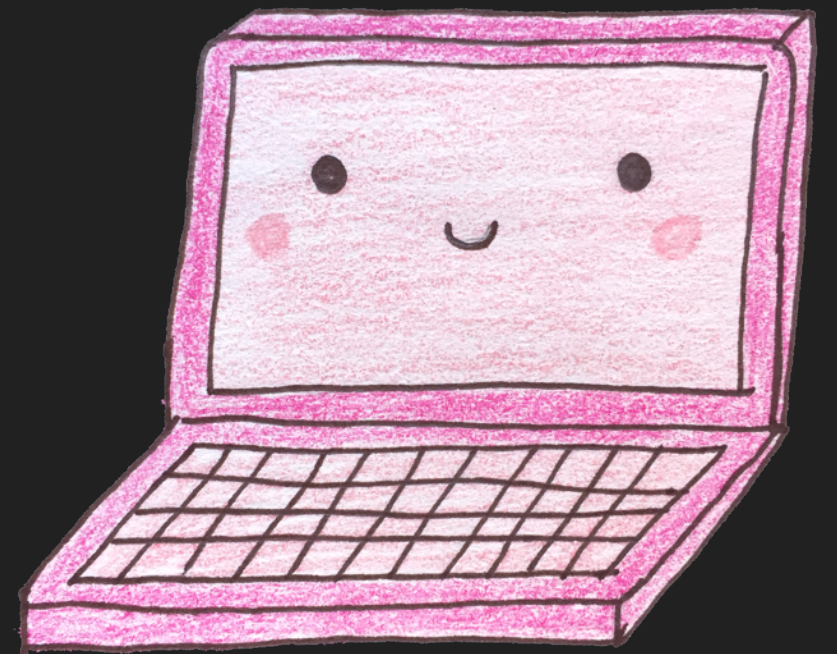
We made computers so we know all the
answers, and we do science on humans
to find out the answers

