NaN

"NaN" stands for:

Not a Number

What kinds of things give us NaN?

Fuzzy math

```
console.log(
  0 / 0,
  Infinity / Infinity,
  0 * Infinity,
  Infinity - Infinity
);
```

```
› NaN NaN NaN NaN
```

Complex Numbers

```
console.log(
  Math.sqrt(-1),
  Math.log(-1),
  Math.acos(2),
  Math.asin(2)
);
```

```
› NaN NaN NaN NaN
```

Turning things into Numbers

```
console.log(
  parseInt('hello'), parseFloat('world'),
  Number(undefined), Number({}),
  +undefined, +{},
  +new Date('hello')
);
```

```
> NaN NaN NaN NaN NaN NaN NaN
```

What is NaN? (in JavaScript)

"Not a Number" is...

```
console.log(NaN);
```

```
> NaN
```

... a particular JavaScript value.

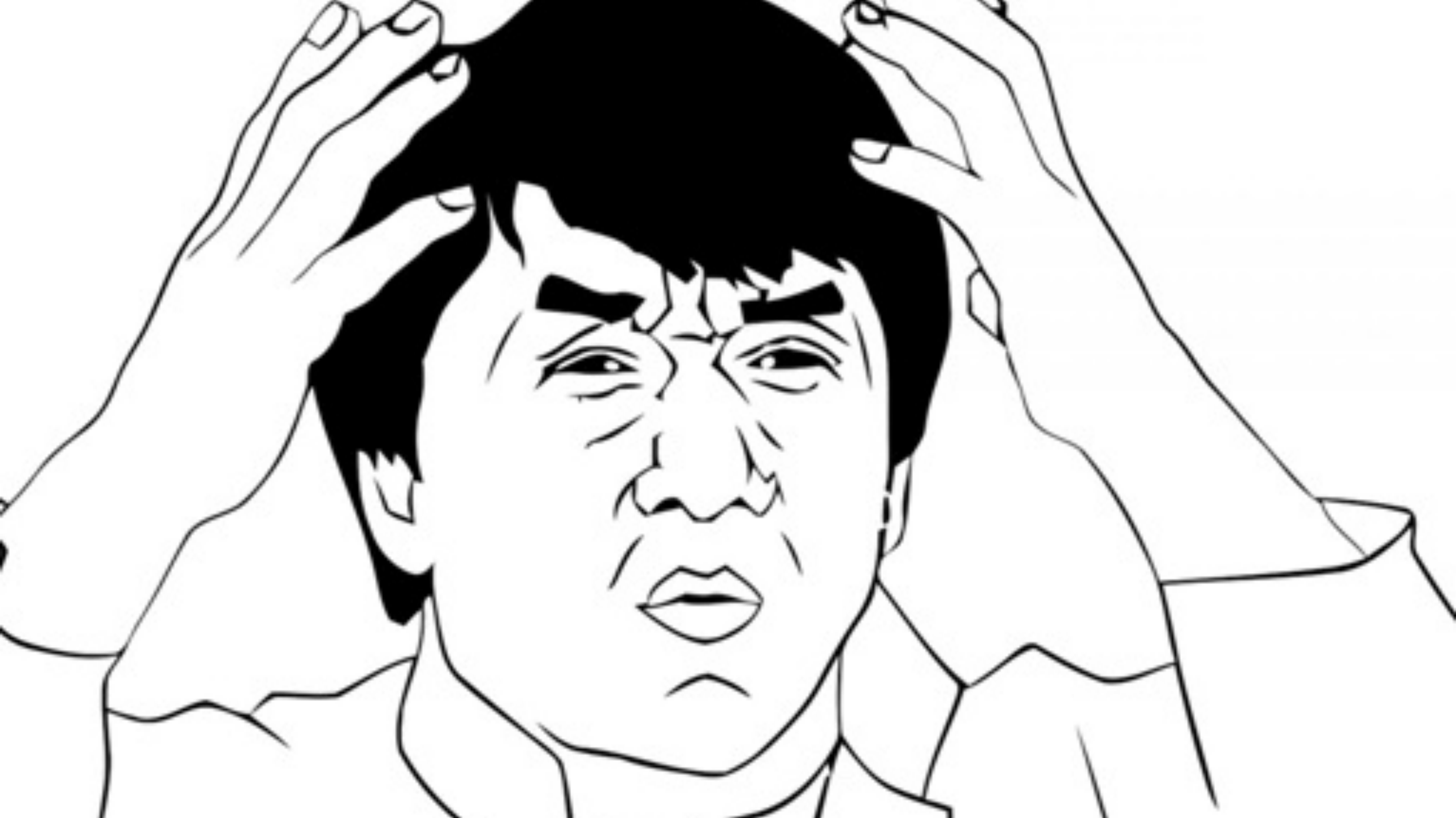
(*very* particular)

