# How to Write PHP like a Haskell Programmer

By Richard


This language is nice
I wonder w
HASKELL!
HASKELL IS AWESOME
EVERYONE SHOULD USE HASKELL
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*“A language that doesn't affect the way you think about programming, is not worth knowing.”*

- Alan Perlis

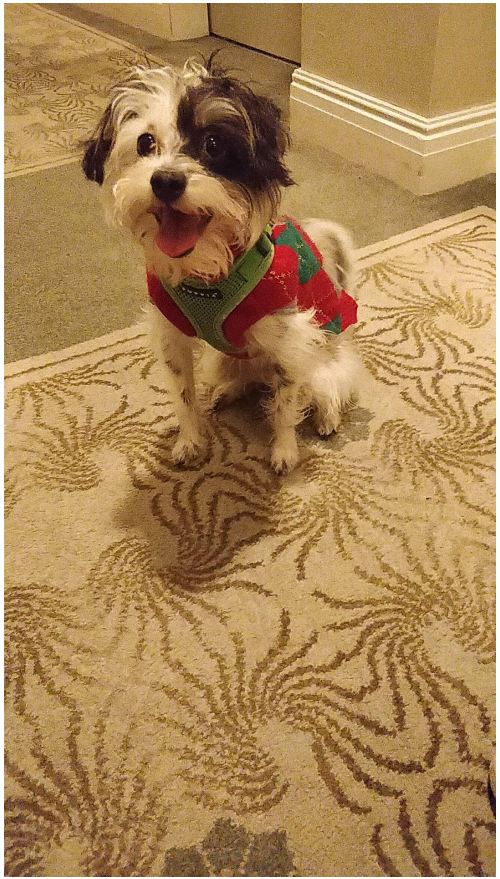
# Three Haskelly Catchphrases

1. *"Make business logic errors into type errors"*
2. *"Make invalid states unrepresentable"*
3. *"Constraints liberate, and liberties constrain"*

# Three Haskell Features/Techniques

1. Newtypes
2. Algebraic Datatypes
3. Parametric Polymorphism (AKA generics, AKA templates)

# Three Dog Pictures



*“Make business logic errors into type errors”*

~ Haskeller Matt Parsons

**Matt Parsons** 🏳️‍🌈
@mattoflambda

Following

when people say "but most business logic bugs aren't type errors" i just want to show them how to make bugs into type errors

10:36 AM - 18 Jun 2018

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11 49 148


String -> String -> String -> String
Types are a lie

# Newtypes

- Newtypes create a new type by “wrapping” another type.
- They let you restrict or redefine the operations that can legally be performed on that type.
- Classic example: units of measure

```
data Video = Video {
  duration :: Int
}
```

```
*VideoDuration> prettyDuration 200
"3:20"
*VideoDuration> prettyDuration 3500
"58:20"
*VideoDuration> prettyDuration 700000
"194:26:40"
```

```
prettyDuration :: Int -> String
prettyDuration duration = undefined
```

```haskell
prettyDuration :: Int -> String
prettyDuration duration = prettyHours <> prettyMinutes <> prettySeconds
  where
    seconds = duration `mod` 60
    minutes = (duration `div` 60) `mod` 60
    hours = (duration `div` 60 `div` 60)
    prettySeconds
      | hours > 0 || minutes > 0 = pad seconds
      | otherwise = show seconds
    prettyMinutes
      | hours > 0 = pad minutes <> ":"
      | minutes > 0 = show minutes <> ":"
      | otherwise = ""
    prettyHours
      | hours > 0 = (show hours) <> ":"
      | otherwise = ""
    pad n
      | n < 1 = "00"
      | n < 10 = "0" <> (show n)
      | otherwise = show n
```

```haskell
data Video = Video {
  duration :: Int
}
```

```
*VideoDuration> prettyDuration 200
"3:20"
*VideoDuration> prettyDuration 3500
"58:20"
*VideoDuration> prettyDuration 700000
"194:26:40"
```

```haskell
prettyDuration :: Int -> String
prettyDuration duration = undefined
```

```haskell
prettyDurationForVideo :: Video -> String
prettyDurationForVideo (Video duration)
  = prettyDuration duration
```

```haskell
data Video = Video {
  duration :: Int
}
```

But what if this is in milliseconds?