Understanding

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

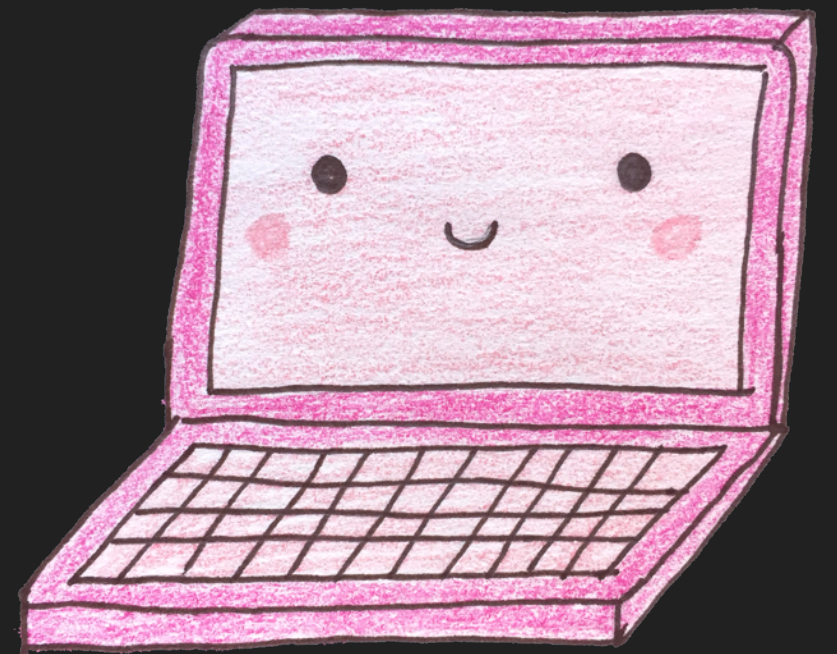
HTML, CSS, & JS

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



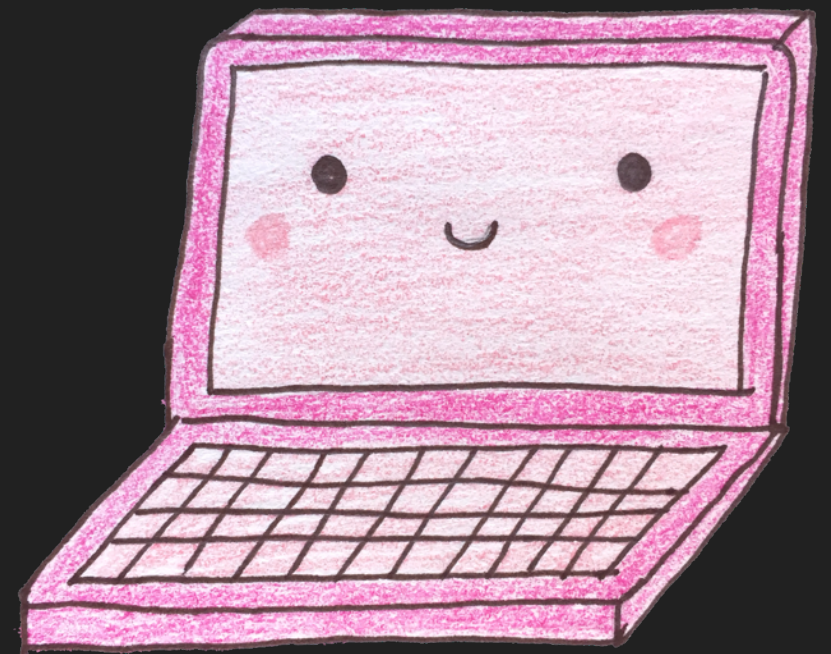
HTML, CSS, & JS

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



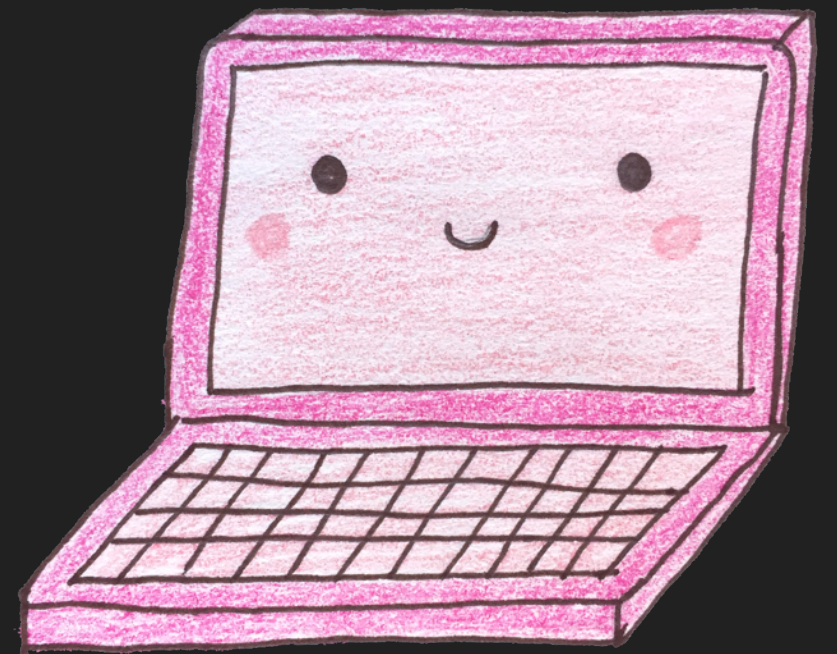
HTML, CSS, & JS

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



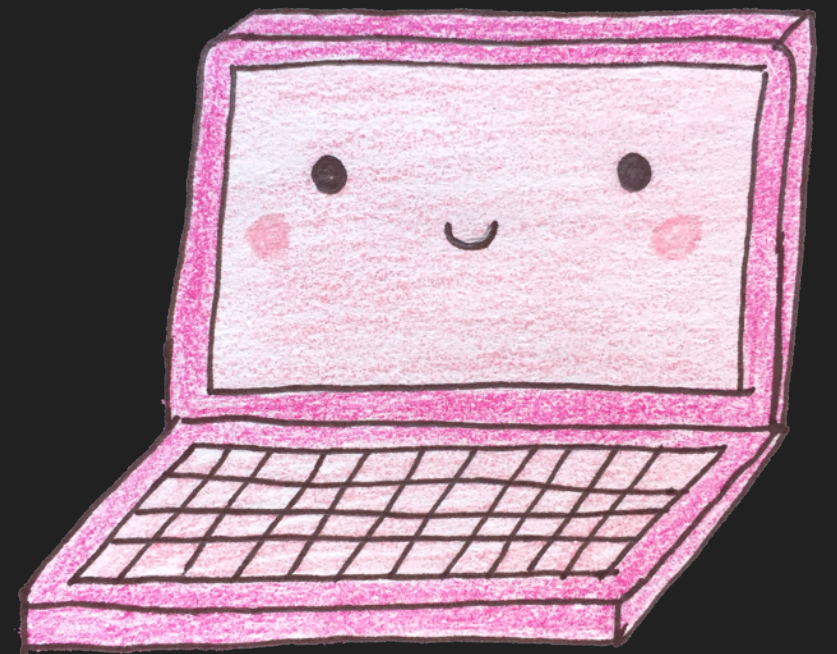
HTML, CSS, & JS

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



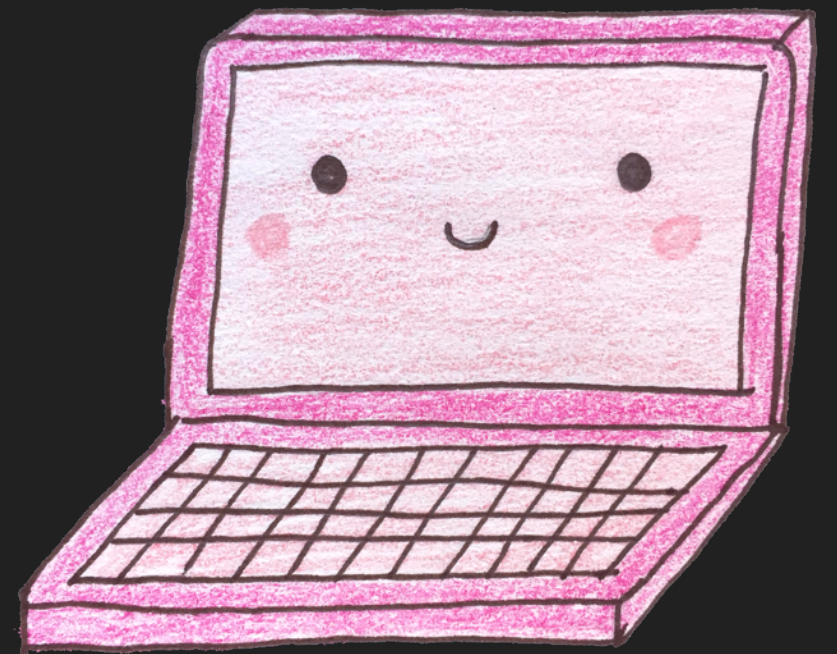
