

From Parentheses To Perception



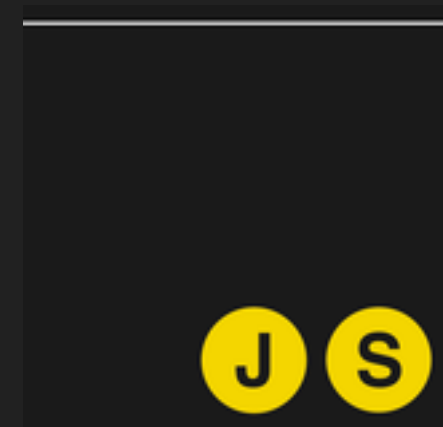
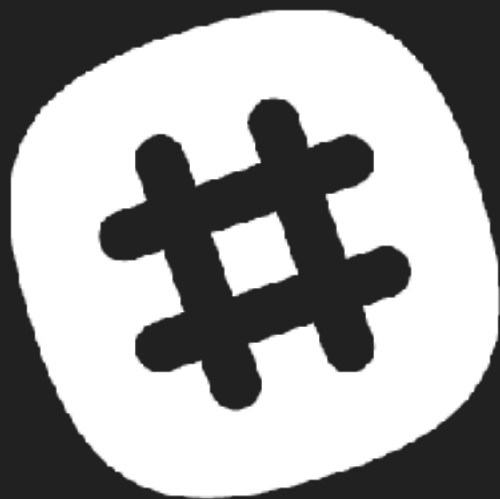
How Your Code Becomes
Another's Reality

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at Slack

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Organizer of BrooklynJS



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```
<button
  type="button"
  class="Button send-button"
>
  Send
</button>
```

```
.Button {
  font-size: 16px;
  background: #128853;
  color: #fff;
  border-radius: 5px;
}
```

```
const button =
  document.querySelector('.send-button');
button.addEventListener('click', onBtnClick);
```

Nom nom nom!





Send

This is a button
and I know I can click
it and it'll do
something!



1. Parsing
2. Rendering
3. Perceiving
4. Comprehending

1. Parsing
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- 

1. Parsing
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- 

We made computers so
we know all the
answers.

We do science on
humans to get closer
to the answers.

Parsing

How does the browser
process HTML, CSS, and
JavaScript?

I begin to parse,
To split the text apart
Break it down into sections
Tokens into selectors



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Parsing

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

Stop! Grammar time!



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

https://en.wikipedia.org/wiki/Context-free_grammar

MC Hammer - U Can't Touch This

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Parsing

Parsers take a document and break it into a structure the browser can use.

It's as if you know me better
Than I ever knew myself
I love how you can tell
All the pieces, pieces, pieces of me
♪♪♪



Parsing

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

This is the parse of me
That you're never gonna ever
Take away from me, no!

♪ ♪ ♪



Parsing

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

Whatever, wherever
I'm gonna make it render!



Parsing

Instead, browsers write custom
parsers for HTML

Yeah, my momma she told me
Don't worry about your size
She says I'm this big 'cause sometimes
humans just aren't so bright!



Parsing

CSS is a context-free language
and therefore easier to parse.