This is seconds

```haskell
prettyDuration :: Int -> String
prettyDuration duration = undefined
```

```haskell
prettyDurationForVideo :: Video -> String
prettyDurationForVideo (Video duration)
  = prettyDuration duration
```

So this is a bug.

```haskell
toSeconds :: Int -> Int
toSeconds ms = ms `div` 1000
```

```haskell
prettyDurationForVideo :: Video -> String
prettyDurationForVideo (Video duration)
  = prettyDuration (toSeconds duration)
```

```haskell
newtype Seconds = Seconds Int
newtype Milliseconds = Milliseconds Int
```

```haskell
toSeconds :: Milliseconds -> Seconds
toSeconds (Milliseconds ms) = Seconds (ms `div` 1000)
```

```haskell
data Video = Video {
  duration :: Milliseconds
}

prettyDuration :: Seconds -> String
prettyDuration (Seconds duration) = undefined


prettyDurationForVideo :: Video -> String
prettyDurationForVideo (Video duration)
  = prettyDuration (toSeconds duration)
```

Now that's the sort of code I like to see.

# So what about PHP?

```php
class Video {
    /** @var int */
    public $duration;

    /** @param int $duration */
    function __construct($duration) {
        $this->duration = $duration;
    }
}

/**
 * @param int $duration
 * @return string
 */
function prettyDuration ($duration) {
    return "";
}
```

- Newtype is just a type with a value inside it.
- In PHP, write a class with a value inside it.

```php
// newtype Milliseconds = Milliseconds Int
class Milliseconds {
    /** @var int */
    public $value;
    /** @param int $value */
    function __construct($value) {
        $this->value = $value;
    }
}
```

```php
// newtype Milliseconds = Milliseconds Int
class Milliseconds {
    /** @var int */
    public $value;
    /** @param int $value */
    function __construct($value) {
        $this->value = $value;
    }
}

// newtype Seconds = Seconds Int
class Seconds {
    /** @var int */
    public $value;
    /** @param int $value */
    function __construct($value) {
        $this->value = $value;
    }
}
```

```php
/**
 * @param Seconds $duration
 * @return PrettyDuration
 */
function prettyDuration ($duration) {
    return new PrettyDuration(
        "" /* insert real implementation here */
    );
}
```

```php
/**
 * @param Milliseconds $ms
 * @return Seconds
 */
function toSeconds ($ms) {
    return new Seconds($ms->value * 1000);
}

class Video {
    /** @var Milliseconds */
    public $duration;

    /** @param Milliseconds $duration */
    function __construct($duration) {
        $this->duration = $duration;
    }
}
```

- Yay! We made a business logic error into a type error!
- So what?
  - Faster feedback
  - Greater maintainability
  - Clearer intent

# Other applications?

- Units of measure
- Timestamp formats
  - Vimeo Live had a terrible “time-travelling event bug” caused by saving a string representing a timestamp to MySQL, but the format was incompatible with how MySQL interprets time zones.
  - newtype MysqlTimestamp = MysqlTimestamp String
- XSS sanitization?
  - newtype Escaped = Escaped String
  - (Although, this would be basically impossible to enforce in the .phtml paradigm, since rendering .phtml is not done by passing input to a function with a type signature)