"Not a Number" is...

```
console.log(typeof NaN);
```

```
> number
```

...a Number.

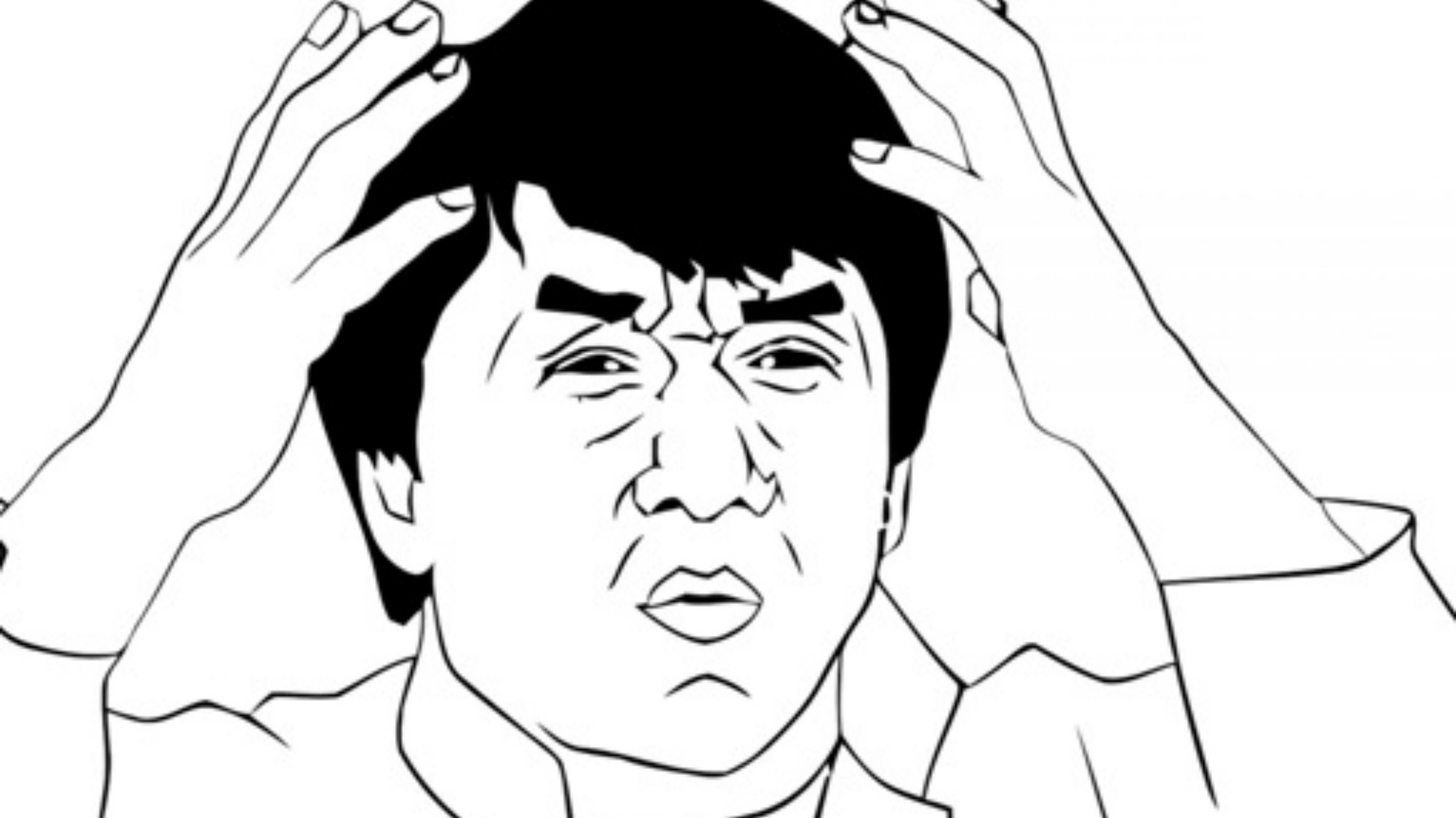


"Not a Number" is...

```
console.log(NaN === NaN);
```

```
› false
```

...not "Not a Number".