This parser's young and wild and
context-free



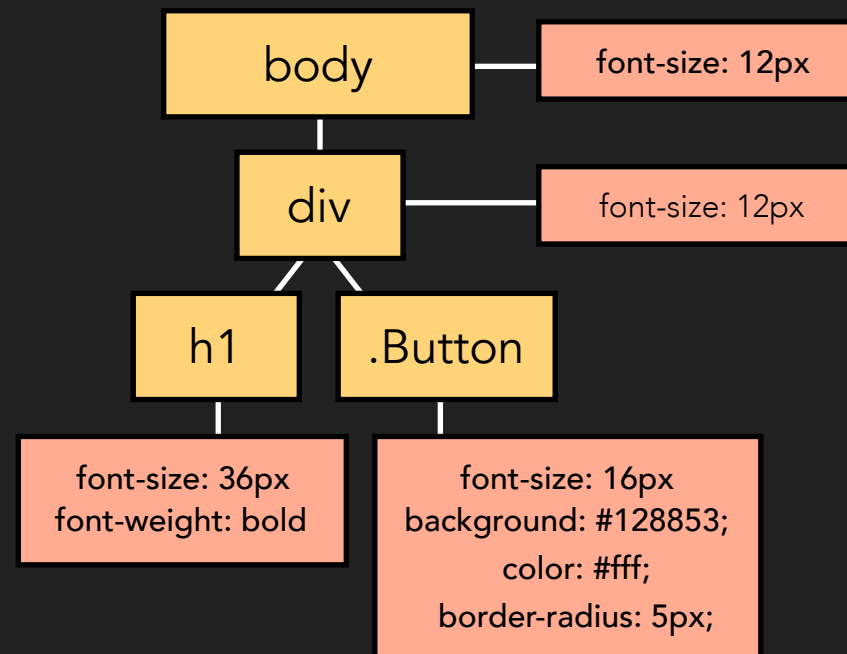
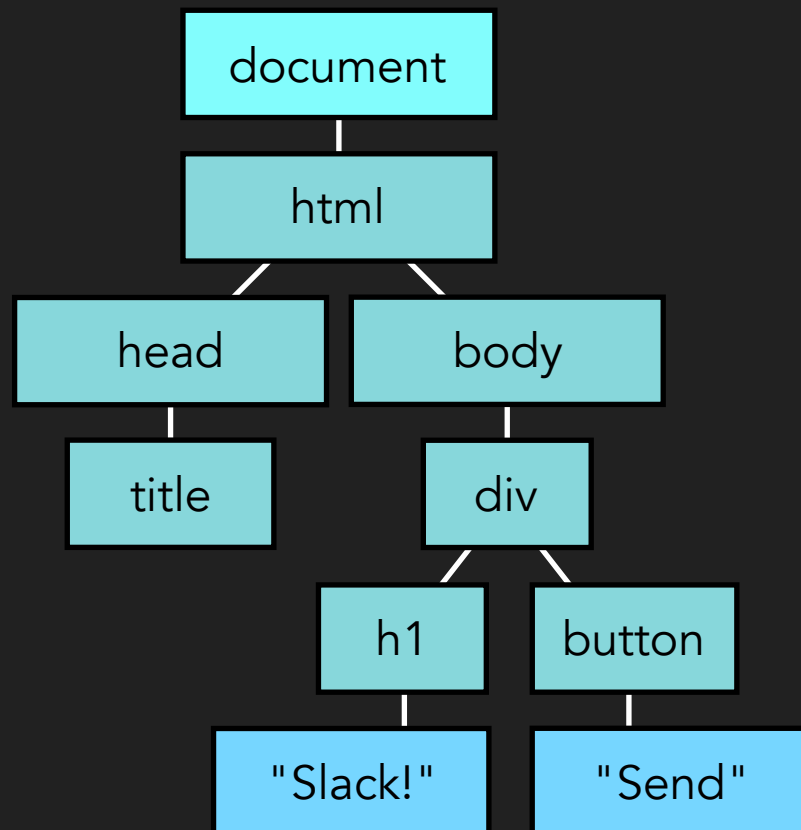
Parsing

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

So build me up, buttercup
Don't break my parse



Parsing



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Parsing

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

Harder, better,
faster parser!



<http://www.ecma-international.org/ecma-262/#sec-notational-conventions>

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

Daft Punk - Harder, Better, Faster, Stronger

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Parsing

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

Scripty's now an abstract syntax tree
Thanks, smart parser (smart parser!)



Parsing

The AST and scope structures get turned into low-level code

The next step is the baseline compiler
It made bytecode (it made bytecode!)
Next thing you know
Scripty got low-low-low
Low-low-low-low-low



Parsing

The low-level code then gets executed

Interpreted by Ignition
Your code's coming to fruition
♪♪♪



Parsing

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

Who can say where that byte goes
Turbofan does, at runtime
And who can say if your code flows
Turbofan knows, just-in-time



Rendering

How does the browser put pixels on the screen and move 'em around?