*“Make invalid states unrepresentable”*

~ OCamler Yaron Minsky

# Example: Video Outros

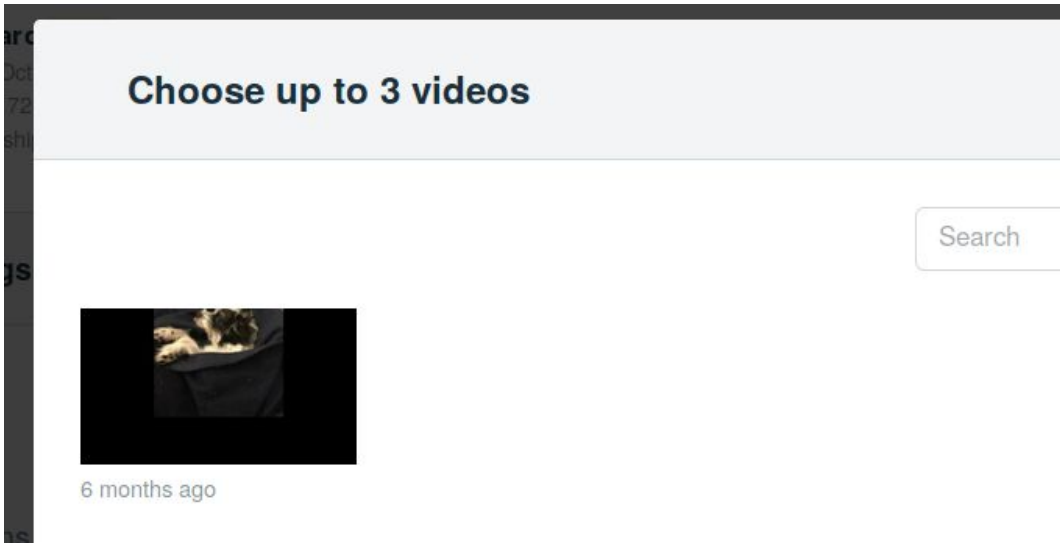
# Example: Video Outros

## After video

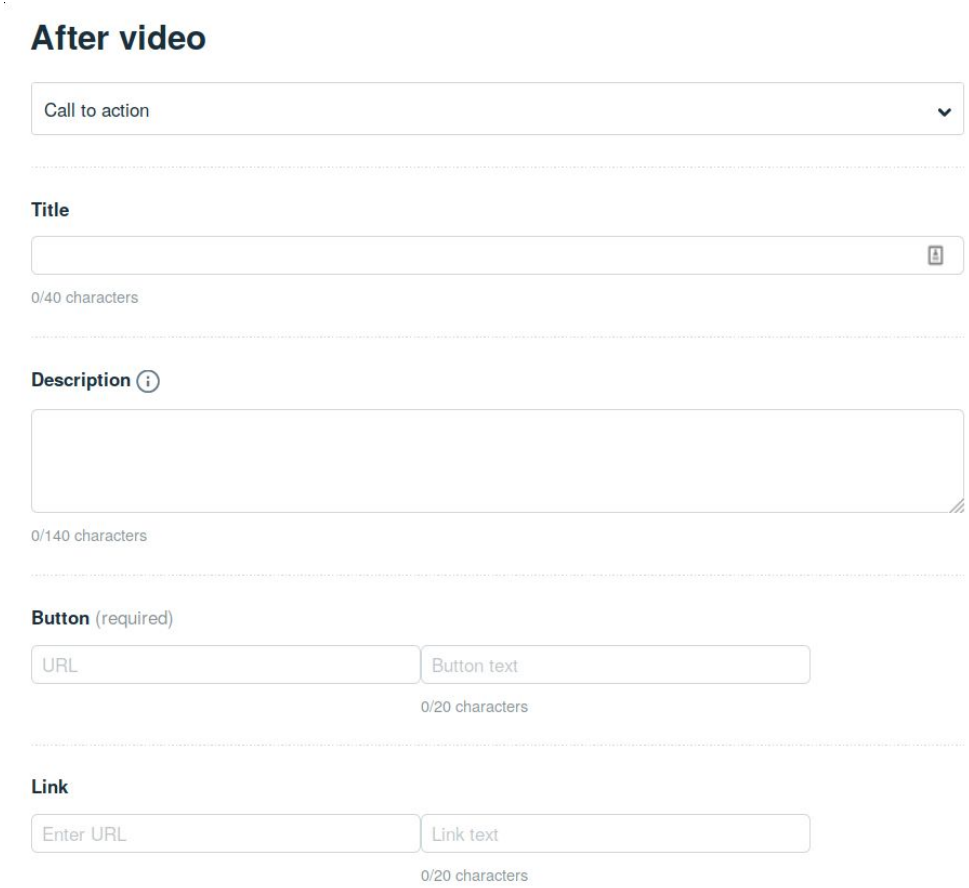
More videos

Shows your three most recent public videos

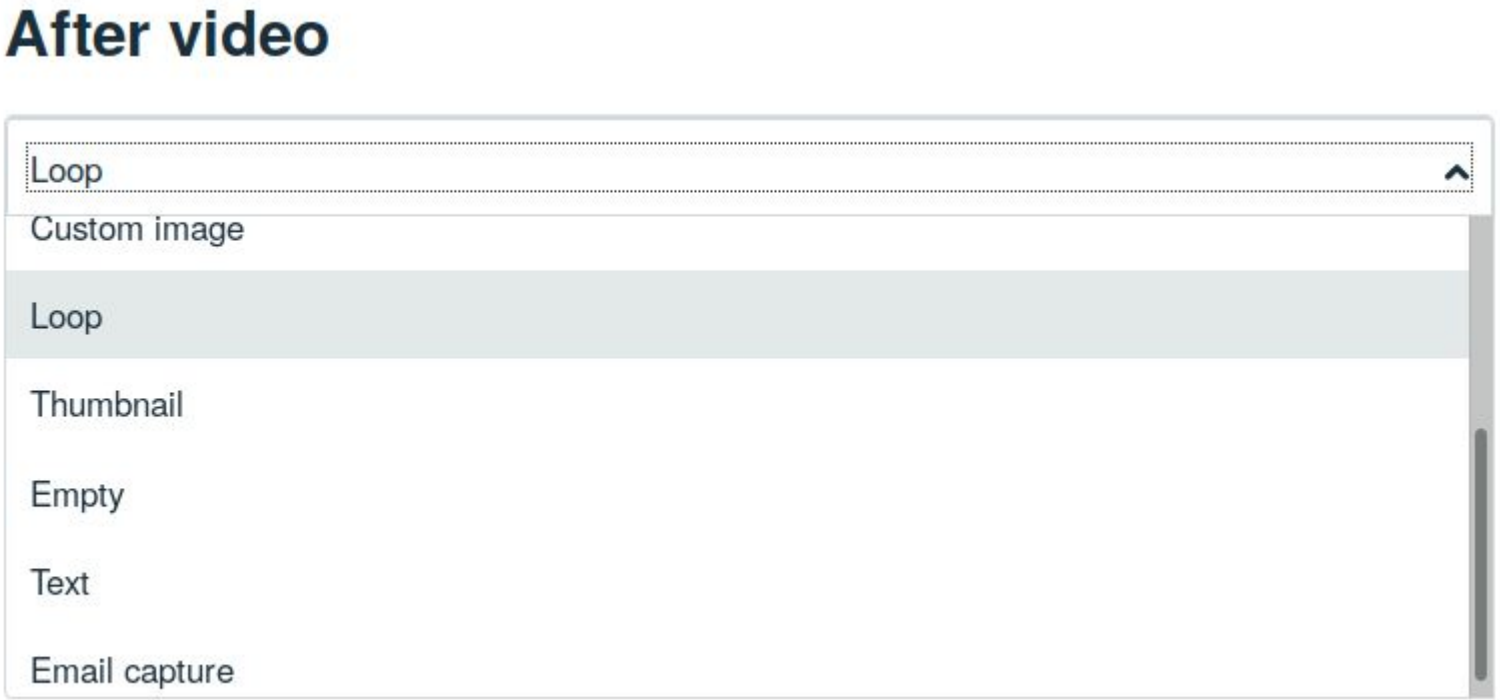
Select specific videos



# Example: Video Outros



# Example: Video Outros

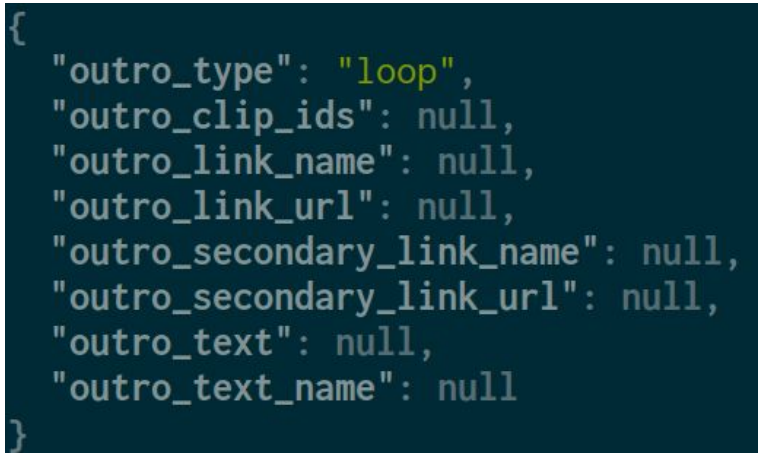


# Example: Video Outros

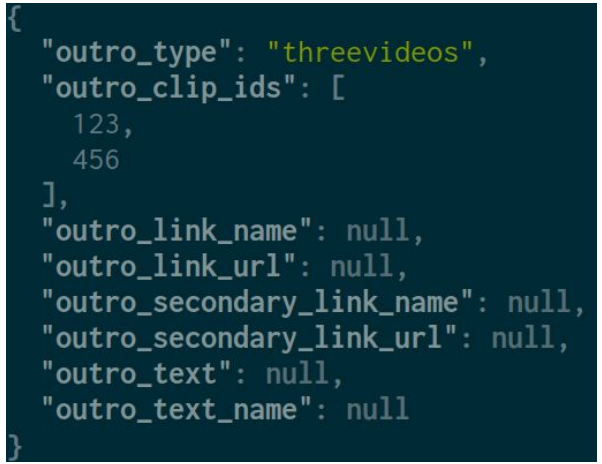
```php
class VideoOutro {
    /** @var string */
    protected $outro_type;

    const OUTRO_TYPE_LOOP = 'loop';

    const OUTRO_TYPE_THREEVIDEOS = 'videos';
    /** @var ?array<int> */
    protected $outro_clip_ids;

    const OUTRO_TYPE_LINK = 'link'; // "Call to Action"
    /** @var ?string */
    protected $outro_link_name;
