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Learning to Love Type Systems

Swipe Left, Uncaught TypeError 💔

PRESENTED BY

Lauren Tan (she/her)

Cinemagraph by /u/orbojunglist

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Bonjour

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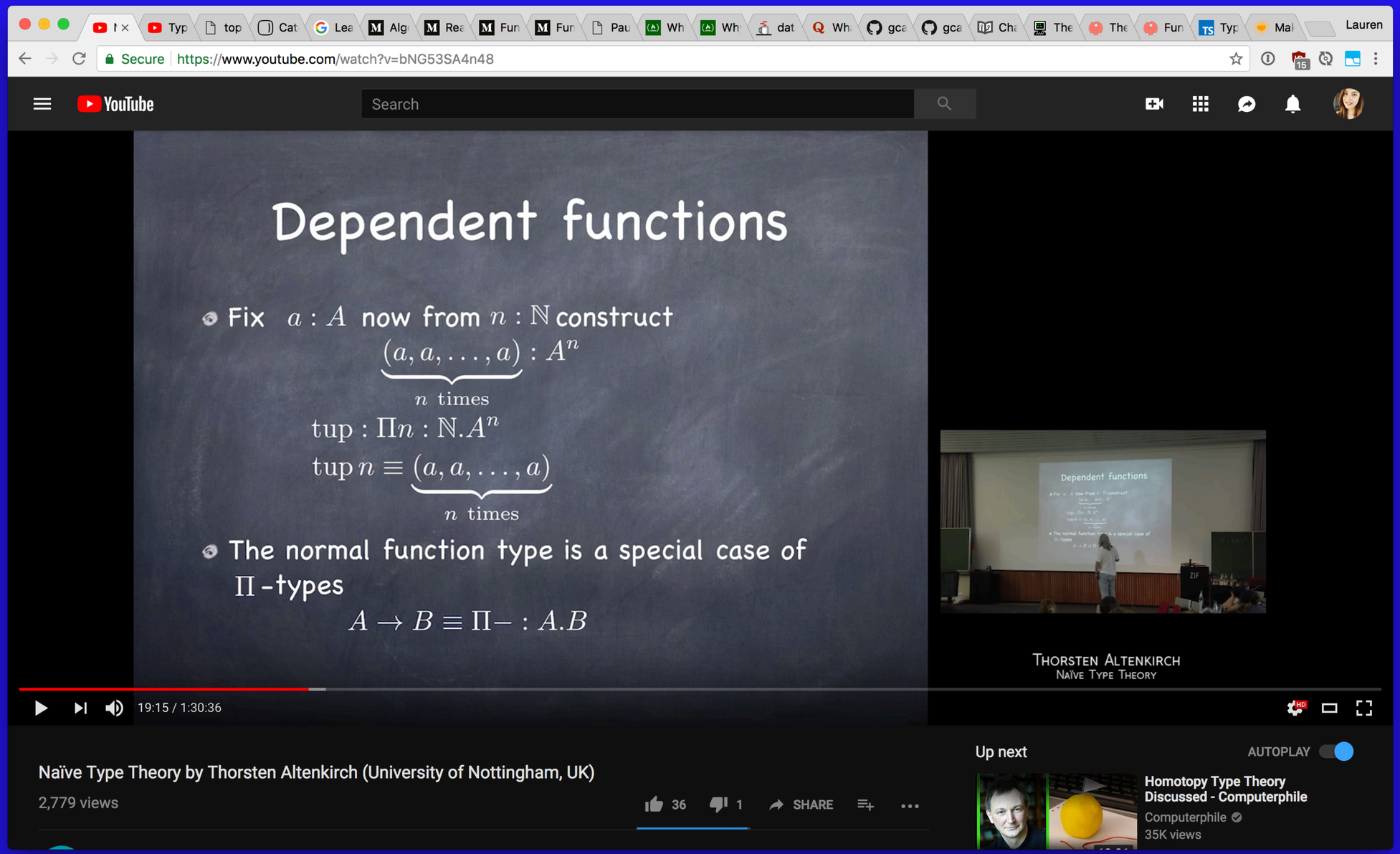
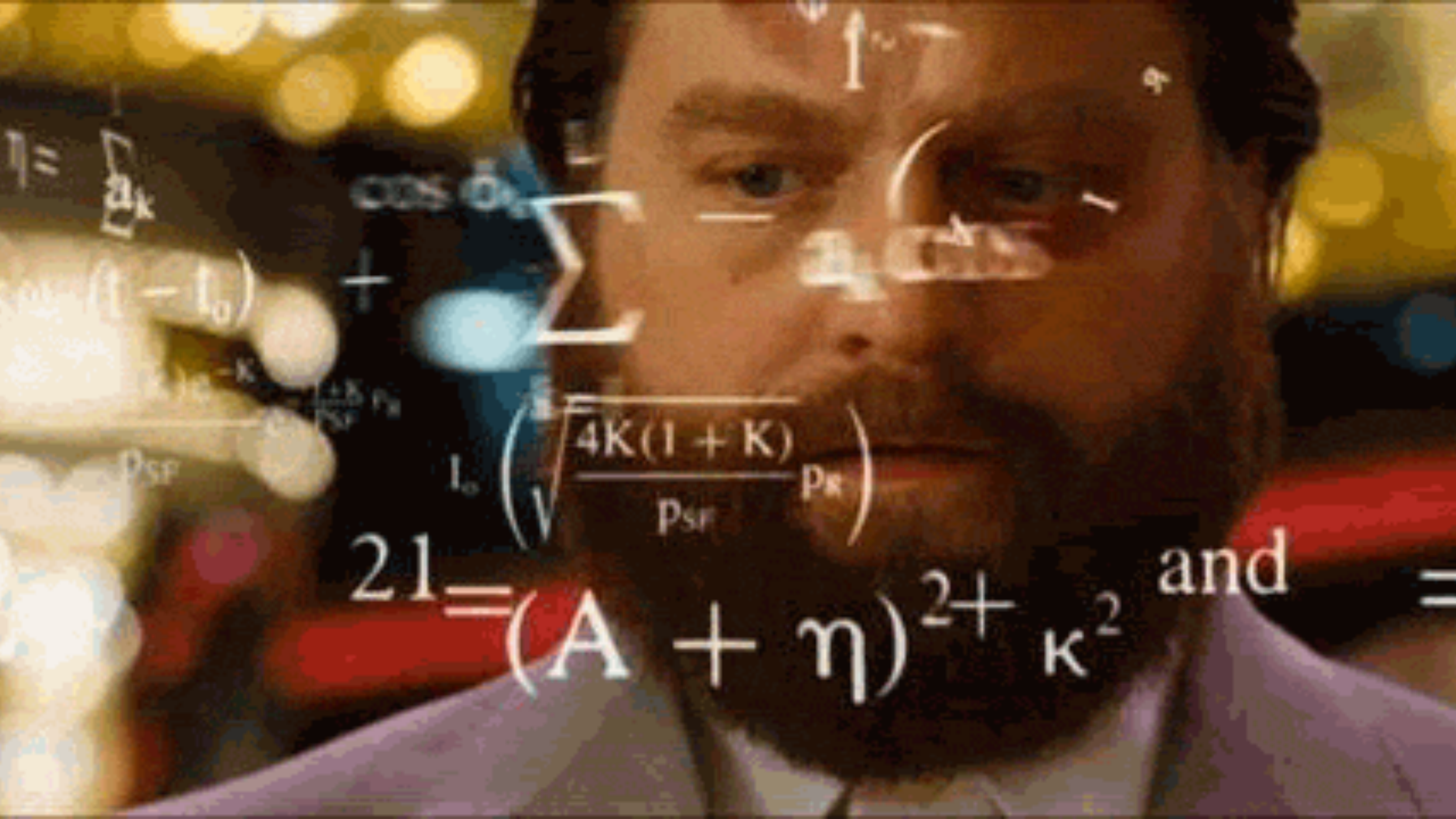
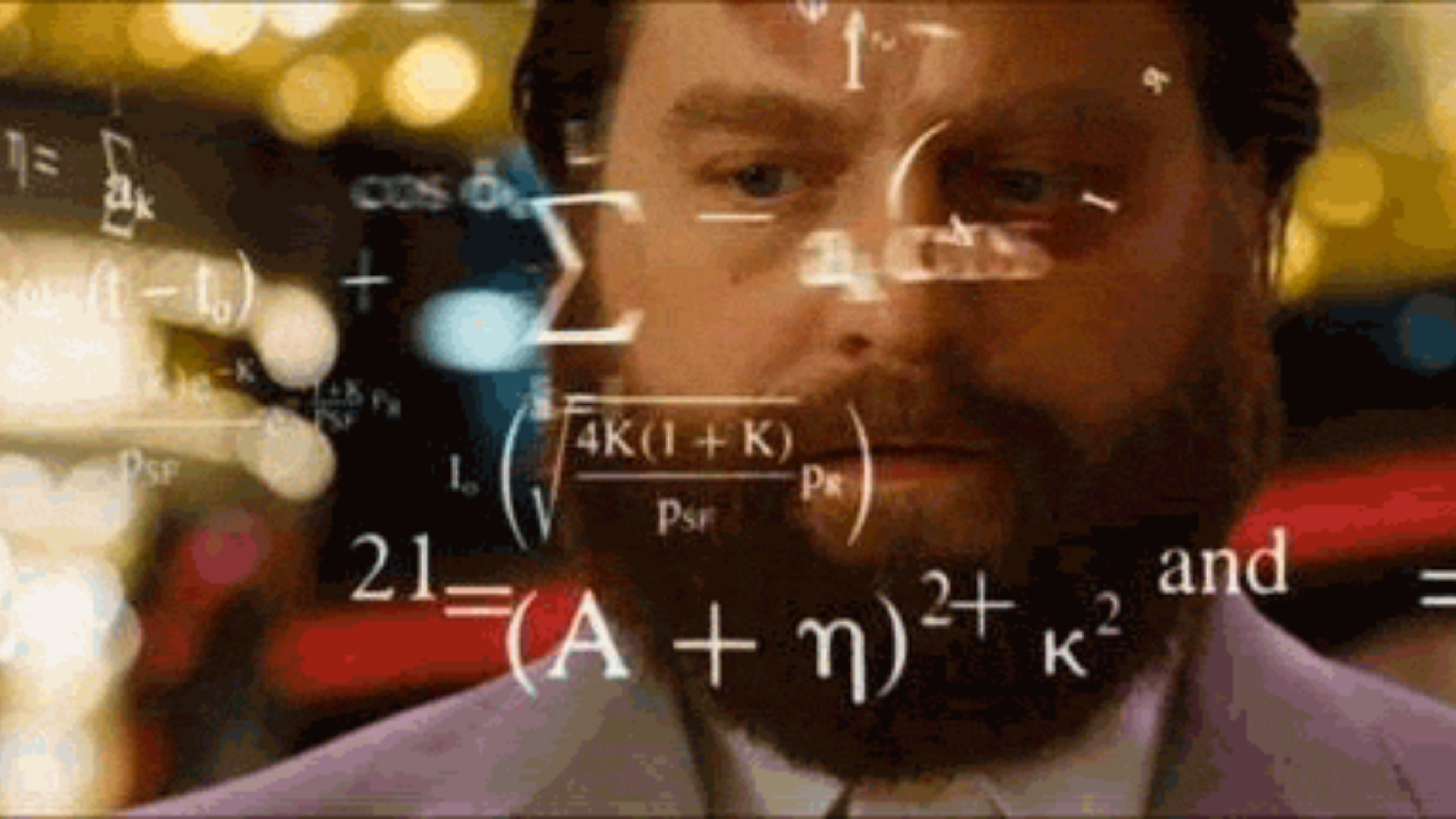



$\eta = \left[a_k \right.$
$\cos \theta$
$\sum$
$\left(t - t_0 \right)$
$\frac{1}{T}$
p_{sr}
$I_o \left(\sqrt{\frac{4K(1+K)}{p_{sr}}} p_k \right)$
$21 = (A + \eta)^2 + \kappa^2$ and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"If debugging is the process of removing software bugs, then programming must be the process of putting them in."