"Not a Number" is...

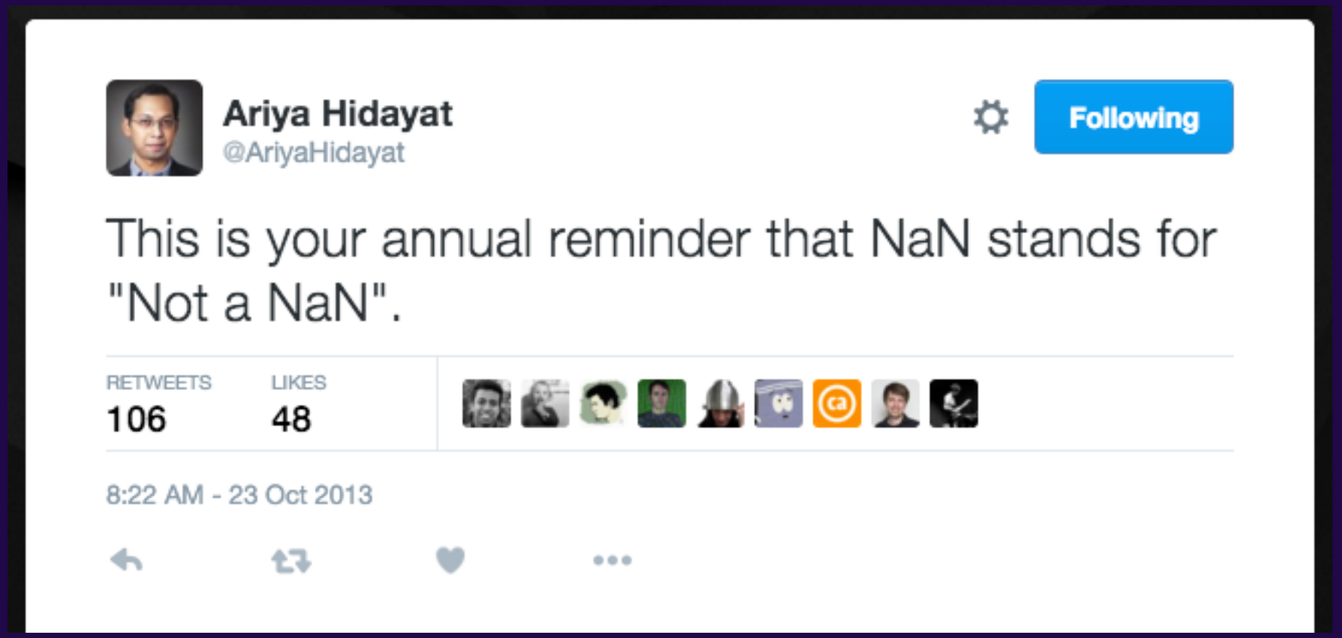
```
var assert = require('assert');
assert.equal(NaN, NaN);
```

```
› AssertionError: NaN == NaN
```

...tricky to test.

"NaN" actually stands for:

Not a NaN


Ariya Hidayat
@AriyaHidayat
Following
This is your annual reminder that NaN stands for "Not a NaN".
RETWEETS
106
LIKES
48
8:22 AM - 23 Oct 2013

So how do we tell if something is NaN?

