From Parentheses To Perception

How Your Code Becomes Another’s Reality

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

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

const button =
  document.querySelector('send-button');</button>
button.addEventListener('click', onBtnClick);
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
2. Rendering
3. Perceiving
4. Comprehending
1. Parsing
2. Rendering
3. Perceiving
4. Comprehending
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
♪ ♪ ♪

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

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
MC Hammer - U Can't Touch This
Parsing

Parserstake 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
♩♩♩

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
Ashlee Simpson - Pieces of Me

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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!
♫♫♫

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
Katy Perry - Part of Me
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!
♪♪♪

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
Shakira - Whenever, Wherever
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!

♪♪♪

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
Meghan Trainor - All About That Bass
Parsing

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

This parser's young and wild and context-free ♪♪♪

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
Snoop Dogg & Wiz Khalifa ft. Bruno Mars – Young, Wild, & 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
♪♪♪

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
The Foundations - Build Me Up Buttercup
Parsing

- `document`
  - `html`
    - `head`
      - `title`
    - `body`
      - `div`
        - `h1` "Slack!"
        - `button"Send"
  - `body`
    - `div`
      - `h1` font-size: 36px, font-weight: bold
      - `.Button` font-size: 16px
        - background: #128853;
        - color: #fff;
        - border-radius: 5px;

https://www.html5rocks.com/en/tutorials/internals/howbrowserswork
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
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!)...
♫♫♫

https://www.youtube.com/watch?v=Fg7niTmNNLg
Flo Rida - Low

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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
♪♪♪

https://www.youtube.com/watch?v=Fg7niTmNNLg
Flo Rida - Low

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Parsing

The low-level code then gets executed

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

https://www.youtube.com/watch?v=Fg7niTmNNLg
R Kelly - Ignition

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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
♪♪♪

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

Counting Crows - Mr. Jones
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
Rendering

```
document
  html
    head
      title
    body
      div
        h1
          "Slack!"
        button
          "Send"

body
  div
    h1
      font-size: 36px
      font-weight: bold
    button
      font-size: 16px
      background: #128853;
      color: #fff;
      border-radius: 5px;

= RenderView
  Scroll
  Block
  Block
  Block
    Block
      Text
      Text
```

Rendering

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

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

♪♪♪


Taylor Swift - Shake it Off

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Rendering

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

And the painter’s gonna paint, paint, paint ♪♪♩♩

[YouTube Video](https://www.youtube.com/watch?v=gqc88qWuiI4)

Taylor Swift - Shake it Off

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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

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

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

Loop loop ba-dooop loop ba-dooop
Loop ba-dooop ba-dooop
Ba-dooop loop ba-dooop loop
Ba-dooop loop ba-dooop, ba-dooop, ba-dooop

♪♪♪

https://www.youtube.com/watch?v=p-iiEDtpy6I
Salt-N-Pepa - Shoop

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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
♪♪♪

James Blunt - You’re Beautiful

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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
♪♪♪

https://en.wikipedia.org/wiki/Flicker_fusion_threshold
Kanye West - All of the Lights
Perceiving

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


Thursday - Signals Over the Air
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
♩♩♩

Zedd, Maren Morris, Grey - The Middle
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Perceiving

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
♩♩♩

Blake, R., & Sekuler, R. (2006)
Joni Mitchell - Both Sides Now
Perceiving

Signals then get sent to the primary visual cortex

I have an edge of glory ♫♫♫

Blake, R., & Sekuler, R. (2006)
Lady Gaga - Edge of Glory
Perceiving

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

Blake, R., & Sekuler, R. (2006)
Passion Pit - Little Secrets

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

Blake, R., & Sekuler, R. (2006)
Kellogg (2007)
Beyoncé - XO

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)
Then, we start to recognize and identify objects.

Blake, R., & Sekuler, R. (2006) KT Tunstall - Suddenly I See

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

♪♪♪

Blake, R., & Sekuler, R. (2006)
Smooth - Santana ft. Rob Thomas
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 ♪♪♪

Blake, R., & Sekuler, R. (2006)
Jack Johnson - Better Together
Comprehending

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

Blake, R., & Sekuler, R. (2006) Arctic Monkeys - Do I Wanna Know?

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 ♫♫♫

Blake, R., & Sekuler, R. (2006)
Arctic Monkeys - Do I Wanna Know?
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
♫♫♫

Lupker (2005)
Justin Bieber - What Do You Mean?
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 ♪♪♪

The Beatles - Magical 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
♪♪♪

Incubus - Just a Phase
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
♪♪♪

https://en.wikipedia.org/wiki/Sentence_processing
Aaliyah - Try Again

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Comprehending

“The horse raced past the barn and fell”

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

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

https://en.wikipedia.org/wiki/Sentence_processing
Chvrches - Keep You on My Side
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'
♪♪♪

Blondie - One Way or Another
Comprehending

Humans are very forgiving of syntax errors

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

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

BLUE  PURPLE  RED
GREEN  PURPLE  GREEN
Comprehending
Comprehending

BLUE PURPLE RED
GREEN PURPLE PURPLE GREEN
Comprehending

BLUE  PURPLE  RED
GREEN  PURPLE  GREEN

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Resources

Books

Websites
- 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/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
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Thanks!

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