Djikstra, supposedly 🤷‍♀️

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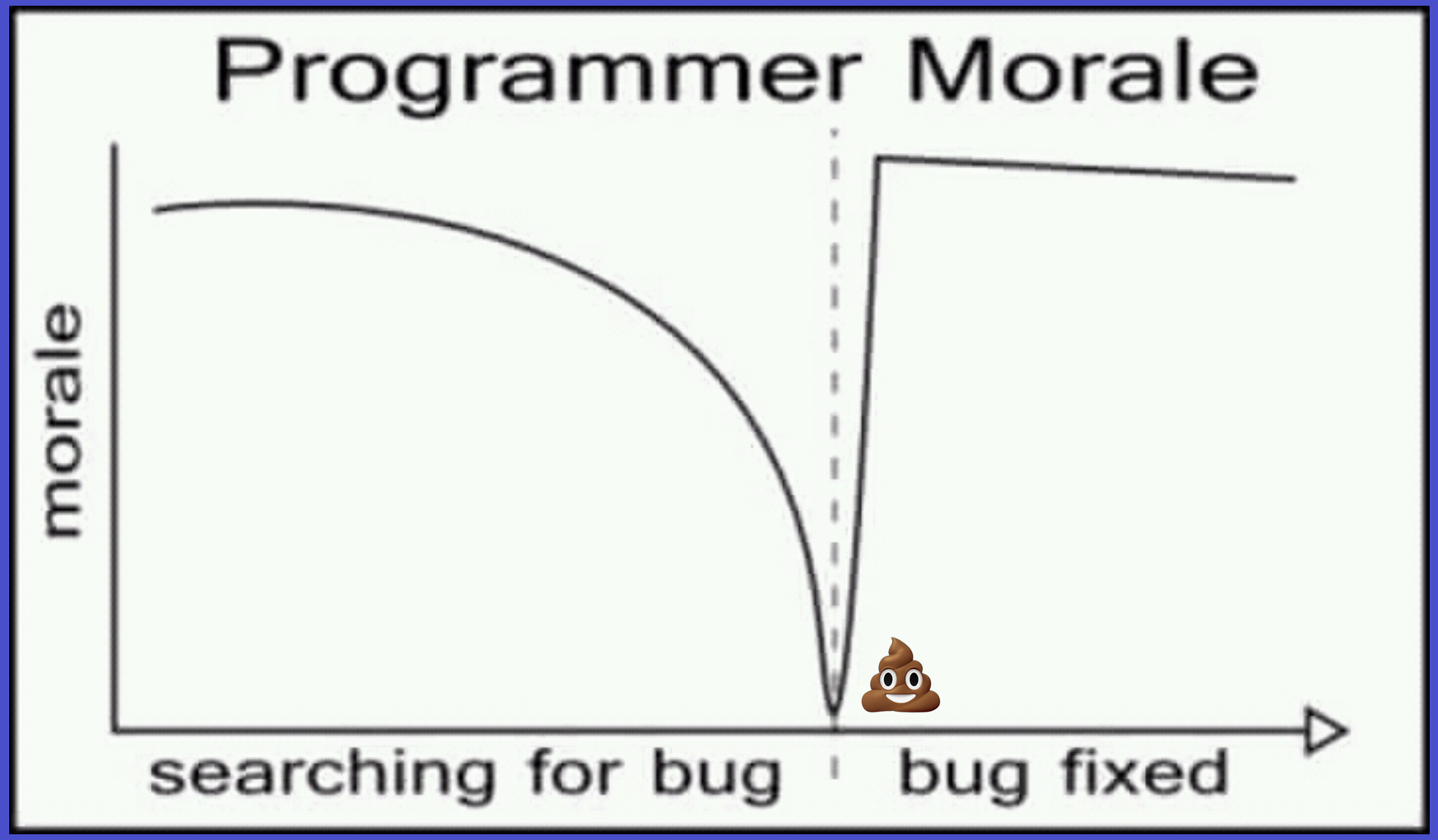

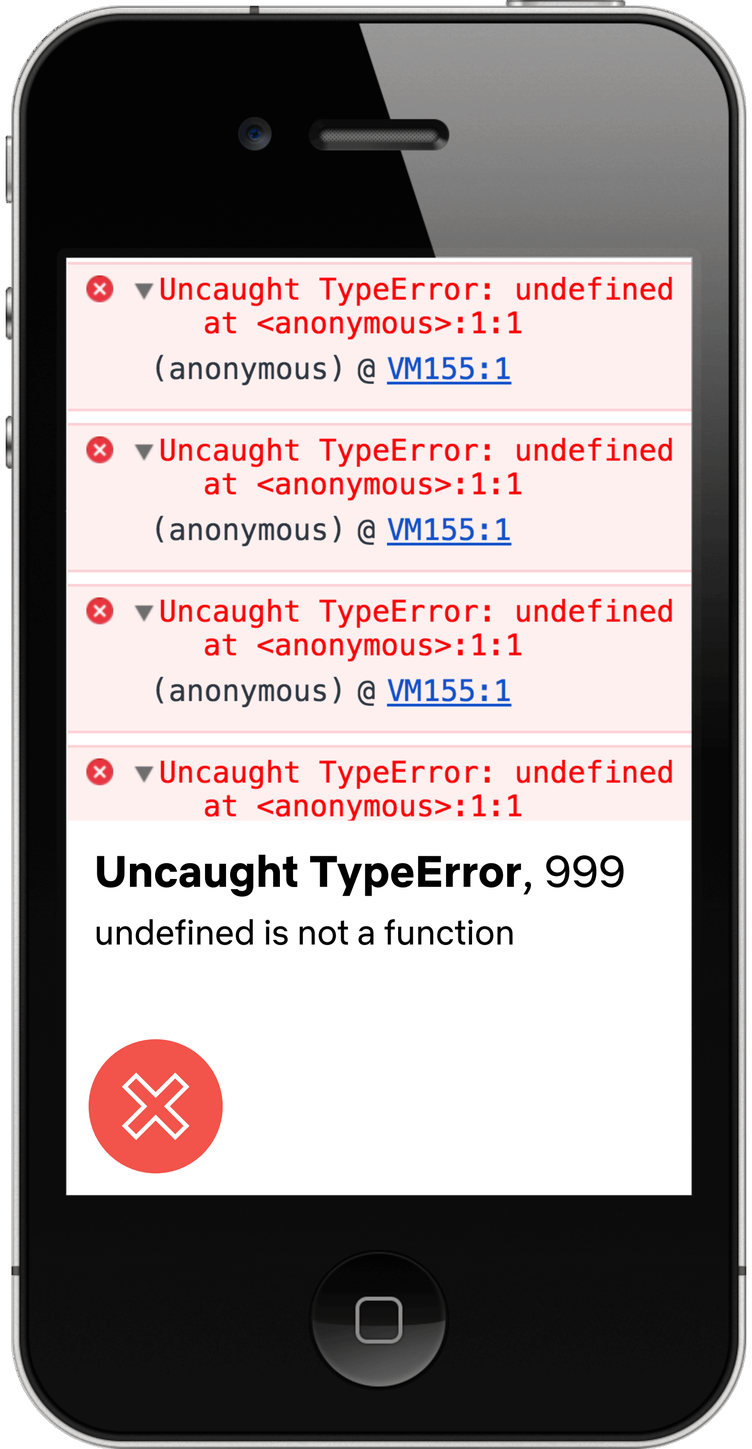
Uncaught TypeError: undefined
at <anonymous>:1:1
(anonymous) @ VM155:1
Uncaught TypeError: undefined
at <anonymous>:1:1
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Uncaught TypeError: undefined
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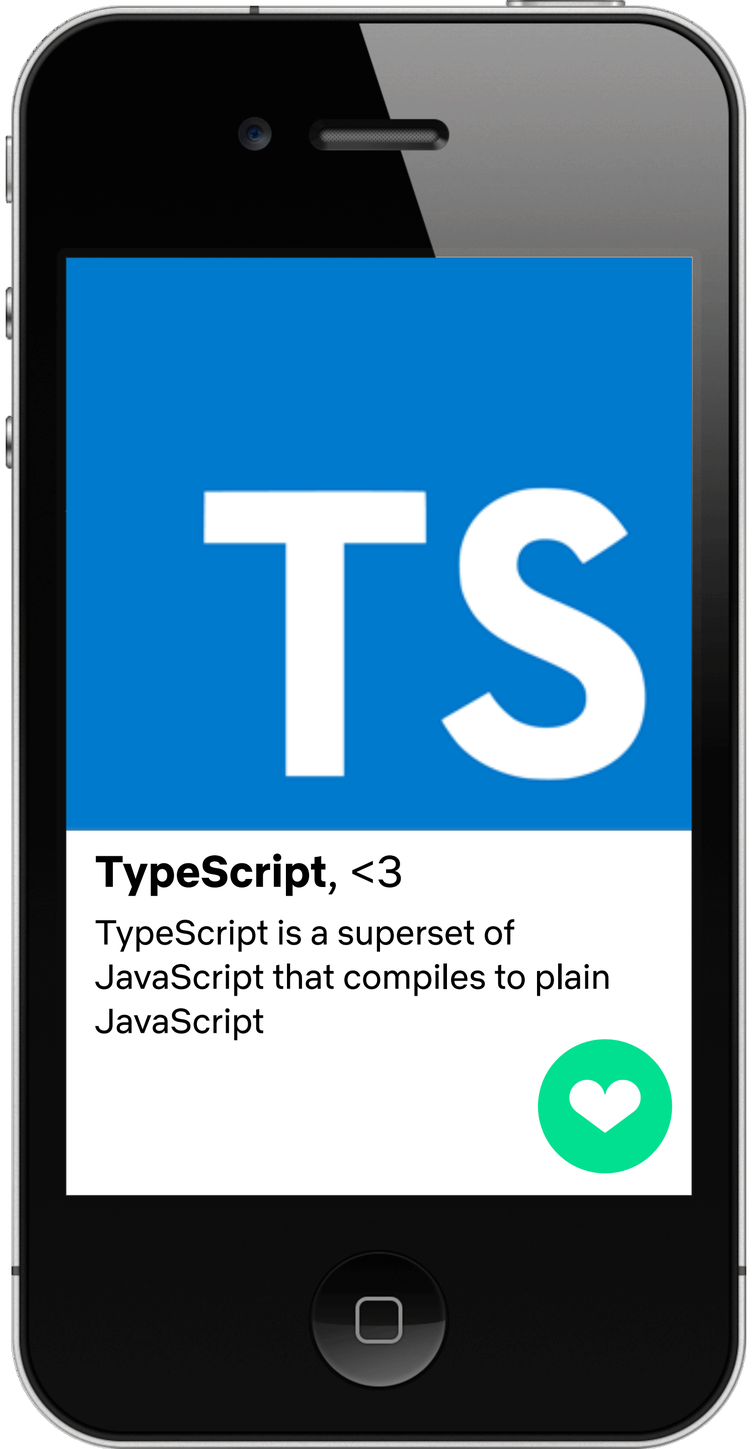
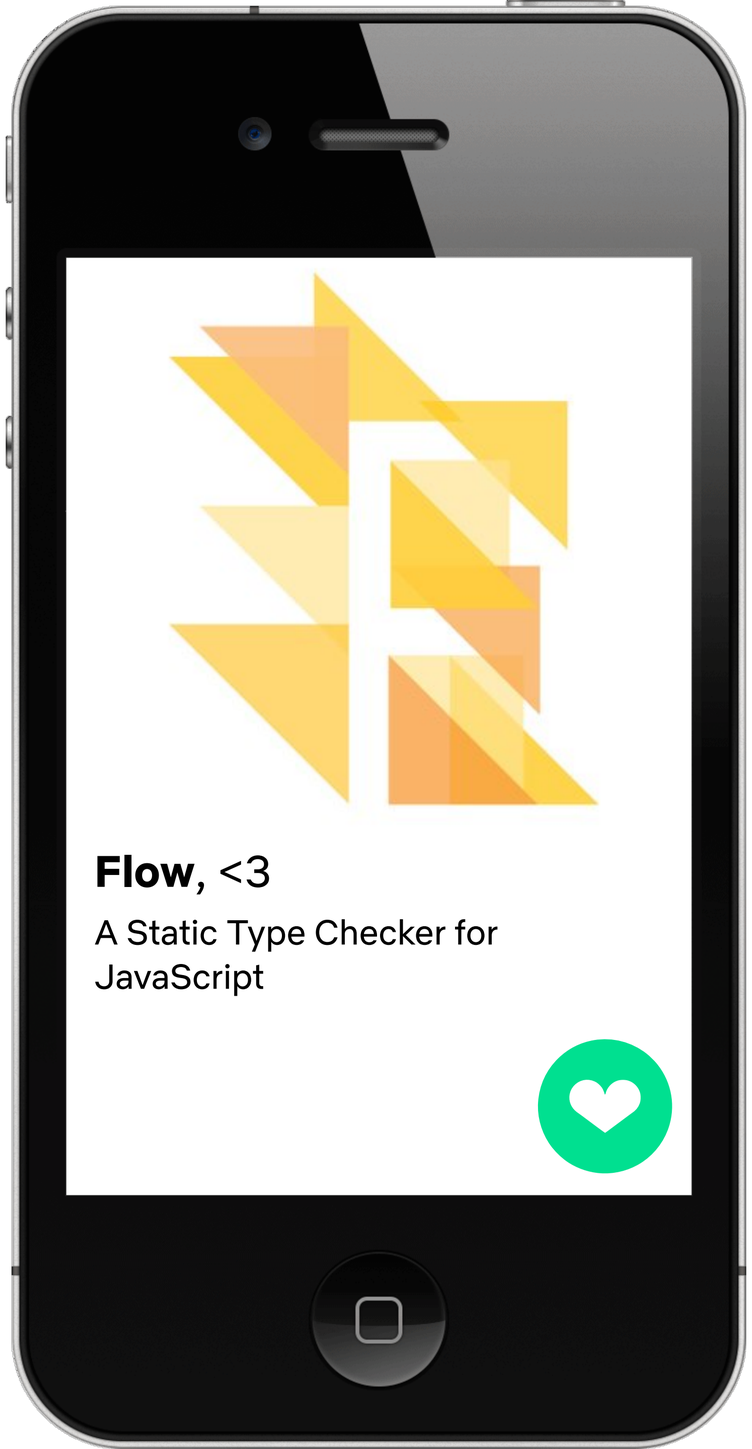
(anonymous) @ VM155:1
Uncaught TypeError: undefined
at <anonymous>:1:1
Uncaught TypeError, 999
undefined is not a function