    /** @var ?string */
    protected $outro_link_url;
    /** @var ?string */
    protected $outro_secondary_link_name;
    /** @var ?string */
    protected $outro_secondary_link_url;
    /** @var ?string */
    protected $outro_text;
    /** @var ?string */
    protected $outro_text_name;
}
```

- All of these properties are nullable.
- But null is not always ok.
- Depending on the value of “outro_type”, null could in fact be forbidden, or mandatory.

# Example: Video Outros




VALID




VALID

# Example: Video Outros

```
{
  "outro_type": "loop",
  "outro_clip_ids": [
    123,
    456
  ],
  "outro_link_name": null,
  "outro_link_url": null,
  "outro_secondary_link_name": null,
  "outro_secondary_link_url": null,
  "outro_text": null,
  "outro_text_name": null
}
```

INVALID

```
$ php embedsettings.php | jq '.'
{
  "outro_type": "link",
  "outro_clip_ids": null,
  "outro_link_name": null,
  "outro_link_url": null,
  "outro_secondary_link_name": "foo",
  "outro_secondary_link_url": "bar",
  "outro_text": null,
  "outro_text_name": null
}
```

INVALID

# What do we do?

- Check at runtime to make sure users never try to create something bad.

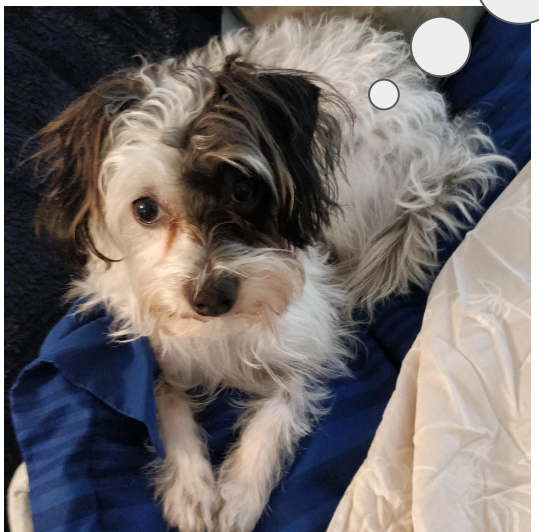
```
if ($this->outro_type === ClipEmbedSettings::OUTRO_TYPE_THREEVIDEOS) {
    $user_clips = Clip::getAllClipsForUser($clip_user, $clip_user);

    $this->requireField('outro_clip_ids');
```

- But what if we could completely eliminate the possibility of invalid outros by construction?

# “Algebraic Data Types”

Ways of combining simple types into more complicated types

- Sum types
- Product types



What are those? It sounds like math...