Well, I'm gonna paint my picture
Paint myself in blue and red and
green and... a

All of the beautiful pixels
are very, very meaningful

♪♪♪



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Rendering

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

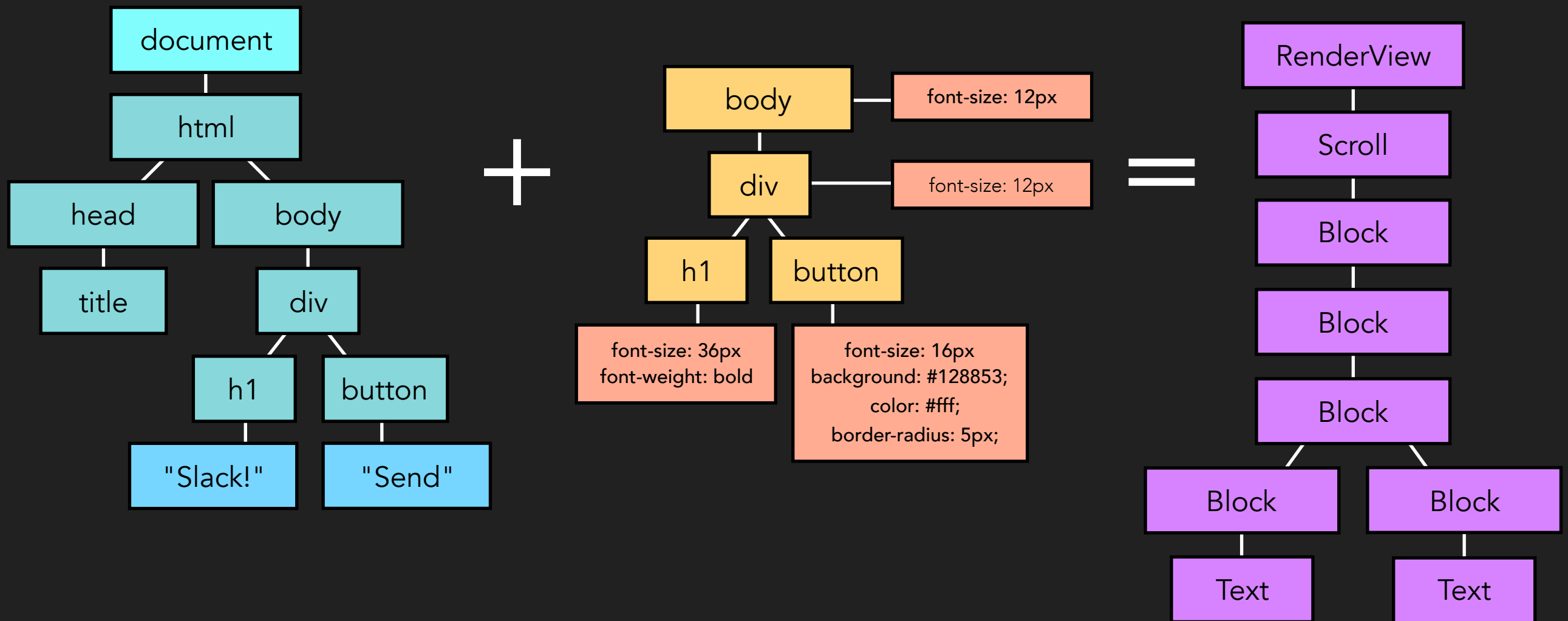
```
0 render tree,  
0 render tree  
How lovely are thy branches  
♪♪♪
```



<https://developers.google.com/web/fundamentals/performance/critical-rendering-path/render-tree-construction>
https://en.wikipedia.org/wiki/O_Tannenbaum

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Rendering



Rendering

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

And the render's gonna
rend, rend, rend?



Rendering

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

And the painter's gonna
paint, paint, paint



Rendering

Bitmaps are sent to the GPU for compositing

And the GPU's gonna
composite, composite, composite...



Rendering

The browser repeats the process,
maybe 60 times a second

Do it alllll agaaaain...



Rendering

JavaScript runs on the browser's main thread with everything else

```
Loop loop ba-doop loop ba-doop
  Loop ba-doop ba-doop
    Ba-doop loop ba-doop loop
Ba-doop loop ba-doop, ba-doop, ba-doop
      ♪ ♪ ♪
```



Perceiving

How does the brain paint pictures of the world and recognize what we see?