TS
TypeScript, <3
TypeScript is a superset of JavaScript that compiles to plain JavaScript


Flow, <3
A Static Type Checker for
JavaScript

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"A type system is a tractable syntactic method for **proving the absence of certain program behaviors** *by classifying phrases according to the kinds of values they compute."*

Types and Programming Languages, Benjamin C. Pierce

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How many ways can this program fail?

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```
const half = x ⟹ x / 2;
```

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```
const TEST_CASES = [
  null,
  undefined,
  Symbol(1),
  10,
  '10',
  'hello world',
  { name: 'Lauren' },
  [1, 2, 3],
  x => x * x
];
```

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```
TEST_CASES.map(testValue ⟹ {
  return {
    result: half(testValue),
    test: testValue.toString()
  }
});
```

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not my type!

```
Uncaught TypeError: Cannot read property 'toString' of null
    at TEST_CASES.map.testValue (<anonymous>:17:21)
    at Array.map (<anonymous>)
    at <anonymous>:14:12
```


OK


OK

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donavon/undefined-is-a-funct

Lauren

GitHub, Inc. [US] | https://github.com/donavon/undefined-is-a-function

donavon / undefined-is-a-function

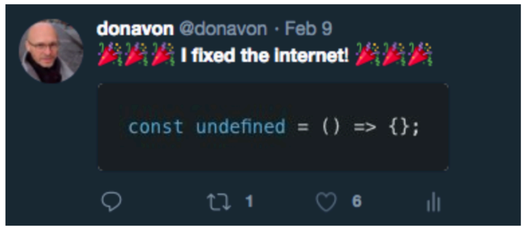
master

- src
- .babelrc
- .gitignore
- .npmignore
- .travis.yml
- LICENSE.md
- README.md
- package-lock.json
- package.json

"undefined is not a function"? — It is now!

build passing npm v0.1.0

A while ago a tweeted that I had fixed the internet.



Well, I guess that wasn't entirely accurate. I gave people the ability for *them* to fix the internet, but not everyone was on board.

So today, I'm making it even easier for you to fix your little corner of the interwebs.

Get the code (i.e. fix the internet)

All you have to do is this:

```
$ npm i --save undefined-is-a-function
```

(or if you like yarn)

```
$ yarn add undefined-is-a-function
```

Then in your code:

```
import { undefined } from 'undefined-is-a-function';
```

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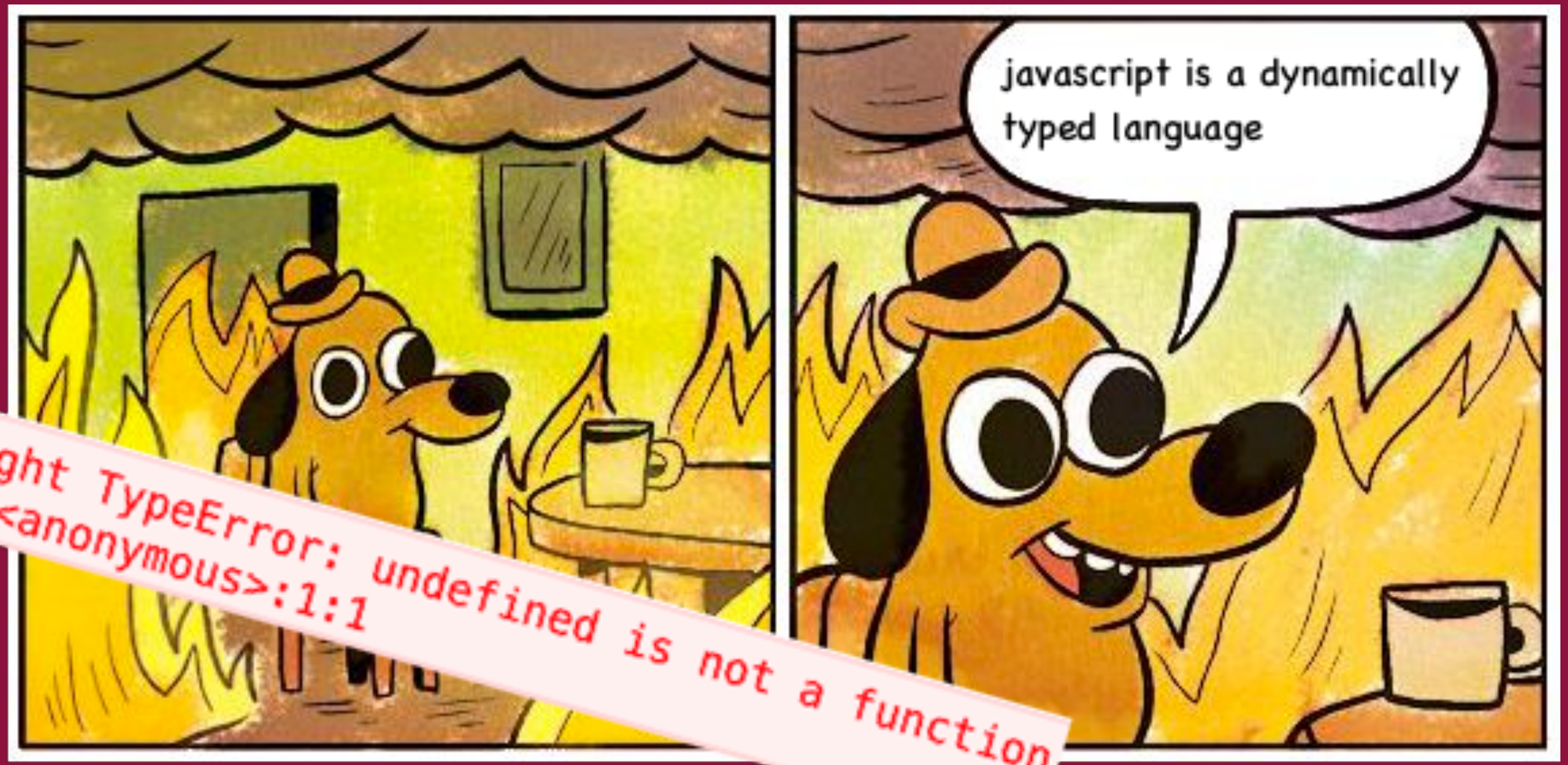

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```
const TEST_CASES = [
  null, // Uncaught TypeError
  undefined, // Uncaught TypeError
  Symbol(1), // Uncaught TypeError
  10, // 5
  '10', // 5 🤷‍♀️
  'hello world', // NaN
  { name: 'Lauren' }, // NaN
  [1, 2, 3], // NaN
  x => x * x // NaN
];
```

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How many ways can this program fail?

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(Infinity)

How fail?