Easy! Just use the `isNaN` function:

```
console.log(isNaN(NaN));
```

```
> true
```

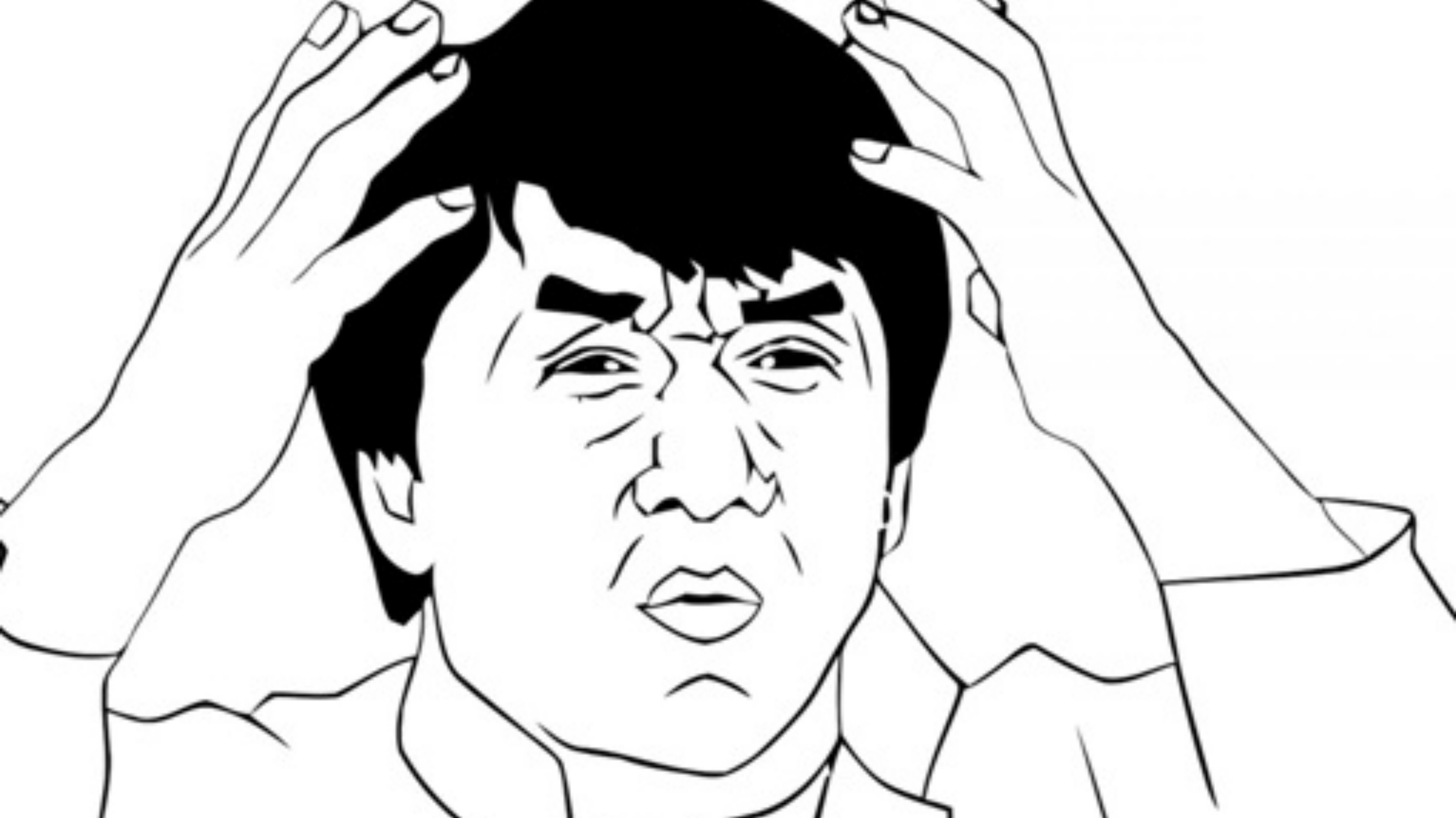
Or maybe not...

```
console.log(isNaN('foo'), isNaN(['bar']), isNaN({}));
```

```
> true true true
```

```
console.log(typeof 'foo', typeof ['bar'], typeof {});
```

```
> string object object
```



So let's just make our own:

```
function myIsNaN(x) {
  return typeof x === 'number' && isNaN(x);
}

console.log([NaN, 'foo', ['bar'], {}].map(isNaN));
console.log([NaN, 'foo', ['bar'], {}].map(myIsNaN));
```

```
> true true true true
> true false false false
```

Or we can recall "Not a NaN":

```
function myIsNaN(x) {
  return x !== x;
}

console.log([NaN, 'foo', ['bar'], {}].map(isNaN));
console.log([NaN, 'foo', ['bar'], {}].map(myIsNaN));
```

```
> true true true true
> true false false false
```

This works because NaN is the only value in JavaScript for which the equality operator is non-reflexive.