HTML, CSS, & JS

CSS is context-free and therefore easier to parse. Yay.



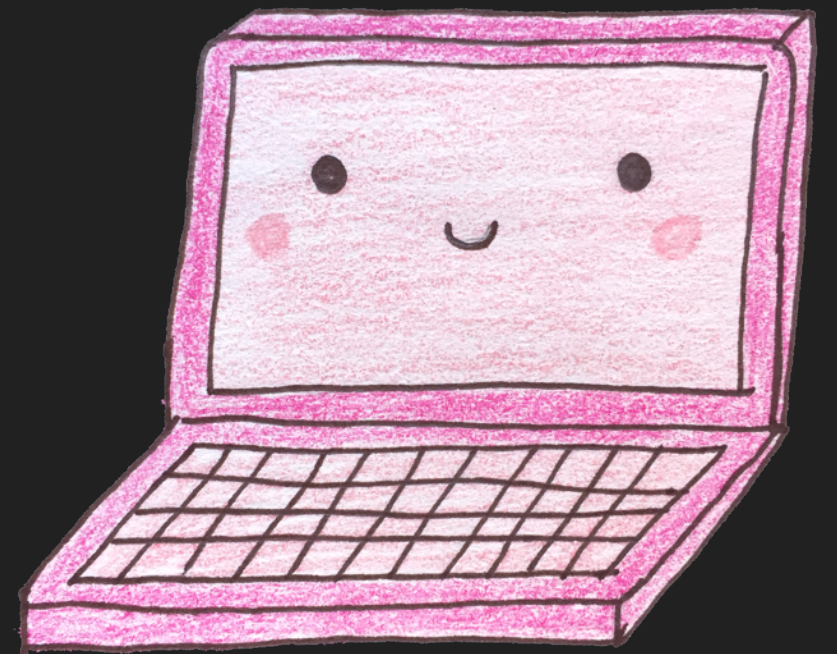
HTML, CSS, & JS

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



HTML, CSS, & JS

JavaScript is also context-free and can use a regular parser, but browsers these days make it more complicated in order to optimize the process



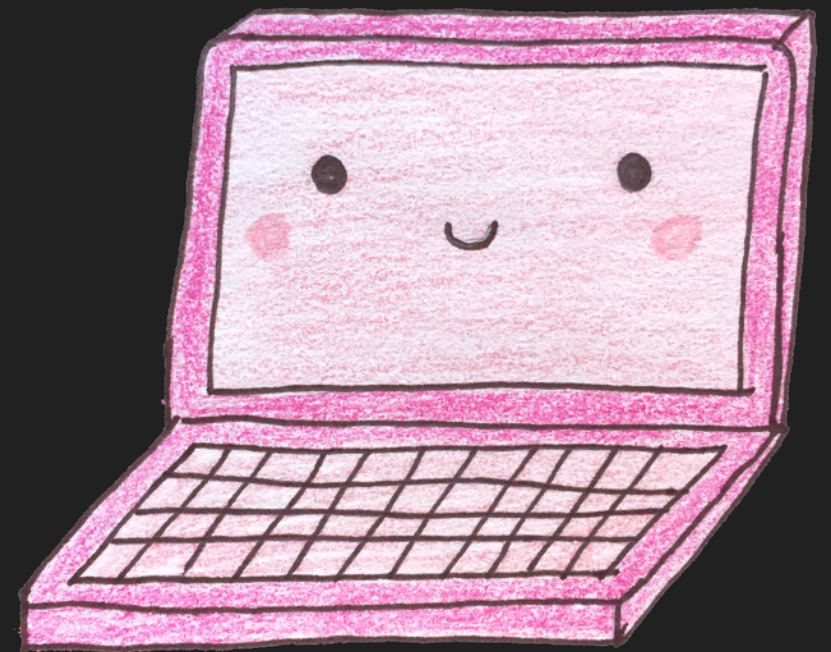
HTML, CSS, & JS

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



HTML, CSS, & JS

The AST and Scope structures get turned into bytecode and then the bytecode gets executed.