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```
const half = (x: number) ⇒ x / 2;
```

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How many ways can this program fail (at compile time)?

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0*


Why Less Is Better
Precise Types Means Less Bugs
Cinemagraph by /u/orbojunglist


Why Less Is Better
Precise Types Means Less Bugs
Cinemagraph by /u/orbojunglist

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Learning from Functional Programming

https://www.youtube.com/watch?v=ev7AYsLljxk&index=5&list=PL8Ky8IYL8-Oh7awp0sqa82o7Ggt4AGhyf

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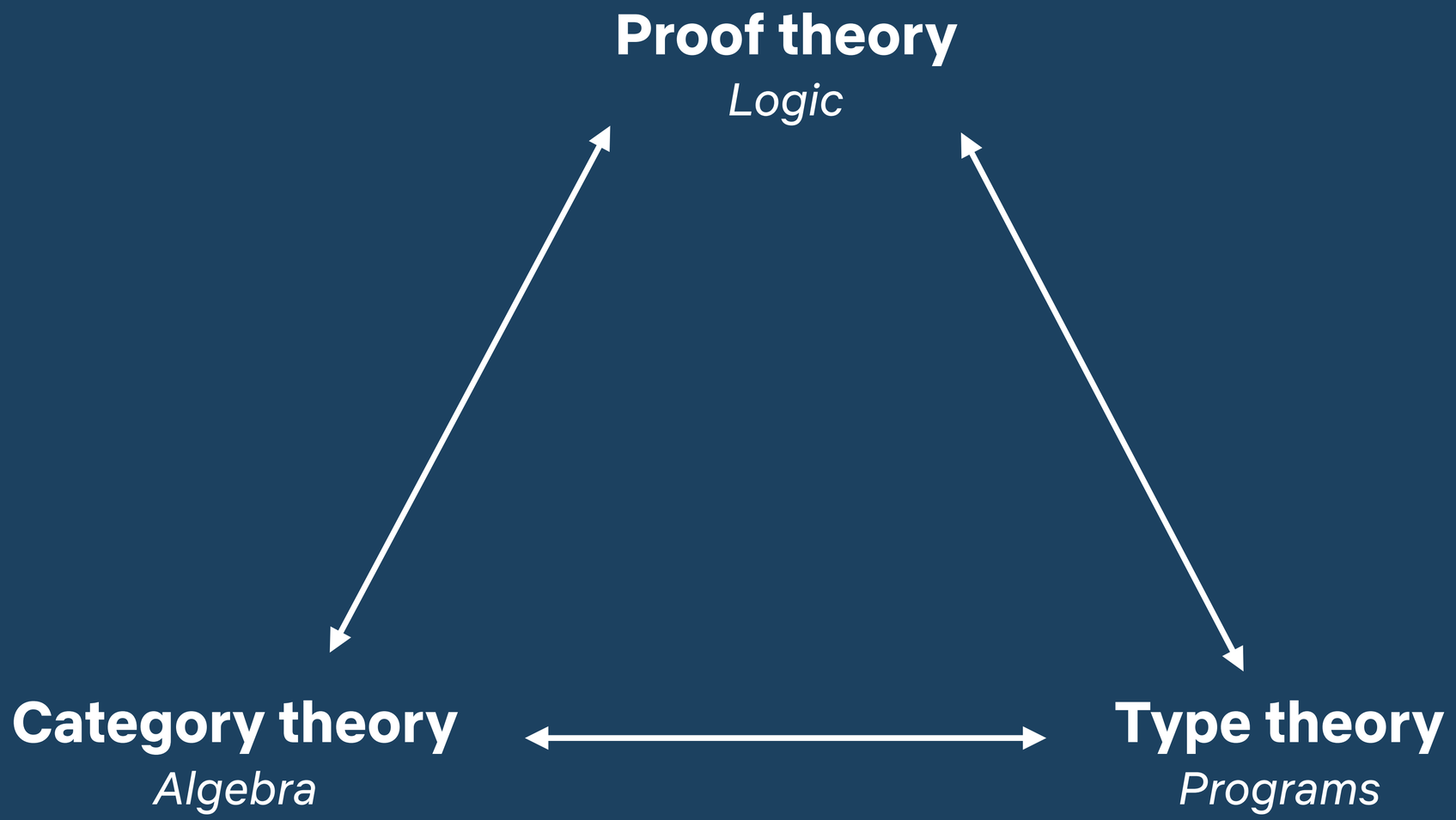

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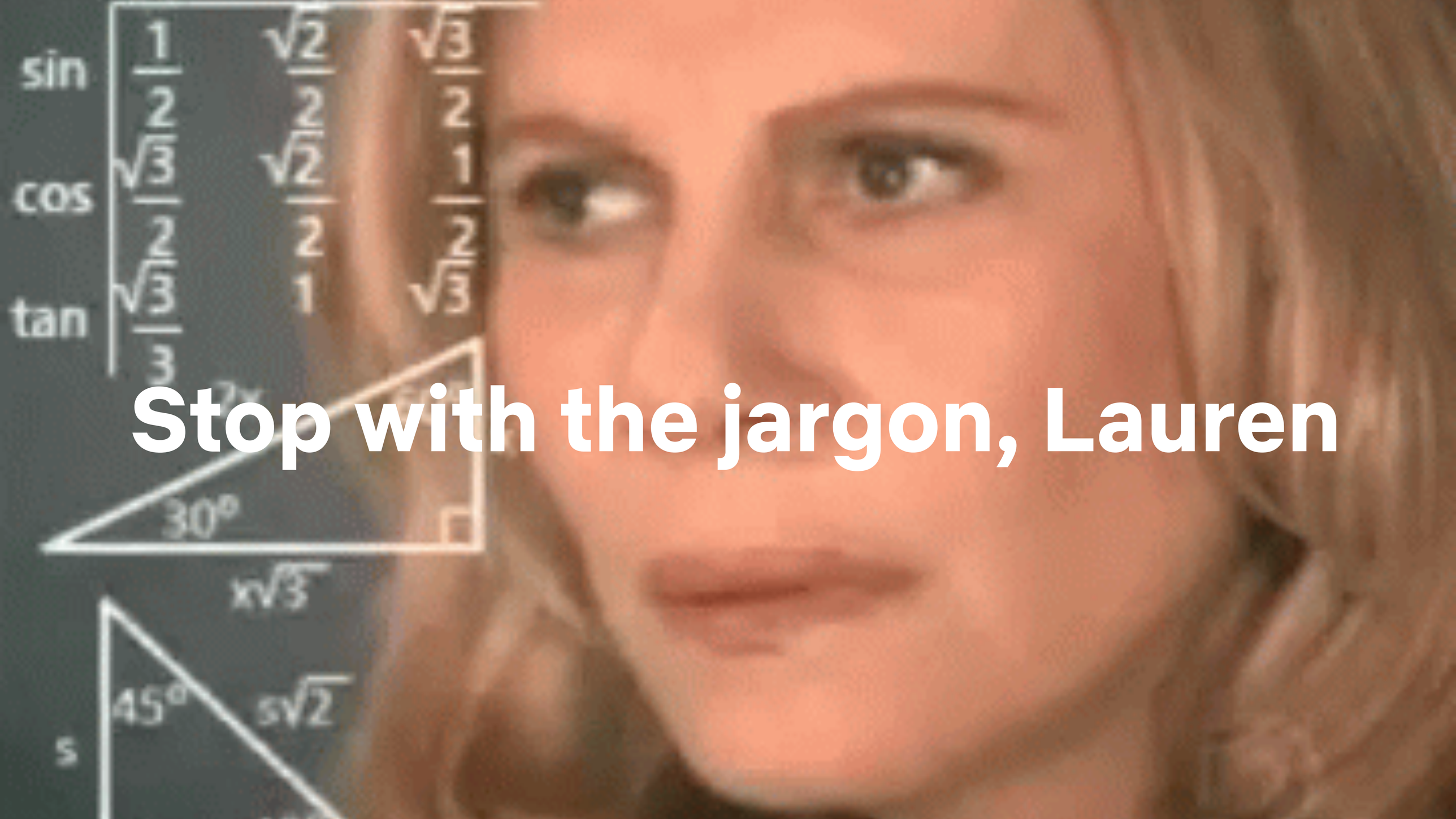
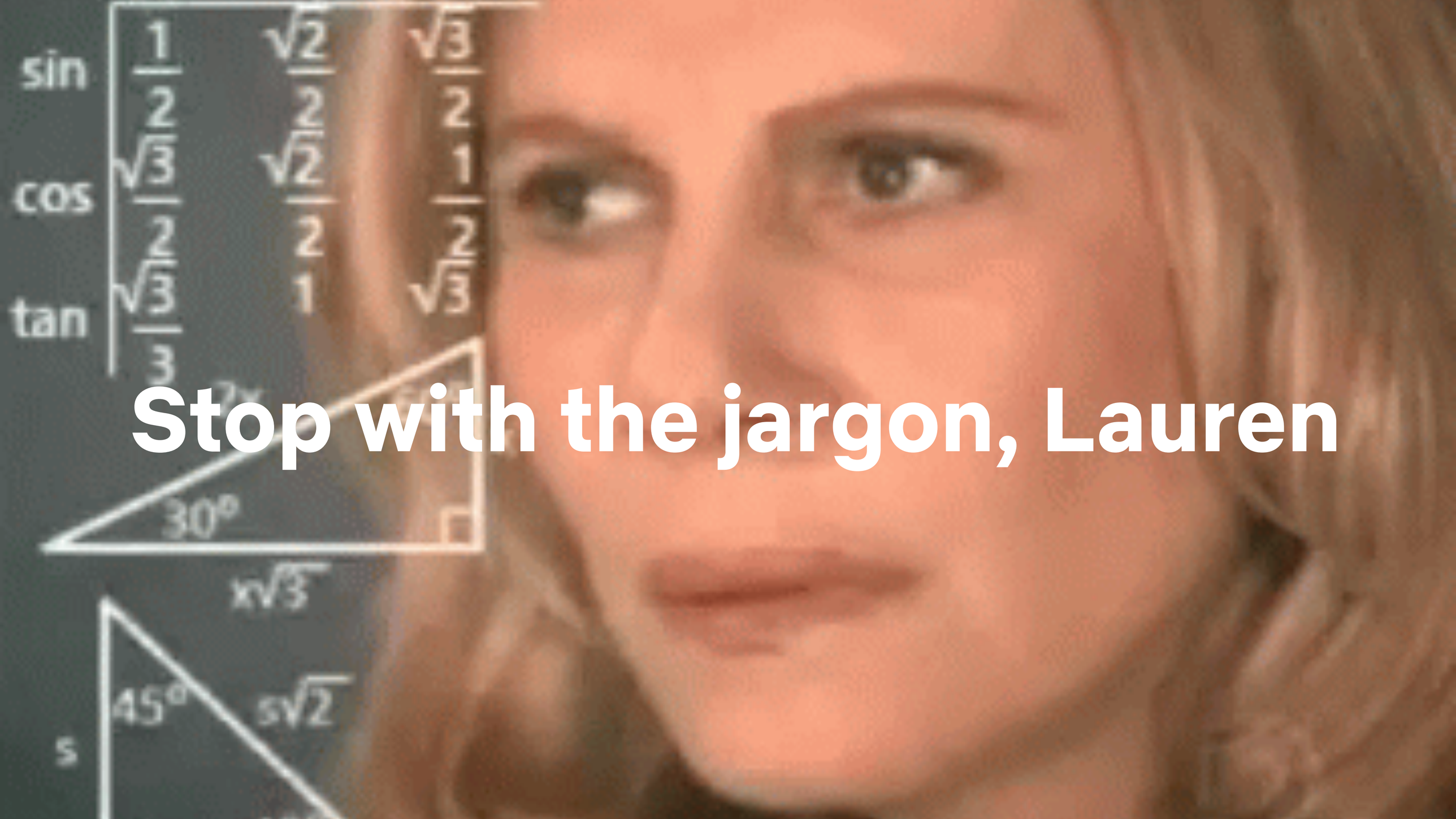
Curry–Howard–Lambek correspondence



Stop with the jargon, Lauren



Stop with the jargon, Lauren

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```
declare function Addition(x: number, y: number): number;      // proposition
function add(x: number, y: number): number { return x + y; }  // proof
```

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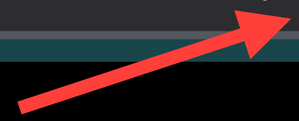
Proposition: If x and y are numbers, a number exists



```
declare function Addition(x: number, y: number): number;      // proposition
function add(x: number, y: number): number { return x + y; }  // proof
```

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Proposition: If x and y are numbers, a number exists

```
declare function Addition(x: number, y: number): number;      // proposition
function add(x: number, y: number): number { return x + y; }  // proof
```

Proof: x + y is a proof that a number exists

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What is a function?