Fortunately, Number.isNaN was added in ES2015:

```
console.log(Number.isNaN(NaN), isNaN(NaN),
  Number.isNaN('hello'), isNaN('hello'),
  Number.isNaN(['hello']), isNaN(['hello']),
  Number.isNaN({}), isNaN({})
);
```

...and it does what we want:

```
> true true false true false true false true
```

But NaN isn't just a JavaScript thing...

NaN is actually defined by the IEEE 754 floating-point standard.

If you understand NaN in one language, you probably understand it in most.

Fun fact about that...

The IEEE 754 spec defines the pow function:

```
pow(0, 0) == 1
pow(Infinity, 0) == 1
pow(1, Infinity) == 1
```

This behavior is inherited from C99 and POSIX 2001.

Most languages follow this.

Most.

Here's what Python does:

```
[0 ** 0, float("inf") ** 0, 1 ** float("inf")]
```

```
› [1 1.0 1.0]
```

And Ruby:

```
[0 ** 0, Float::INFINITY ** 0, 1 ** Float::INFINITY]
```

```
› [1 1.0 1.0]
```

But JavaScript?

```
Math.pow(0, 0);
```

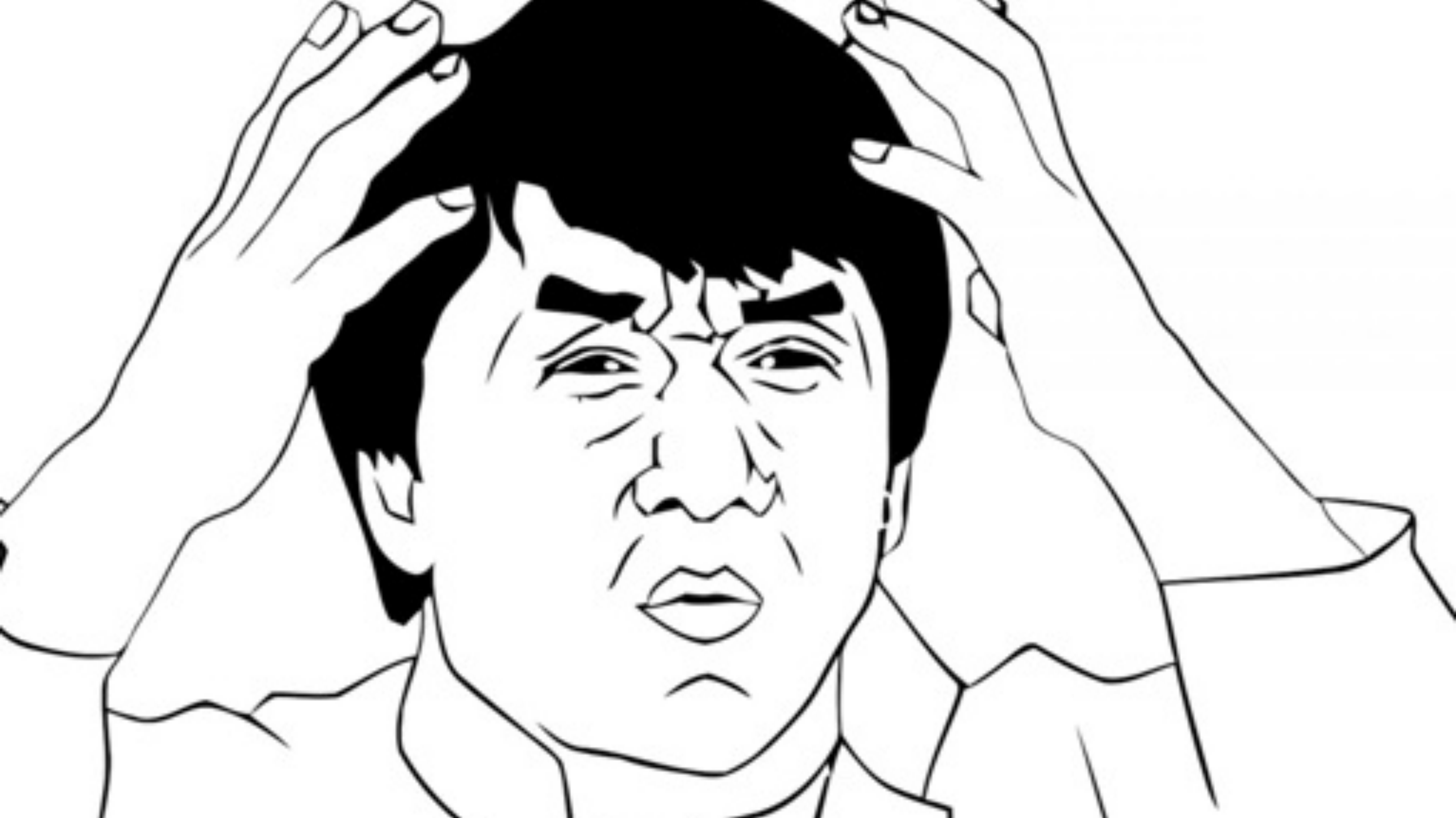
```
Math.pow(0, 0);

> 1
```

```
Math.pow(0, 0);

> 1

Math.pow(Infinity, 0);
```

```
Math.pow(0, 0);

> 1

Math.pow(Infinity, 0);

> 1
```

```
Math.pow(0, 0);

> 1

Math.pow(Infinity, 0);

> 1

Math.pow(1, Infinity);
```

```
Math.pow(0, 0);

> 1

Math.pow(Infinity, 0);

> 1

Math.pow(1, Infinity);

> NaN
```