It's beautiful
It's beautiful
It's beautiful, it's true
This interface, it's a crowded place
But I know just what to do
♪♪♪



Perceiving

Light goes into the eye via the cornea and lens

I can see clearly now
The light is on



Perceiving

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

Turn up the lights in here, baby
You know what I need
Want you to see everything
Want you to see all of the lights



Perceiving

The neural signals get sent via the optic nerve to the brain

The signals that we send
Over the nerves
Over the nerves
Over the nerves
Over the nerves.



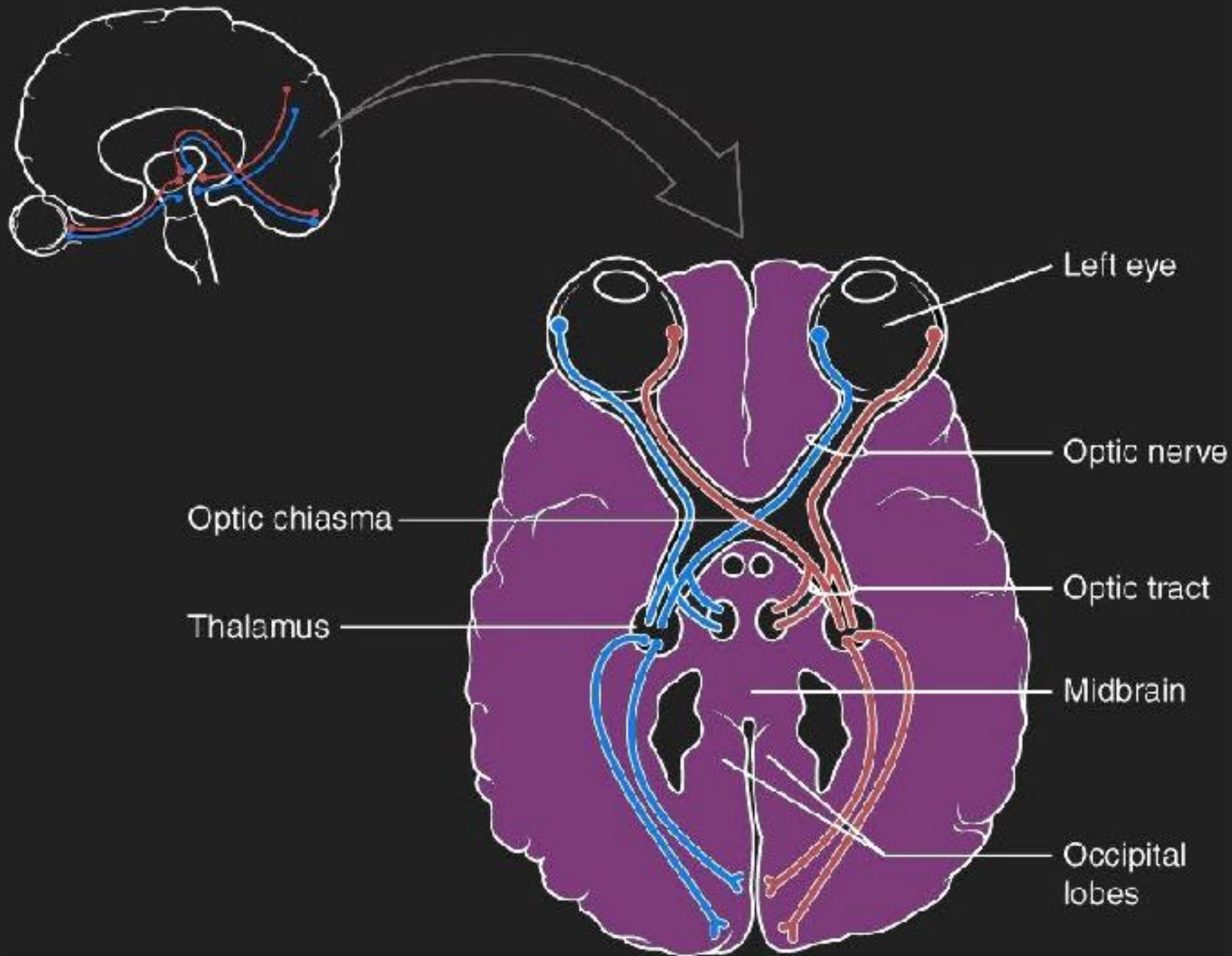
Perceiving

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

Why don't you just meet me in the middle,
In the middle



Perceiving



It me!