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$$f : A \to B$$

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```
f :: function from type A to type B
```

** not a JS object*

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Types are propositions
Programs are proofs

Curry-Howard Correspondence

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Let the type system suggest the implementation

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```
function head<T>(list: T[]): T {
  // ...
}
```

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```
[ts] Type 'T[]' is not assignable to type 'T'.
(parameter) list: T[]
```

```ts
function head<T>(list: T[]): T {
  return list;
}
```

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```
function head<T>(list: T[]): T {
  return list[0];
}
```

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Writing better functions

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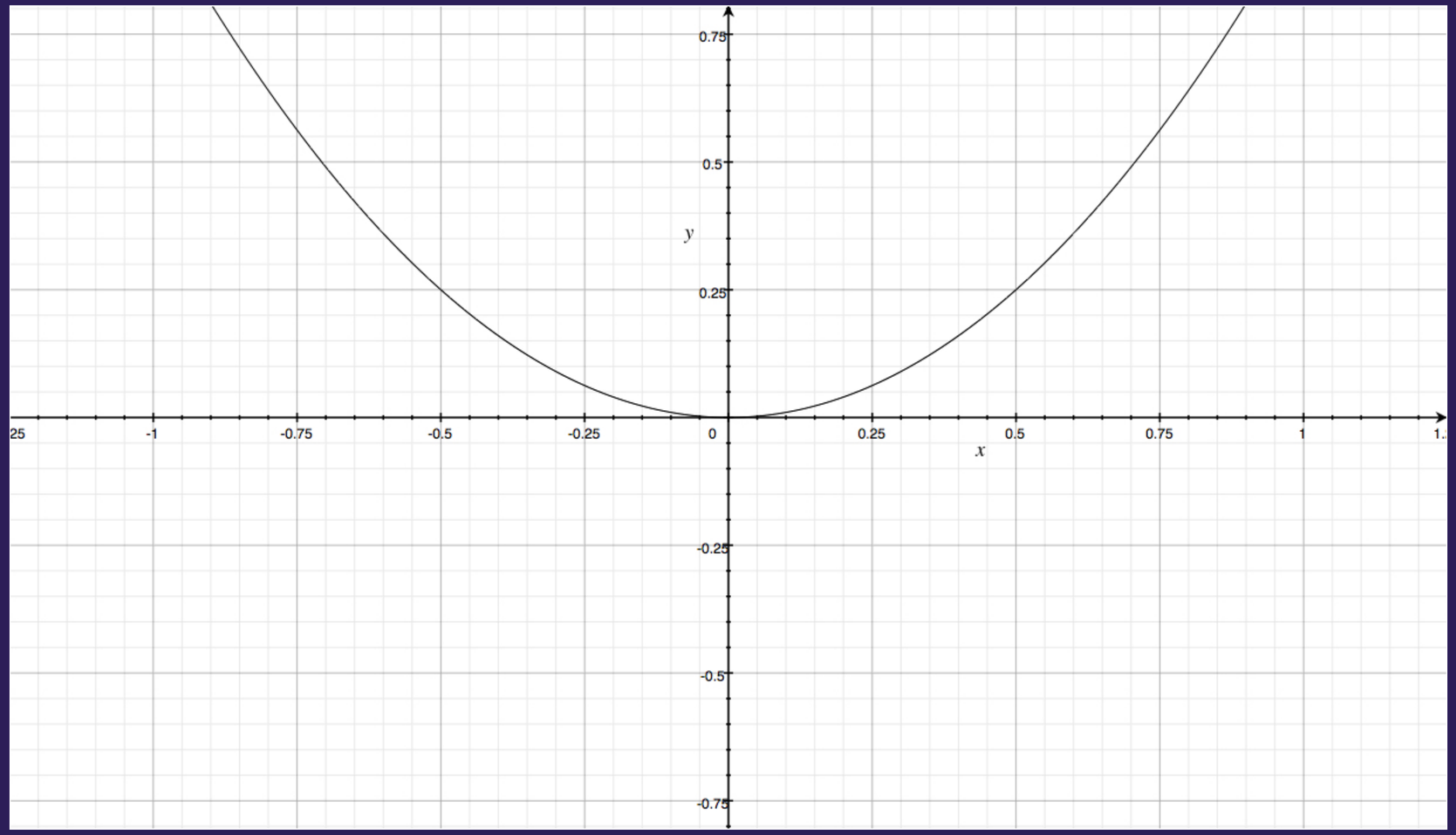

$$f(x) = x^2$$

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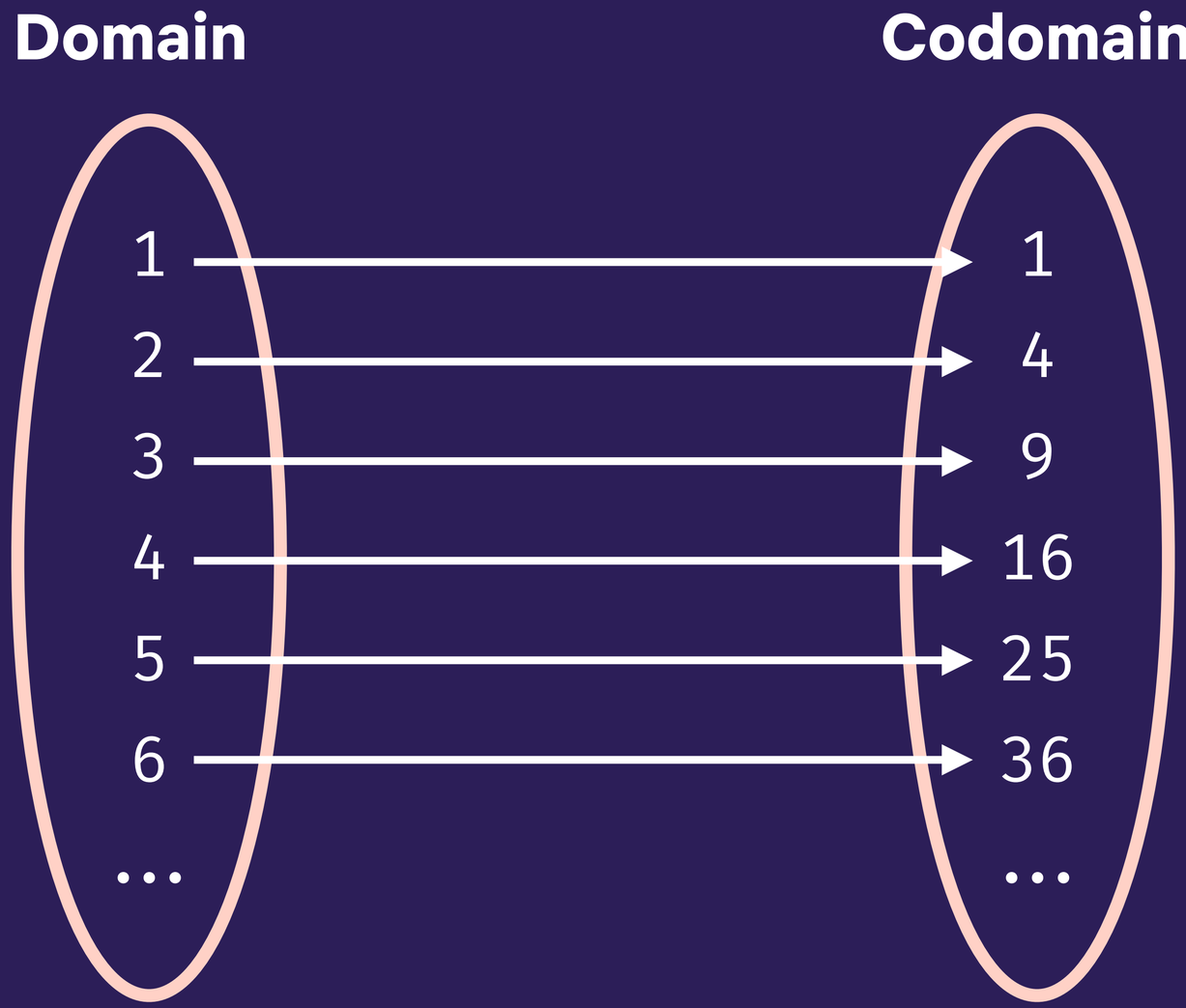
$$f(x) = x^2$$



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Total vs Partial functions

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	Partial	Total
Pure	Pure & Partial	Pure & Total
Impure	Impure & Partial	Impure & Total

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Partial

A partial function is a function that is not defined for all possible input values.

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```
const half = x ⟹ x / 2;
```

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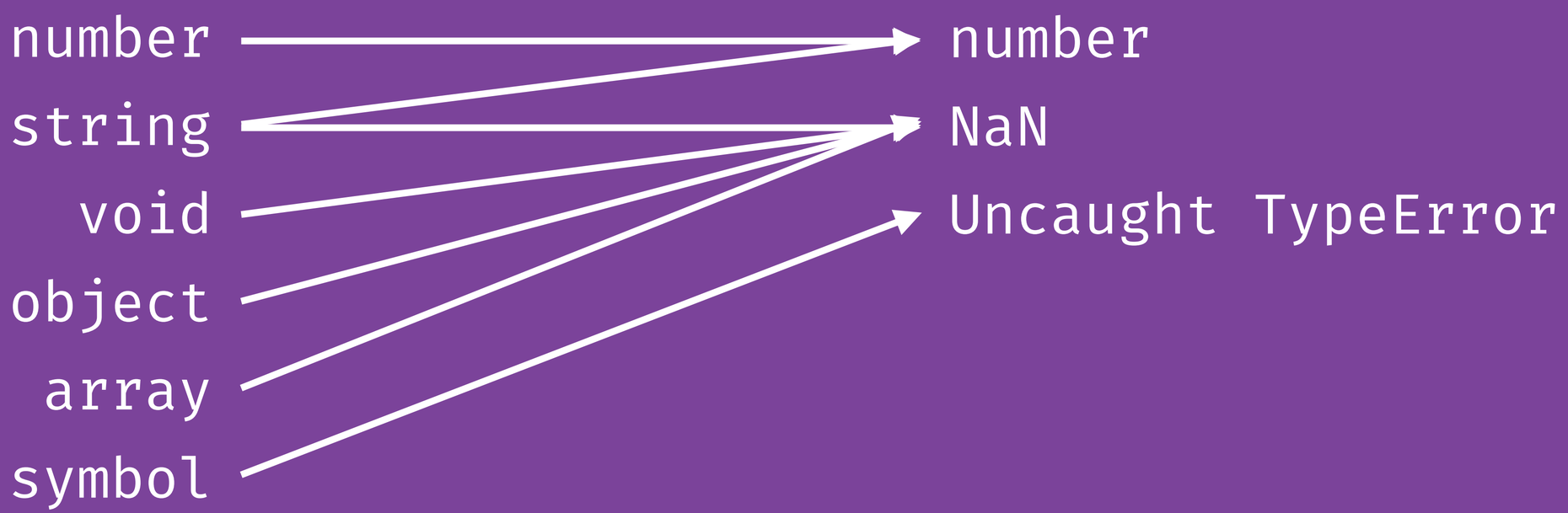
```
const half = x ⇒ x / 2;
```

Possible Domains

Possible Codomains



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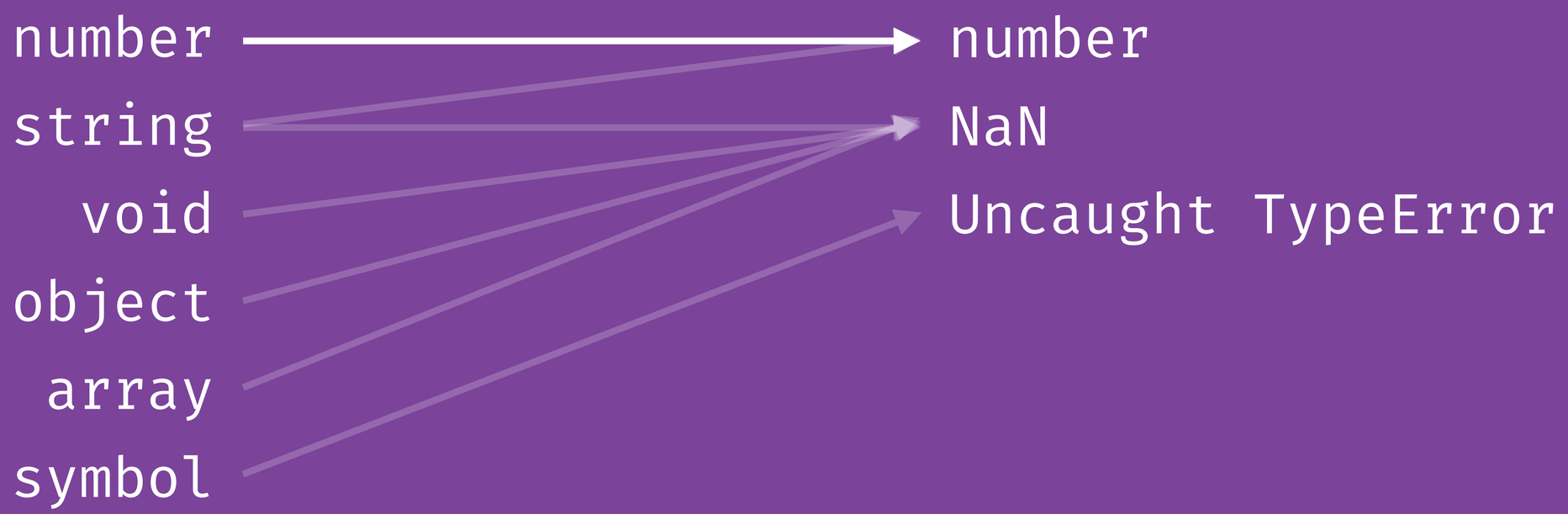
```
const half = x ⇒ x / 2;
```

Possible Domains

Possible Codomains



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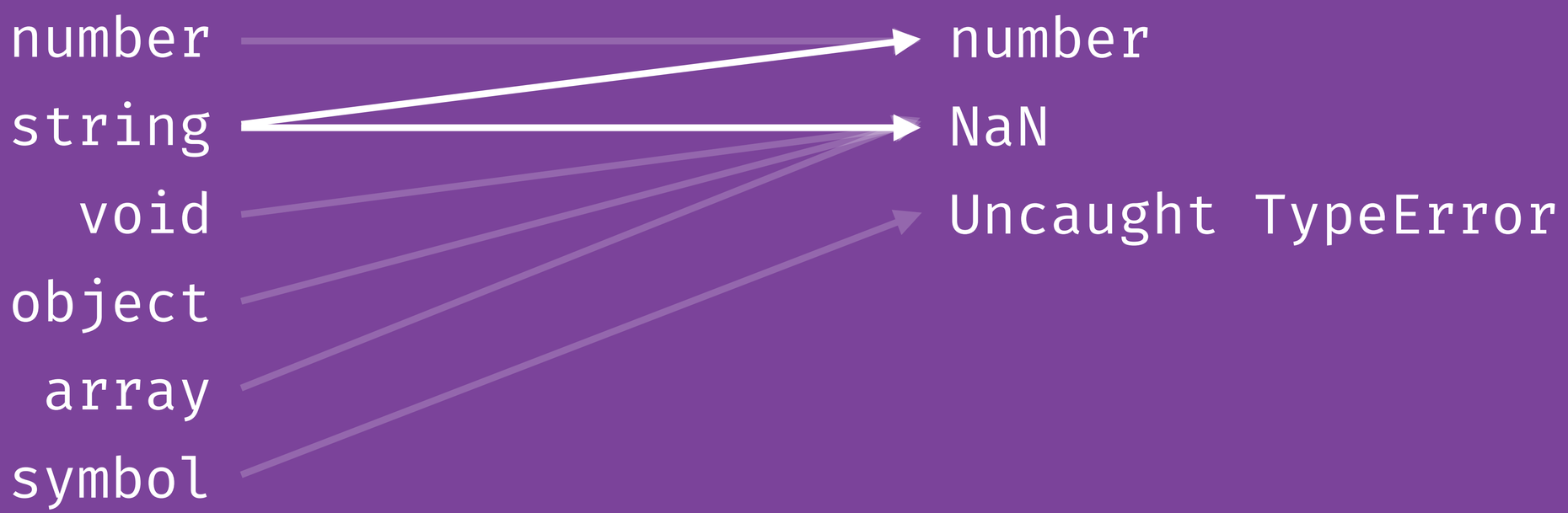
```
const half = x ⇒ x / 2;
```

Possible Domains

Possible Codomains



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```
const half = x ⇒ x / 2;
```