HTML, CSS, & JS

The bytecode also gets fed to the optimizing compiler, spitting out machine code, which then gets executed



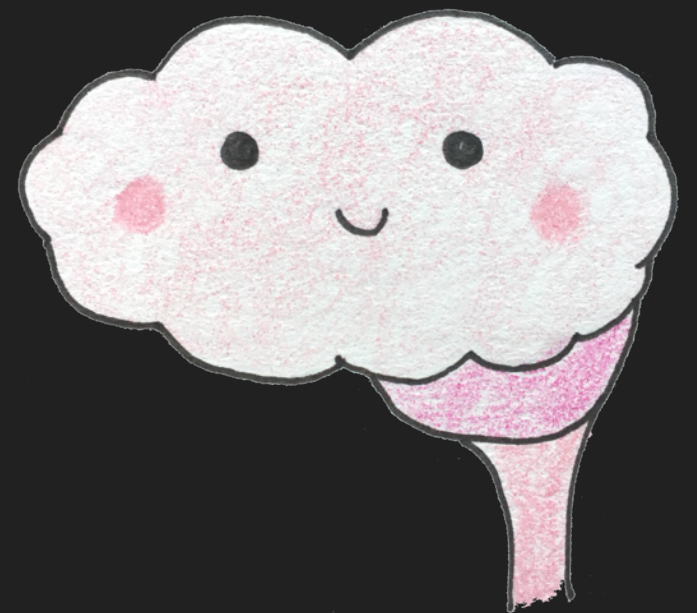
Natural Language

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



Natural Language

Humans are forgiving of syntax errors.



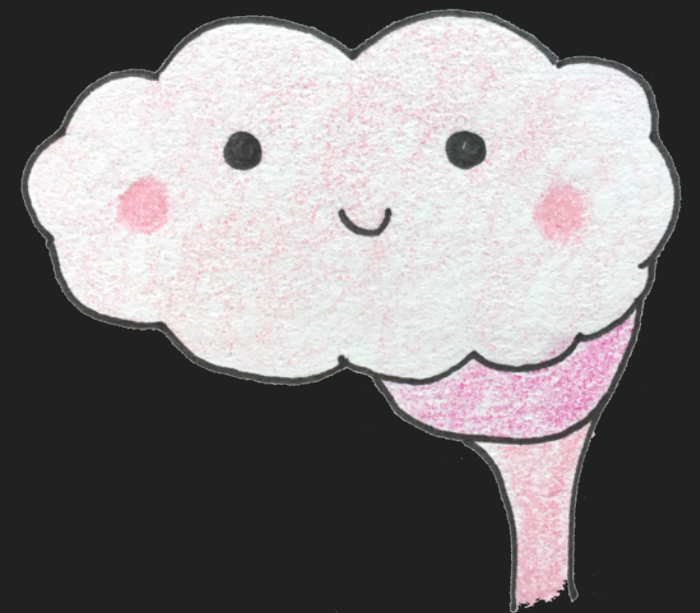
Natural Language

Humans language contains a ton of ambiguity.