Perceiving

Most signals get sent to the lateral geniculate nuclei, which collates information from different eyes

I've looked at life from both sides now
From left and right and still somehow



Perceiving

Signals then get sent to the primary visual cortex

I have an edge of glory



Perceiving

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

It's the way I see
Everything I need

...
Higher and higher and higher
Higher and higher and higher



Perceiving

We start to figure out what is background and what are different objects

In the darkest night I'll
I'll search through the crowd
Your shape is all that I see
I'll give you everything



Perceiving

We translate data about different regions into data about different forms, such as size and shape

Every day discovering something brand new
I can discern the shape of you



(no, not `<form>`s, silly)



Perceiving

Then, we start to recognize and identify objects.

Send

Suddenly I see (suddenly I see)
What that's supposed to be
Suddenly I see (suddenly I see)
Why the hell it means so much to me
♪♪♪



Perceiving

Our minds take choppy, discrete inputs and create a seamless experience that we perceive as continuous

You got the kind of vision
That can be so ~smooth~, yeah
Might be choppy, make it real
Or else forget about it



Comprehending

How do we understand
written language?

Do you read me?



Comprehending

To understand written language,
we first have to recognize
pixels on the screen as words

word.



Comprehending

We process words as holistic units, not as separate letters, and we recognize words faster than non-words.

It's not always easy and
Sometimes words can be deceiving
I'll tell you one thing,
Letters are better when they're together



Comprehending

We are also able to understand words when they are smashed together better than if they have spaces in arbitrary places

I wanna know
Does this meaning flow both ways
♪♪♪



Comprehending

We are also able to understand words when they are smushed together better than if they have spaces in arbitrary places

I wanna know
Does this meaning flow both ways
♪ ♪ ♪



Comprehending

Our minds match the word we see to the representations of words we have stored in our minds

First you're up and you're down
And then between
Oh I really want to know
What do you mean? Ooh
♪ ♪ ♪



Comprehending

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

Role up!
Role up for the magic mystery tour
♪♪♪



Comprehending

We then parse the sentence,
construct a representation of
its meaning

Yeah, it's just a phrase
It will be over soon
Yeah, it's just a phrase
Yeah, it's just a...
Phrase
♪ ♪ ♪



Comprehending

Garden Path Theory: We construct the simplest parse first, and then see if it makes sense semantically based on context

If at first you don't succeed
(First you don't succeed),
Dust yourself off, and try again