Possible Domains

Possible Codomains

```
half('10') // 5
half('hello world') // NaN
```

void

object

array

symbol

Uncaught TypeError

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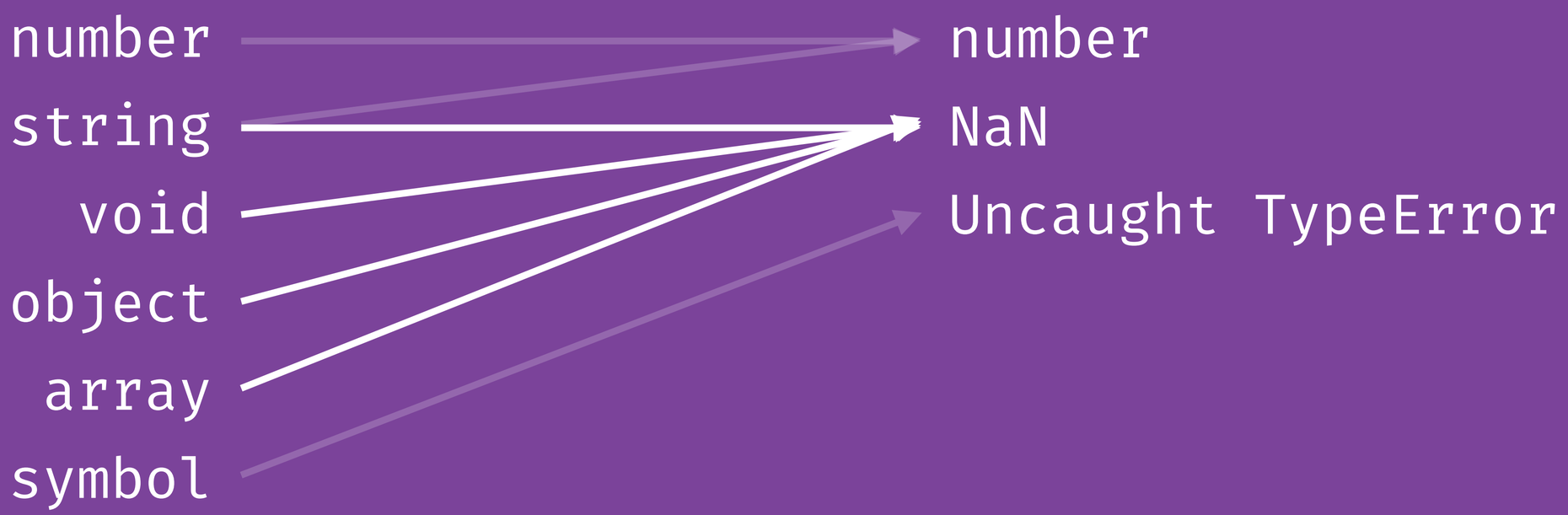
```
const half = x ⇒ x / 2;
```

Possible Domains

Possible Codomains



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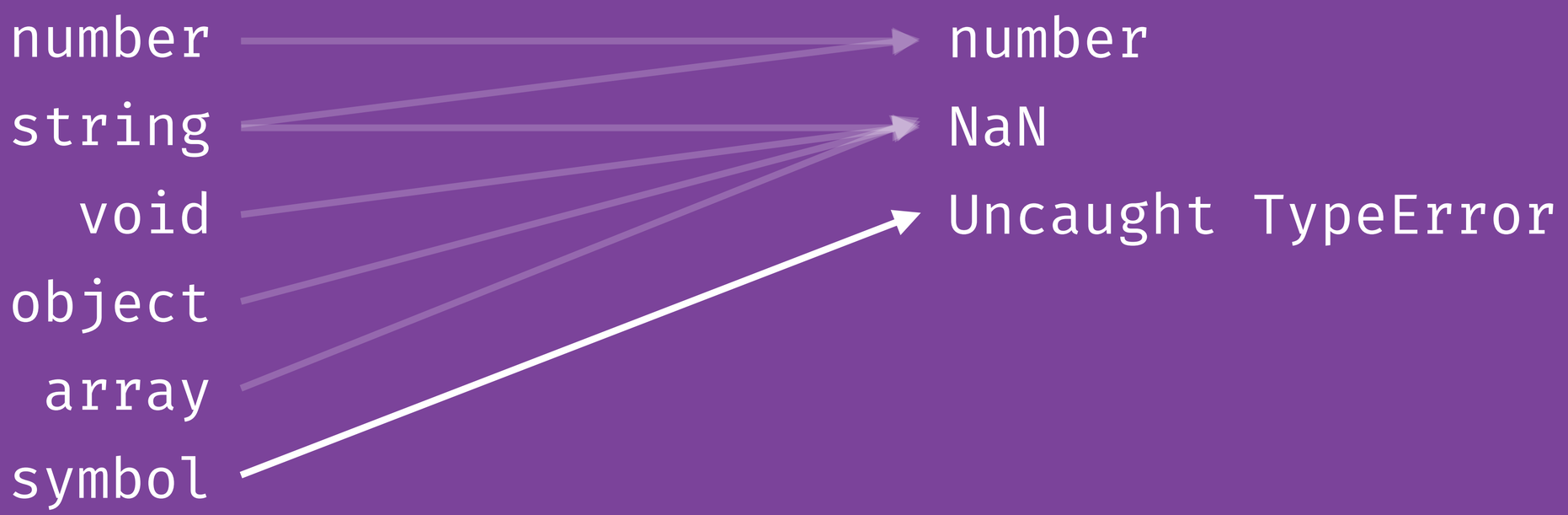
```
const half = x ⇒ x / 2;
```