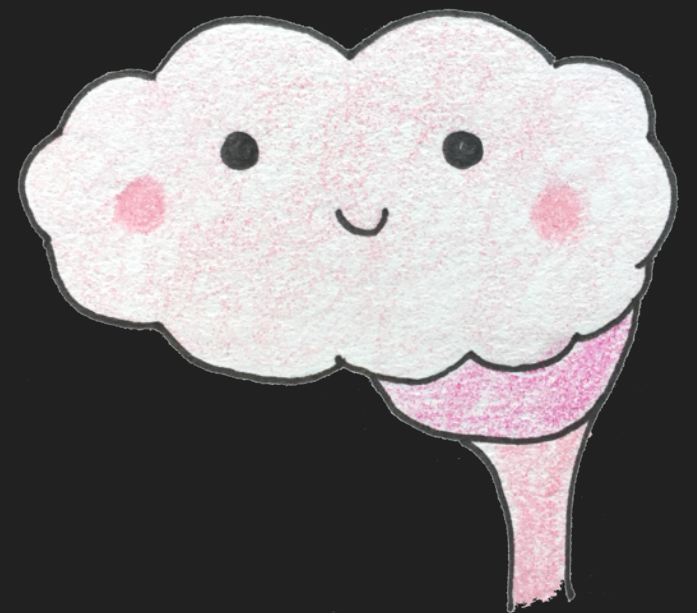
Natural Language

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



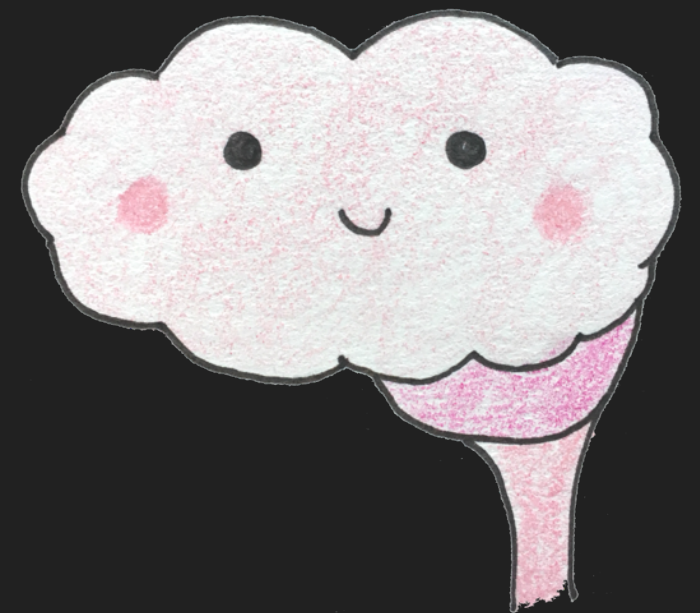
Natural Language

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



Natural Language

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



Natural Language

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



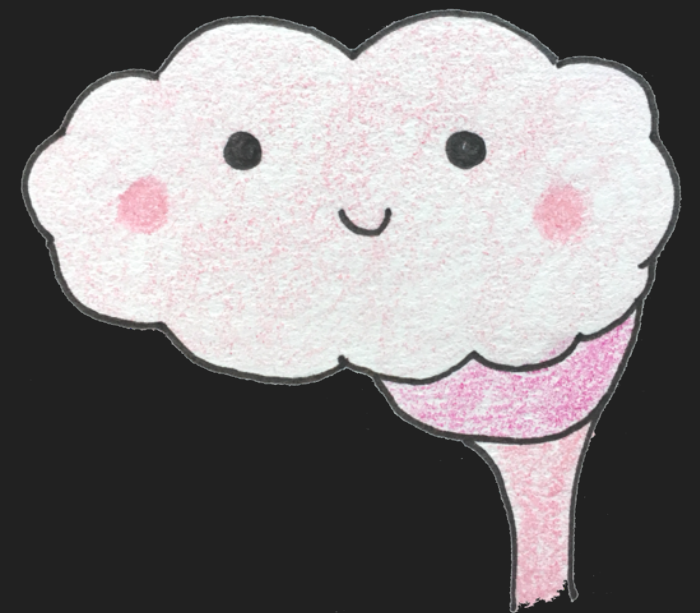
Natural Language

Modular View: the phases involved
occur separately in different modules



Natural Language

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



Natural Language

Does this happen in serial or in parallel?