You can dust it off and try again
Try again
♪ ♪ ♪



Comprehending

“The horse raced
past the barn
fell”



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Comprehending

“The horse (that)
raced past the
barn fell”



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Comprehending

Constraint-based Theories: we interpret sentences based on probabilistic constraints

We feel the same
With these constraints
We feel the same
Within our brains



Comprehending

Human language contains a ton of ambiguity, both semantic and syntactic

One way or another, I'm gonna find ya'
I'm gonna get ya', get ya',
Get ya', get ya'
♪♪♪



Comprehending

Humans are very forgiving of
syntax errors

And here's to you
'Cause forgiveness is a nice thing to do



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Comprehending

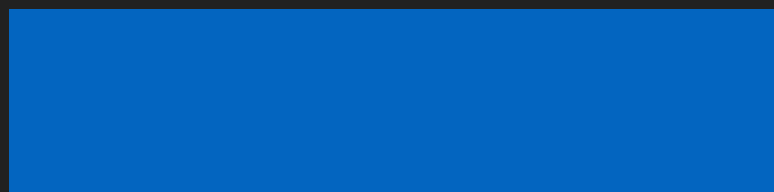
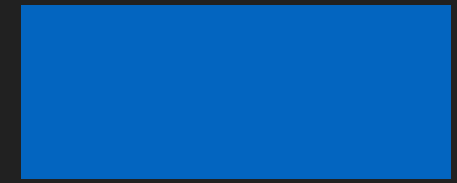
BLUE PURPLE RED

GREEN PURPLE

GREEN



Comprehending



Comprehending

BLUE PURPLE RED

GREEN PURPLE

GREEN




Comprehending

BLUE PURPLE RED

GREEN PURPLE

GREEN



1. Parsing
 2. Rendering
 3. Perceiving
 4. Comprehending
- 

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>
- Marja Hölttä: Parsing JavaScript - better lazy than eager? (Video)
- Franziska Hinkelmann: JavaScript engines - how do they even? (Video)
- Chelsea Derrick: True Grit: Debugging CSS & Render Performance (Video)
- www.ecma-international.org/ecma-262/
- 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
- Visual Word Recognition: Theories and Findings

Tracklist

The Notorious B.I.G. - Sky's The Limit

MC Hammer - U Can't Touch This

Ashlee Simpson - Pieces of Me

Katy Perry - Part of Me

Shakira - Whenever, Wherever

Meghan Trainor - All About That Bass

Snoop Dogg & Wiz Khalifa ft. Bruno Mars - Young, Wild, & Free

The Foundations - Build Me Up Buttercup

Daft Punk - Harder, Better, Faster, Stronger

Flo Rida - Low

R Kelly - Ignition

Enya - Only Time

Counting Crows - Mr. Jones

Traditional - O Tannenbaum

Taylor Swift - Shake it Off

Katy Perry - Last Friday Night (T.G.I.F.)

Salt-N-Pepa - Shoot

James Blunt - You're Beautiful

Johnny Nash - I Can See Clearly Now

Tracklist

Kanye West - All of the Lights

Thursday - Signals Over the Air

Zedd, Maren Morris, Grey - The Middle

Joni Mitchell - Both Sides Now

Lady Gaga - Edge of Glory

Passion Pit - Little Secrets

Beyoncé - X0

Ed Sheehan - Shape of You

KT Tunstall - Suddenly I See

Smooth - Santana ft. Rob Thomas

Jack Johnson - Better Together

Arctic Monkeys - Do I Wanna Know?

Justin Bieber - What Do You Mean?

The Beatles - Magical Mystery Tour

Incubus - Just a Phase

Aaliyah - Try Again

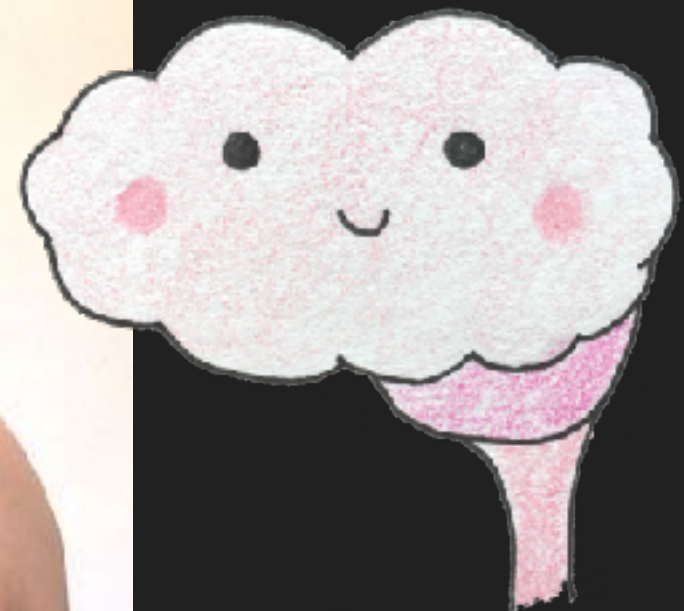
Chvrches - Keep You on My Side

Blondie - One Way or Another

Taylor Swift - This is Why We Can't Have Nice Things

Thanks!

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