Possible Domains

Possible Codomains



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```
const half = (x: number) ⇒ x / 2;
```

Possible Domains

number
string
void
object
array
symbol

Possible Codomains

number
NaN
Uncaught TypeError

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Total

A total function is a function that is defined for all possible values of its input. That is, it terminates and returns a value.

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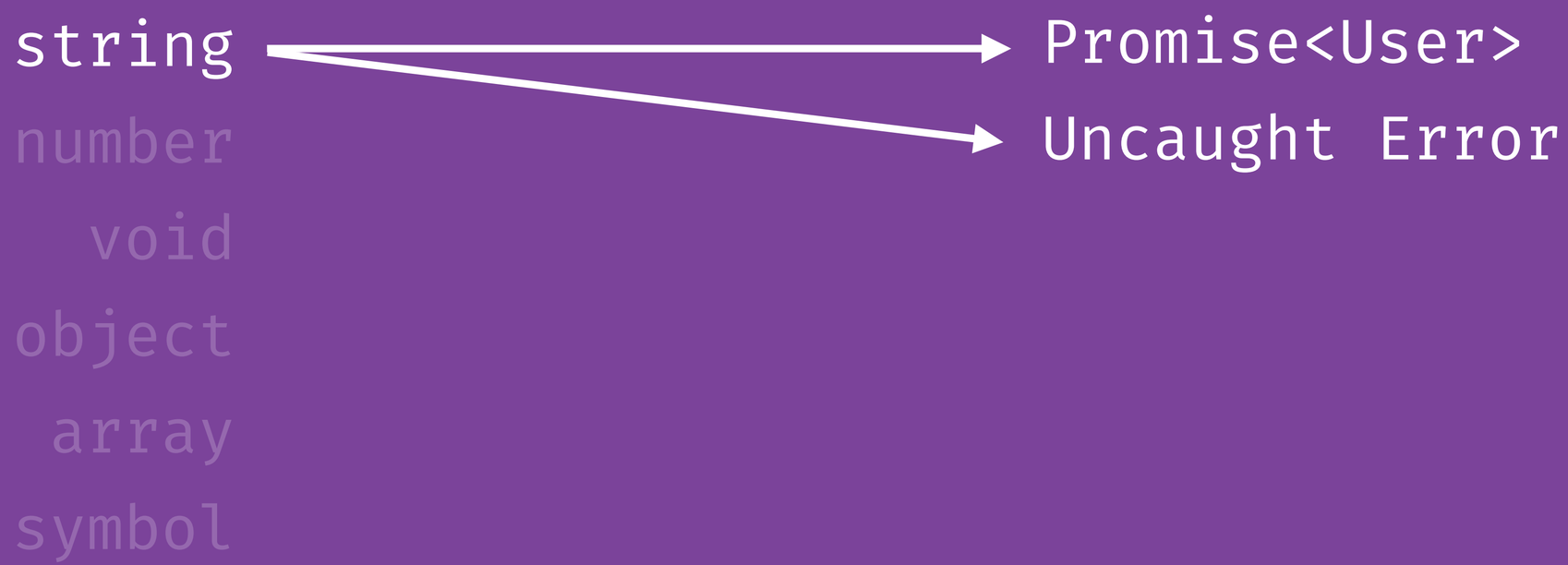
```
function fetchUser(username: string): Promise<User>
```

Possible Domains

Possible Codomains



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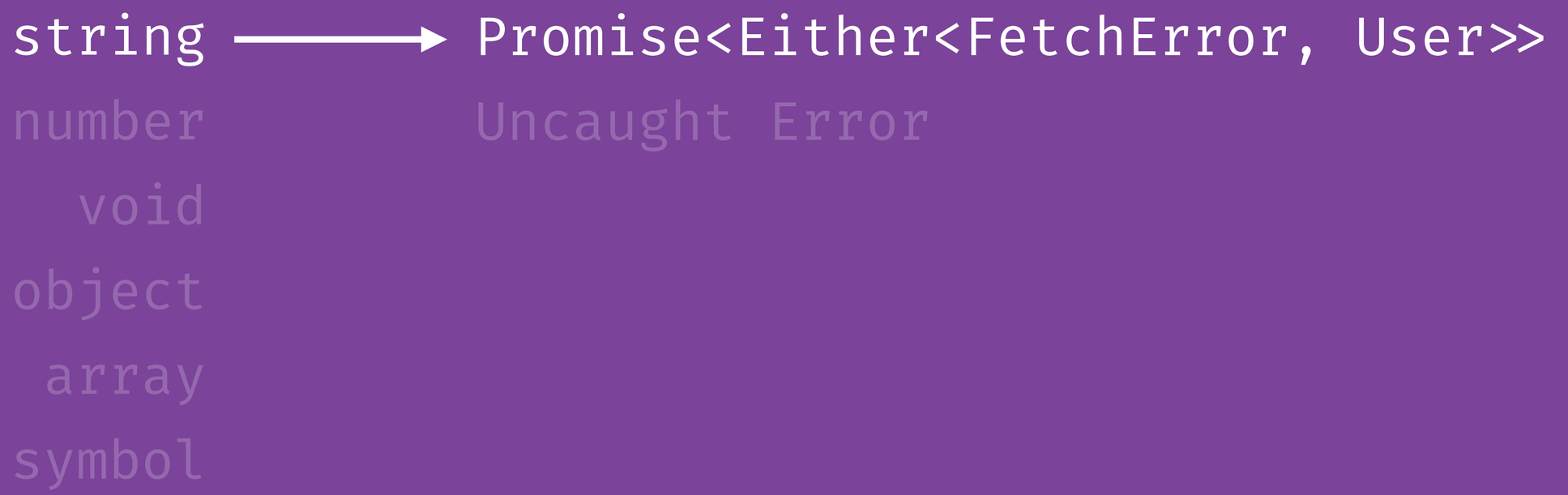
```
function fetchUser(username: string): Promise<Either<FetchError, User>>
```

Possible Domains

Possible Codomains



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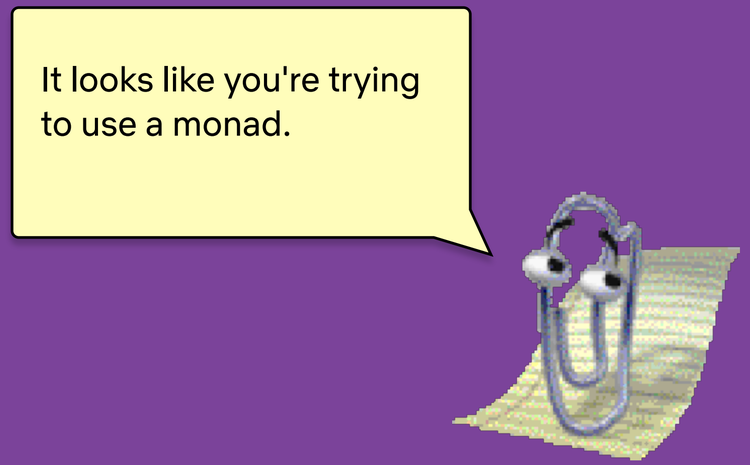
```
type Either<L, A> = Left<L, A> | Right<L, A>
```



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type Either<L, A> = Left<L, A> | Right<L, A>
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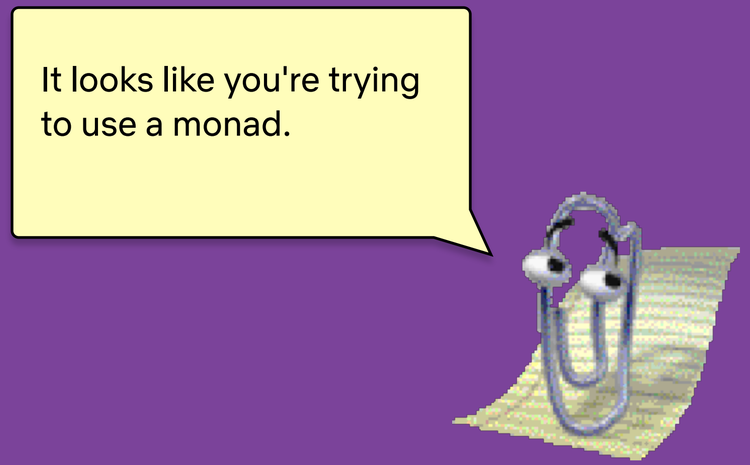

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```ts
import { Either, left, right } from 'fp-ts/lib/Either';
import fetch from 'node-fetch';

async function fetchUser(username: string): Promise<Either<FetchError, User>> {
  const res = await fetch(`https://api.sugarpirate.com/users/${username}`);
  if (!res.ok) { return left(new FetchError(`[${res.status}] ${res.statusText}`)) }
  return right(await res.json());
}
```

https://github.com/gcanti/fp-ts

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import { Either, left, right } from 'fp-ts/lib/Either';
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async function fetchUser(username: string): Promise<Either<FetchError, User>> {
  const res = await fetch(`https://api.sugarpirate.com/users/${username}`);
  if (!res.ok) { return left(new FetchError(`[${res.status}] ${res.statusText}`)) }
  return right(await res.json());
}
```

https://github.com/gcanti/fp-ts

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```
async function doIt() {
  const maybeLauren = await fetchUser('lauren');
  const maybeNoOne = await fetchUser('asdjasjdashjdkahjksd');
  maybeLauren
    .map(lauren ⇒ lauren.projects)
    .map(projects ⇒ console.log(projects.map(p ⇒ p.name)));
  maybeNoOne
    .map(noOne ⇒ noOne.projects)
    .map(projects ⇒ console.log(projects.map(p ⇒ p.name)));
}
```

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```
async function doIt() {
  const maybeNoOne = await fetchUser('asdjasjdashjdkahjksd');
  maybeNoOne
    .mapLeft(e ⇒ console.log(e.message)); // e: FetchError
}
```

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```
export function firstVisibleElement(
  selector: string,
  scrollableAreaSelector: string
): Element | undefined
```

Possible Domains

[string, string]

number

void

object

array

symbol

Possible Codomains

Element

undefined

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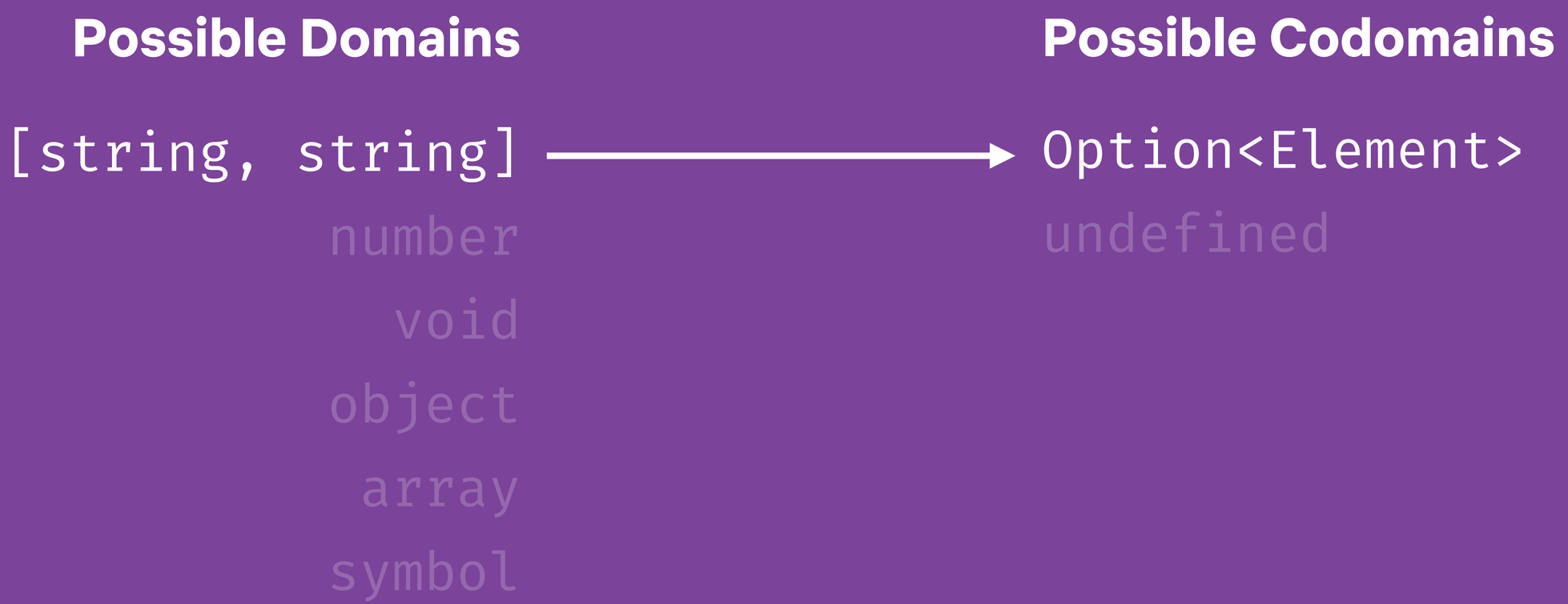
```
export function firstVisibleElement(
  selector: string,
  scrollableAreaSelector: string
): Option<Element>
```



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```
type Option<A> = None<A> | Some<A>
```

https://github.com/gcanti/fp-ts

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```
export function firstVisibleElement(
  selector: string,
  scrollableAreaSelector: string
): Option<Element> {
  const scrollableElement = document.querySelector(scrollableAreaSelector);
  if (!scrollableElement) return none;
  const scrollableBounds = scrollableElement.getBoundingClientRect();
  const firstVisibleItem = Array.from(document.querySelectorAll(selector)).find(
    el ⇒ {
      const elBounds = el.getBoundingClientRect();
      const isInViewport = detectInViewport(elBounds, scrollableBounds);
      return isInViewport && elBounds.top - scrollableBounds.top ⩽ 0;
    }
  );
  return firstVisibleItem ? some<Element>(firstVisibleItem) : none;
}
```

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```
export function firstVisibleElement(
  selector: string,
  scrollableAreaSelector: string
): Option<Element> {
  const scrollableElement = document.querySelector(scrollableAreaSelector);
  if (!scrollableElement) return none;
  const scrollableBounds = scrollableElement.getBoundingClientRect();
  const firstVisibleItem = Array.from(document.querySelectorAll(selector)).find(
    el => {
      const elBounds = el.getBoundingClientRect();
      const isInViewport = detectInViewport(elBounds, scrollableBounds);
      return isInViewport && elBounds.top - scrollableBounds.top <= 0;
    }
  );
  return firstVisibleItem ? some<Element>(firstVisibleItem) : none;
}
```

sugarpirate_ poteto

```
export function firstVisibleElement(
  selector: string,
  scrollableAreaSelector: string
): Option<Element> {
  const scrollableElement = document.querySelector(scrollableAreaSelector);
  if (!scrollableElement) return none;
  const scrollableBounds = scrollableElement.getBoundingClientRect();
  const firstVisibleItem = Array.from(document.querySelectorAll(selector)).find(
    el => {
      const elBounds = el.getBoundingClientRect();
      const isInViewport = detectInViewport(elBounds, scrollableBounds);
      return isInViewport && elBounds.top - scrollableBounds.top <= 0;
    }
  );
  return firstVisibleItem ? some<Element>(firstVisibleItem) : none;
}
```

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```
export function firstVisibleElement(
  selector: string,
  scrollableAreaSelector: string
): Option<Element> {
  const scrollableElement = document.querySelector(scrollableAreaSelector);
  if (!scrollableElement) return none;
  const scrollableBounds = scrollableElement.getBoundingClientRect();
  const firstVisibleItem = Array.from(document.querySelectorAll(selector)).find(
    el => {
      const elBounds = el.getBoundingClientRect();
      const isInViewport = detectInViewport(elBounds, scrollableBounds);
      return isInViewport && elBounds.top - scrollableBounds.top <= 0;
    }
  );
  return firstVisibleItem ? some<Element>(firstVisibleItem) : none;
}
```

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```
firstVisibleElement('.item', '.item-container').map(el ⇒
  el.getAttribute('data-whatever') // string
);
```

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```
(method) map<string>(f: (a: Element) ⇒ string):
Option<string>
```

Takes a function `f` and an `Option` of `A`. Maps `f` either on `None` or `Some`, Option's data constructors. If it maps on `Some` then it will apply the `f` on `Some`'s value, if it maps on `None` it will return `None`.