Natural Language

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



Visualizing

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

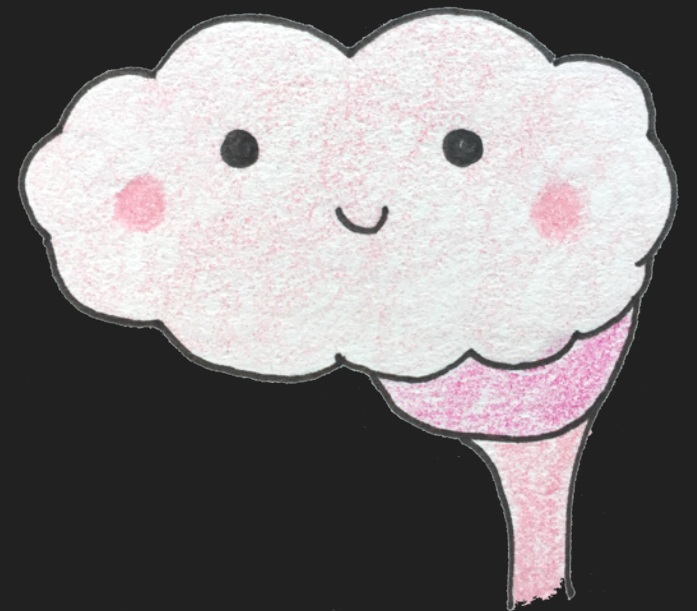
Human Vision

Step 1: Light goes into the eye



Human Vision

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



Human Vision

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



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



Human Vision

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



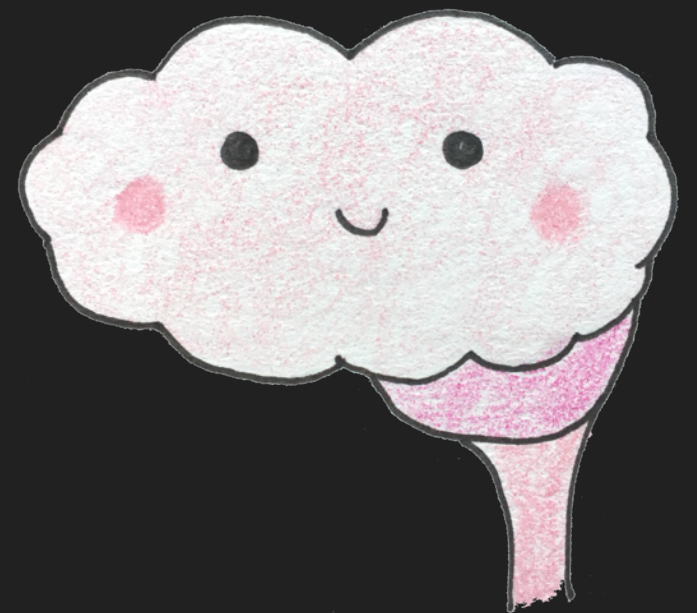
Human Vision

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



Human Vision

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



Rendering

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



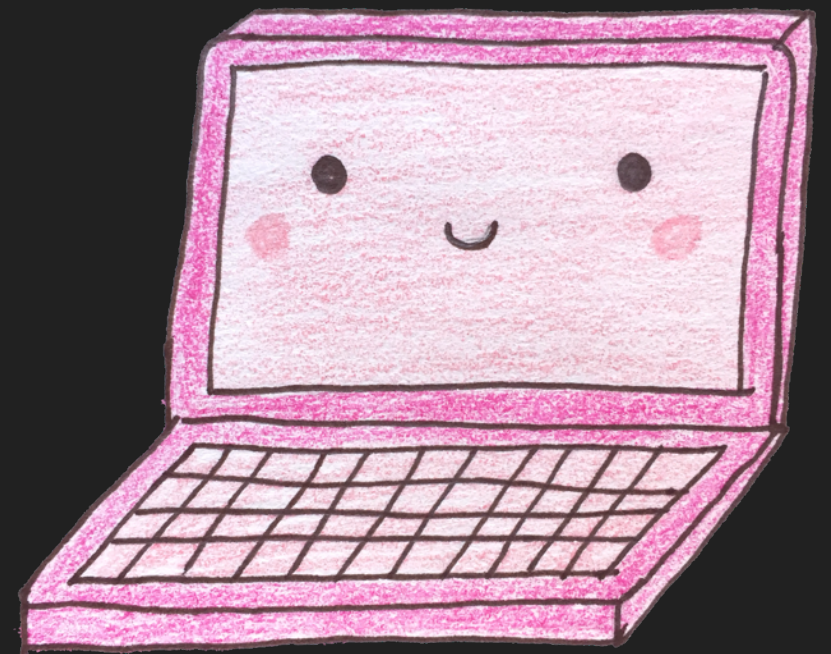
Rendering

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



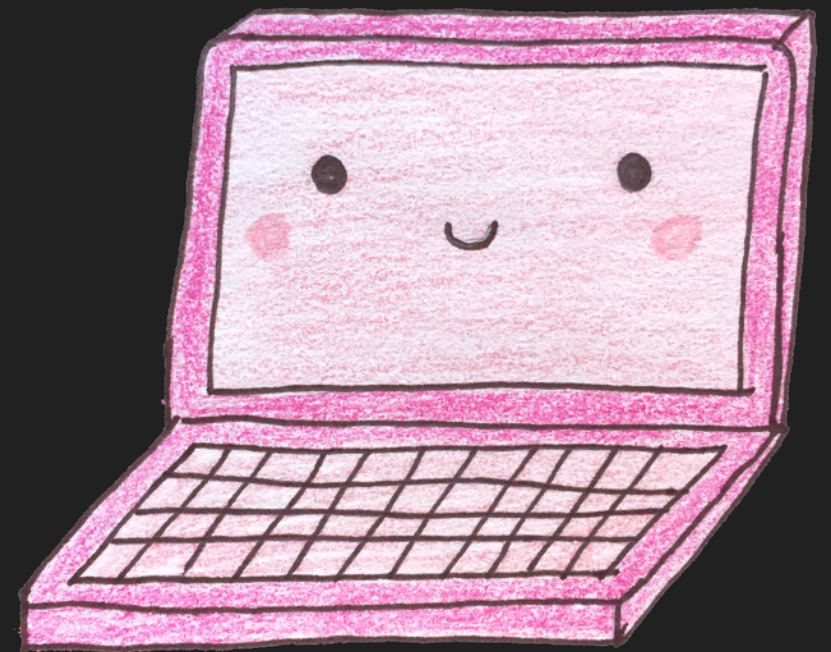
Rendering

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



Rendering

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



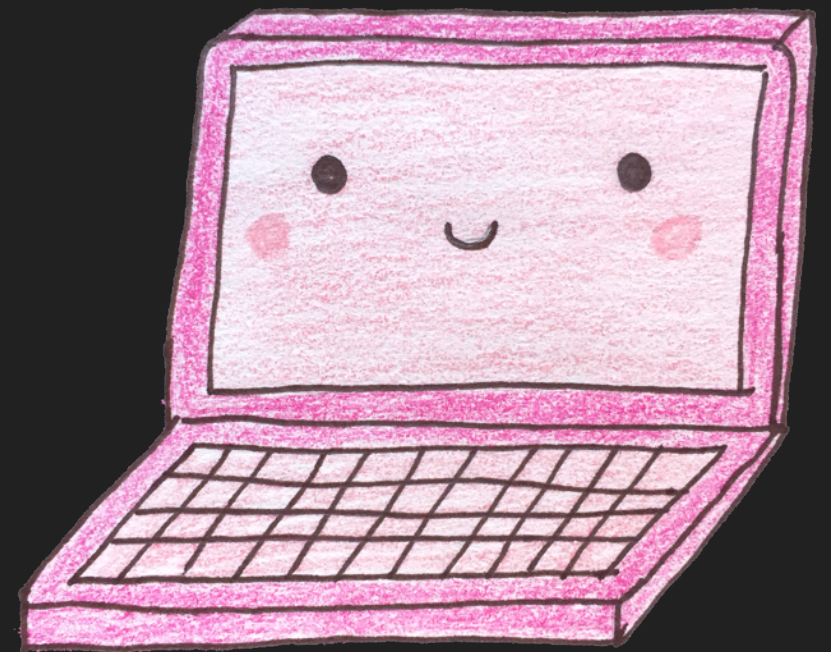
Rendering

Step 5: Bitmaps are sent to the GPU for compositing