# You already know Product Types

- Most languages let you define your own “product types”.
- Examples: structs, classes, tuples
- A product type has something AND something else, at the same time.

```php
class LinkOutro {
    /** @var string */
    public $name;
    /** @var string */
    public $url;
    /** @var ?string */
    public $secondary_name;
    /** @var ?string */
    public $secondary_url;
    /** @var ?string */
    public $text;
    /** @var ?string */
    public $text_name;
}
```

```go
type LinkOutro struct {
    Name string
    Url string
    SecondaryName *string
    SecondaryURL *string
    Text *string
    TextName *string
}
```

# You already know Sum Types

- All languages have Sum Types
- Only cool languages let you define your own.
- A sum type is something OR it is something else. Not at the same time. Like Enums.

```
data Boolean
  = True
  | False
```

```
data Integer
  = 1
  | 2
  | 3
  | ...
  | MAX_INT
  | -1
  | -2
  | ...
  | MIN_INT
```

```
data OutroType
  = Loop
  | Link
  | ThreeVideos
```

Way cooler than Enums, because you can have Sums of Products.

```
data Shape
  = Rectangle { height: Float, width: Float }
  | Circle { radius: Float }

area :: Shape -> Float
area (Rectangle h w) = h * w
area (Circle r) = pi * r * r
```

# VideoOutro as a Sum of Products

```
data Outro
  = Loop
  | Link {
      name :: String,
      url :: String,
      secondary_name :: Maybe String,
      secondary_url :: Maybe String,
      text :: Maybe String,
      text_name :: Maybe String
    }
  | ThreeVideos { video_ids :: [Int] }
```

# Sum types can be expressed using OOP inheritance

```php
abstract class VideoOutro {}

class LoopOutro extends VideoOutro {}

class ThreeVideosOutro extends VideoOutro {
    /** @var array<int> */
    public $video_ids;
}

class LinkOutro extends VideoOutro {
    /** @var string */
    public $name;
    /** @var string */
    public $url;
    /** @var ?string */
    public $secondary_name;
    /** @var ?string */
    public $secondary_url;
    /** @var ?string */
    public $text;
    /** @var ?string */
    public $text_name;
}
```

# Exhaustiveness Checking for Sum Types

Let’s serialize our outro to a JSON object, for the browser javascript to read.

```
instance JSON Outro where
  showJSON :: Outro -> JSValue
  showJSON outro = case outro of
    Loop -> makeObj [("type", showJSON "loop")]
    ThreeVideos v_ids -> makeObj
      [ ("type", showJSON "three_videos")
      , ("video_ids", showJSON v_ids )
      ]
```

- Oops! We forgot about “Link”.
- Haskell compiler will helpfully point this out!

```
Main.hs:49:20: error: [-Wincomplete-patterns, -Werror=incomplete-patt
    Pattern match(es) are non-exhaustive
    In a case alternative: Patterns not matched: (Link _ _ _ _ _ _)
   |
49 |   showJSON outro = case outro of
   |                    ^^^^^^^^^^^^^...
```

# Exhaustiveness Checking for Subclasses?

- Not a thing.

```php
/**
 * @param VideoOutro $outro
 * @return string
 */
function serializeToJson ($outro) {
    switch (get_class($outro)) {
    case LoopOutro::class:
        return json_encode([
            "type" => "loop"
        ]);
    case ThreeVideosOutro::class:
        return json_encode([
            "type" => "three_videos",
            "video_ids" => $outro->video_ids
        ]);
    }
    return "";
}
```

- Psalm forces you to have a fallback, because it is not clever enough (yet?) to see if you handled all possible subclasses. Stay tuned!

# Typescript has union types that support exhaustiveness checking

```
interface LoopOutro { "outro_type": "loop" }
interface ThreeVideosOutro { "outro_type": "three_videos", "video_ids": Array<Number> }
interface LinkOutro {
    outro_type : "link",
    name: string,
    url: string,
    secondary_name?: string,
    secondary_url?: string,
    text?: string,
    text_name?: string
}
type VideoOutro
    = LoopOutro
    | ThreeVideosOutro
    | LinkOutro
```

# Typescript has union types that support exhaustiveness checking

```
17 function checkExhaustive(x: never): never {
18     throw new Error("Exhaustiveness check fails for: " + x)
19 }
20
21 function displayOutro (outro: VideoOutro): string {
22     if (outro.outro_type === "loop") {
23         return "<LoopOutro/>"
24     } else if (outro.outro_type === "three_videos") {
25         return `<ThreeVideosOutro videoIds=${outro.video_ids}`
26     }
>> 27     checkExhaustive(outro)
```

# Advantages?

- If you add a new member to your sum type, you will get a bunch of type errors. Once you've fixed them, you can be confident you've handled it everywhere you need to if you fix all the type errors.
- For example, we recently added a new "clip privacy setting", "CLIP_PRIVACY_STOCK_FOOTAGE".
  - There are 41 places in the codebase where "CLIP_PRIVACY_STOCK_FOOTAGE" occurs, in a dozen different files.
  - I didn't implement this -- but I bet it was a very tedious and manual process for the developers who did.
- All properties that in our database are encoded as "enums" should be encoded as sum types in our code.