@example

```
assert.deepEqual(some(1).map(n ⇒ n * 2),
some(2))
```

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Cardinality

cardinality · number of elements of the set

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Lower cardinality = Less bugs*

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Lower cardinality = Less bugs*

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Pragmatic Set Theory

set · collection of objects

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```
type Conferences = 'QConSF' | 'dotJS' | 'React Rally';
```

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(not real syntax)

```
|Conferences| = 3
```

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```
type Conferences = string;
```

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(not real syntax)

```
|Conferences| = Infinity
```

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Primitive types are not precise

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(not real syntax)

```
|string|    = Infinity
|number|    = Infinity
|symbol|    = Infinity
|boolean|   = 2
|null|      = 1
|undefined| = 1
```

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(not real syntax)

```
|object| = Infinity
```

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Be precise

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```
function toString<T>(x: T): string { return x.toString(); }
toString(undefined);
toString(null);
```

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```
function toString<undefined>(x: undefined): string
```

```
function toString<T>(x: T): string { return x.toString(); }
toString(undefined);
toString(null);
```

```
function toString<null>(x: null): string
```

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```
function toString<T>(x: T): string
```

Possible Domains

- string
- number
- object
- array
- symbol
- void

Possible Codomains

- string
- Uncaught TypeError

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```
function toString<T>(x: NonNullable<T>): string { return x.toString(); }
toString(undefined);
toString(null);
```

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```
function toString<T>(x: NonNullable<T>): string { return x.toString(); }
toString(undefined);
toString(null);
```

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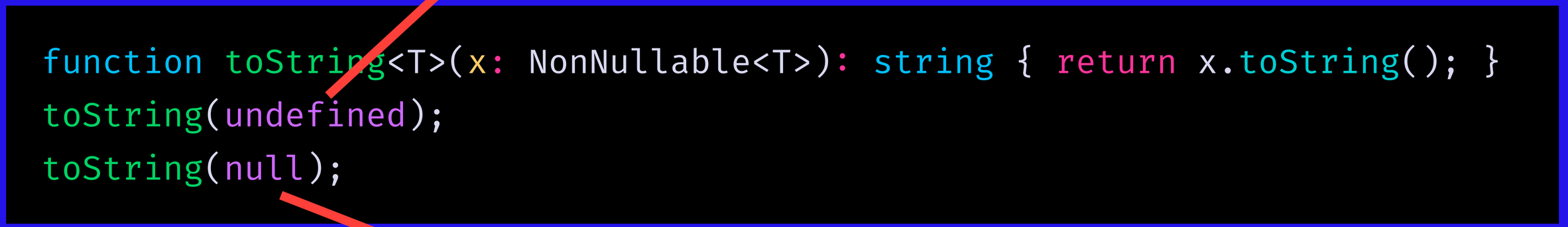
```
[ts] Argument of type 'undefined' is not
assignable to parameter of type '{}'.
```



```
function toString<T>(x: NonNullable<T>): string { return x.toString(); }
toString(undefined);
toString(null);
```

```
[ts] Argument of type 'null' is not
assignable to parameter of type '{}'.
```

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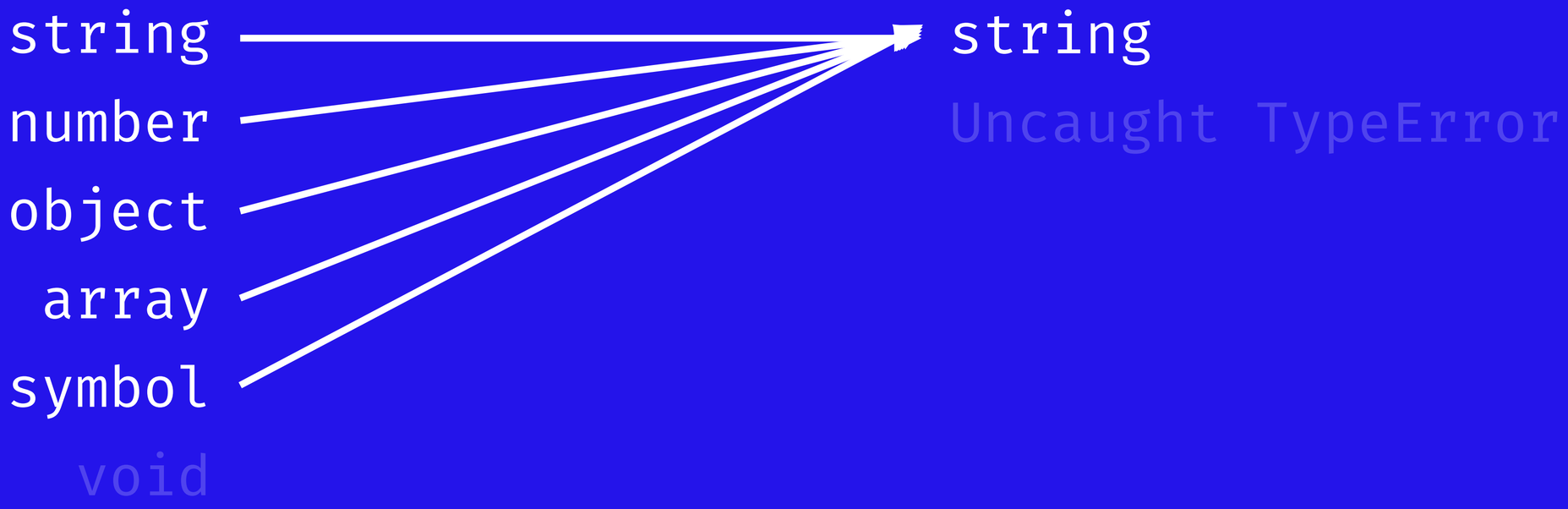
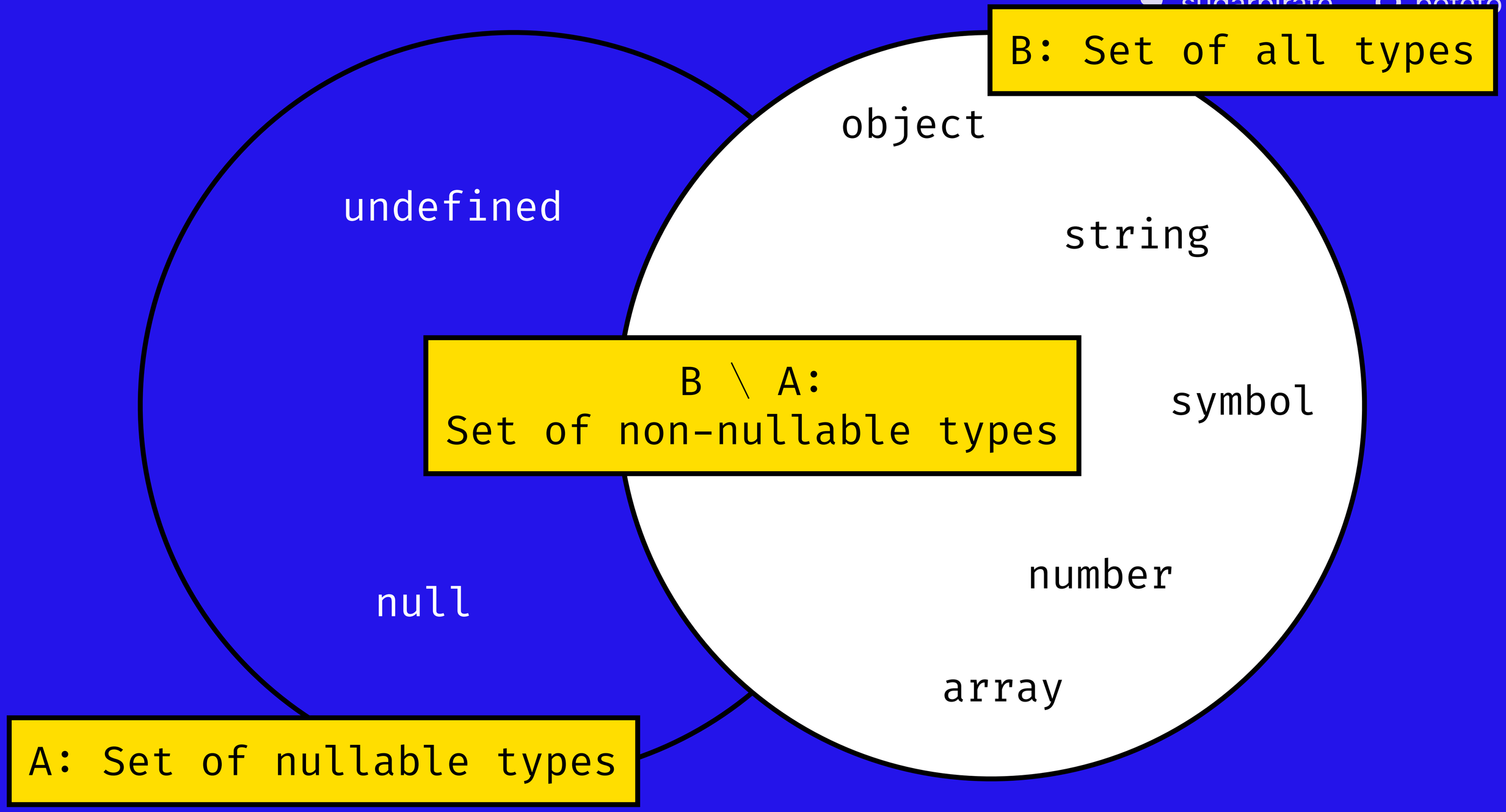
```
function toString<T>(x: NonNullable<T>): string
```

Possible Domains

Possible Codomains




B: Set of all types
undefined
object
string
B \ A:
Set of non-nullable types
symbol
number
null
array
A: Set of nullable types

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```
type NonNullable<T> = T extends null | undefined ? never : T
type T34 = NonNullable<string | number | undefined>;  // string | number
type T35 = NonNullable<string | string[] | null | undefined>;  // string | string[]
```

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```ts
type Partial<T> = { [P in keyof T]?: T[P]; };
type Required<T> = { [P in keyof T]-?: T[P]; };
type Readonly<T> = { readonly [P in keyof T]: T[P]; };
type Pick<T, K extends keyof T> = { [P in K]: T[P]; };
type Record<K extends keyof any, T> = { [P in K]: T; };
type Exclude<T, U> = T extends U ? never : T;
type Extract<T, U> = T extends U ? T : never;
type NonNullable<T> = T extends null | undefined ? never : T;
type ReturnType<T extends (...args: any[]) => any> = T extends (...args: any[]) => infer R ? R : any;
```

https://github.com/Microsoft/TypeScript/blob/v3.0.1/src/lib/es5.d.ts

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eto

Be pragmatic

"No matter what language you work in, programming in a functional style provides benefits. You should do it whenever it is convenient, and you should think hard about the decision when it isn't convenient."

John Carmack


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Merci beaucoup
Cinemagraph by /u/fezzo


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Merci beaucoup
Cinemagraph by /u/fezzo