Rendering

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



Task Management

Can the human mind multitask? Can the browser?

Human Attention

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



Human Attention

BLUE PURPLE RED

GREEN PURPLE

GREEN

Human Attention



Human Attention

BLUE PURPLE RED

GREEN PURPLE

GREEN

Human Attention

BLUE PURPLE RED

GREEN PURPLE

GREEN

Human Attention

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



Human Attention

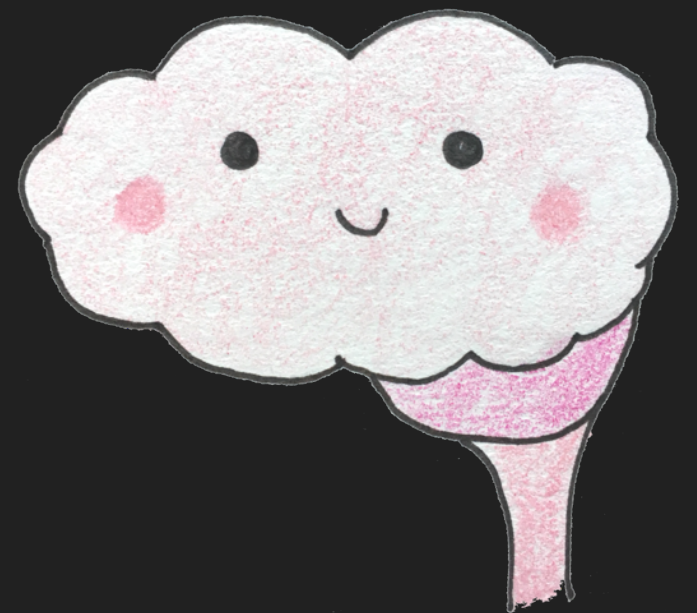
- attention as a filter
- attention as a spotlight
- attention as glue
- attention as threads!



Human Attention

Humans are pretty bad at multitasking:

- inattentional blindness
- dichotic listening task
- shadowing



Human Attention

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

"These are the words you aren't supposed to be listening to."

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



Human Attention

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

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

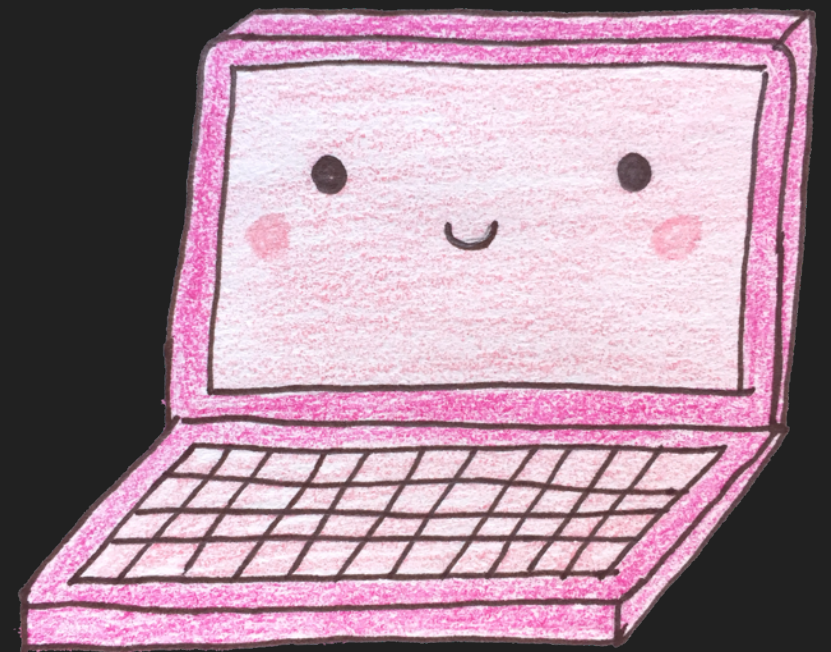
"These are the words you need to repeat back."