*“Constraints liberate, and liberties constrain”*

~ Scalaer Rúnar Bjarnason

```
f :: Bool -> Bool
g :: a -> a
```

Parametric Polymorphism
(AKA generics)

f and g are **pure** functions (they do not depend on anything but the inputs described in their type signature, and do not perform any action but returning an output)

# Counting the number of functions from Bool to Bool

| Name | Input | Output |
|---|---|---|
| const true | True | True |
| | False | True |
| const false | True | False |
| | False | False |
| id | True | True |
| | False | False |
| not | True | False |
| | False | True |

If you know type a, and you know type b, then the number of functions from a to b is $B^A$

# Counting the number of functions from a to a

(where a is a generic type parameter)

| Name | Input | Output |
| --- | --- | --- |
| id | a | a |

- We “liberated” our types, which “constrained” the number of possibilities
- The type is now a more complete description of the function.

```
f :: (Int, Int) -> Bool
g :: (a,   a)   -> Bool
```

- 2^(2^64) = 2^(18446744073709551616) possibilities for f
- 2 possibilities for g
  - \x -> true
  - or \x -> false
- Those are pretty pointless functions.
- We've "liberated" it too much, can we add back a constraint?

```
g :: (Eq a) => (a, a) -> Bool
```

Equality “Typeclass”
like saying “a implements the ‘equals’ interface”

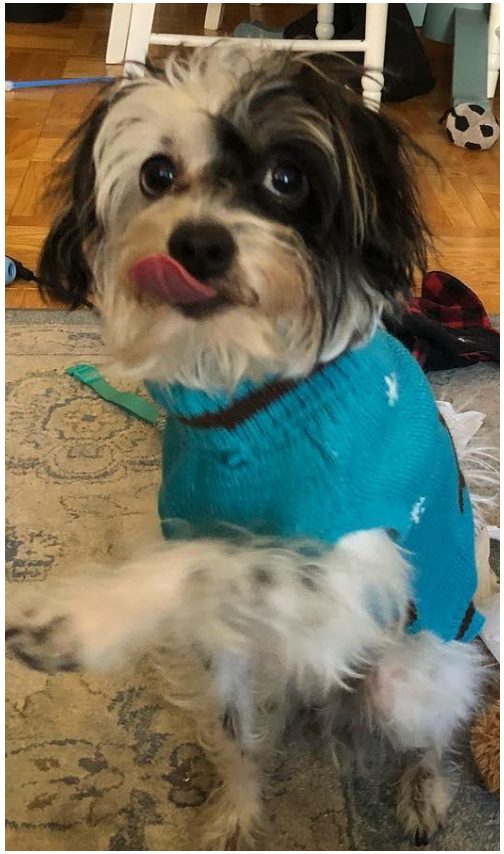
| Name | a1 == a2 | Output |
|---|---|---|
| != | True | False |
| | False | True |
| == | True | True |
| | False | False |
| const true | True | True |
| | False | True |
| const false | True | False |
| | False | False |

# So what?

- Code to general interfaces, not concrete implementations
- We already knew this. OOP theorists told us this helps reduce coupling.
- Still, generic type signatures look complicated and feel like overengineering.
- But they make things simpler, at least in this abstract mathematical sense
- And your types will be a more complete description of your code.

# Inertia

- Types, if you take full advantage of them, can be a wonderful tool to keep your code maintainable and robust.
- Most code at Vimeo was written before we had a type system.
- Taking full advantage of our type system will require a deliberate choice.
  - Make business logic errors into type errors
  - Make invalid states unrepresentable
  - Liberties constrain, constraints liberate



Thank you!

Thanks to Matt & Collin & r/haskell for help with this talk