Browser "Attention"

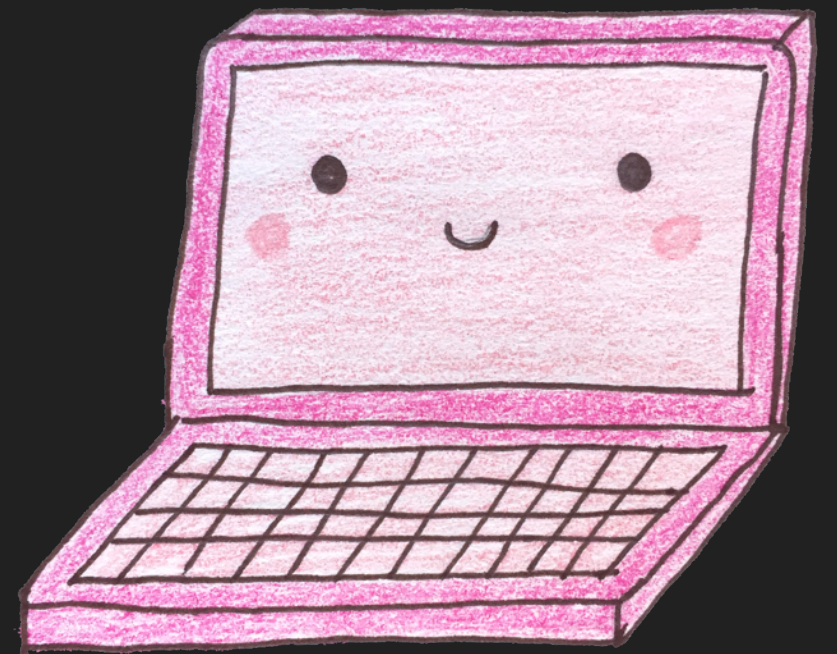
JavaScript itself doesn't multitask.

- single-threaded
- non-blocking
- asynchronous



Browser “Attention”

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



Resources

Books

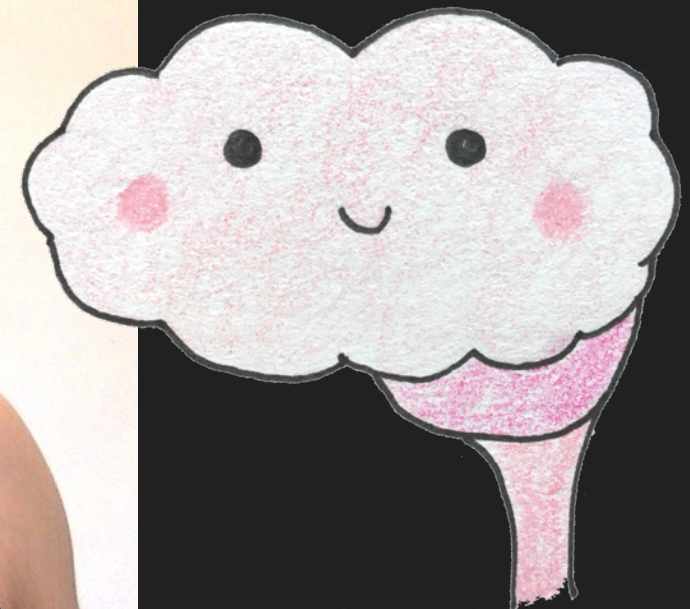
- Blake, R., & Sekuler, R. & (2006). *Perception (5th ed.)*. Boston: McGraw-Hill.
- Harley, T. A. (2008). *Psychology of Language: From Data to Theory (3rd ed.)*. New York: Psychology Press.
- Kellogg, R. T. (2007). *Fundamentals of cognitive psychology*. Thousand Oaks, CA: SAGE.

Websites

- <https://www.html5rocks.com/en/tutorials/internals/howbrowserswork>
- <https://www.html5rocks.com/en/tutorials/speed/layers/>
- <https://developers.google.com/web/fundamentals/performance/critical-rendering-path/render-tree-construction>
- <https://www.youtube.com/watch?v=Fg7niTmNNLg>
- <https://www.youtube.com/watch?v=p-iiEDtpy6I>
- <https://www.youtube.com/watch?v=gqc88qWuiI4>
- https://en.wikipedia.org/wiki/Visual_system
- https://en.wikipedia.org/wiki/Lateral_geniculate_nucleus
- https://en.wikipedia.org/wiki/Language_processing_in_the_brain
- https://en.wikipedia.org/wiki/Sentence_processing
- <http://www.imdb.com/title/tt0112123/quotes>

Thanks!

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