Why?

15.8.2.13 pow (x, y)

Returns an implementation-dependent approximati

- If *y* is NaN, the result is NaN.
- If *y* is +0, the result is 1, even if *x* is NaN.
- If *y* is –0, the result is 1, even if *x* is NaN.
- If *x* is NaN and *y* is nonzero, the result is NaN.
- If abs(*x*)>1 and *y* is +∞, the result is +∞.
- If abs(*x*)>1 and *y* is –∞, the result is +0.
- If abs(*x*)==1 and *y* is +∞, the result is NaN.
- If abs(*x*)==1 and *y* is –∞, the result is NaN.

12.7.3.4 Applying the ** Operator

- If abs(*base*) is 1 and *exponent* is +∞, the result is **NaN**.
- If abs(*base*) is 1 and *exponent* is -∞, the result is **NaN**.

- ES1 specifies pow: 1997
- C99 specifies pow: 1999
- POSIX specifies pow: 2001
- IEEE 754 inherits pow: 2008

NOTE

The result of *base* ****** *exponent* when *base* is **1** or **-1** and *exponent* is **+Infinity** or **-Infinity** differs from IEEE 754-2008. The first edition of ECMAScript specified a result of **NaN** for this operation, whereas later versions of IEEE 754-2008 specified **1**. The historical ECMAScript behaviour is preserved for compatibility reasons.

So just like every other question about JavaScript, the answer is...

Backwards compatibility

So anyway, what does IEEE 754 say about how we represent NaN?

Bit representation of a float32 value:

- 1-bit sign
- 8-bit exponent, offset by `127`
- 23-bit significand
- `(-1) ^ s * 2 ^ (exp - 127) * 1.significand`

Note: the significand is actually 24 bits, but only 23 are explicitly stored.

Example float32 value:

0 10000000 01000000000000000000000

➔ (-1) ^ 0 = 1

➔ 2 ^ (10000000b - 127) = 2

➔ 1.01b = 1.25

➔ 1 * 2 * 1.25 = 2.5

Bit representations of special values:

```
0 11111111 00000000000000000000000 -> Infinity
1 11111111 00000000000000000000000 -> -Infinity
0 11111111 10000000000000000000000 -> NaN
```

NaN values have a maximized exponent and a nonzero significand.

So these are also all NaN:

```
1 11111111 10000000000000000000000 -> NaN (quiet, negative)
0 11111111 10000000000000000000001 -> NaN (quiet, but different)
0 11111111 00000000000000000000001 -> NaN (signaling)
0 11111111 00000000000000000000010 -> NaN (signaling, but different)
0 11111111 00000000000000000000011 -> NaN (we can start counting!)
```

So these are also all NaN:

```
1 11111111 10000000000000000000000 -> NaN (quiet, negative)
0 11111111 10000000000000000000001 -> NaN (quiet, but different)
0 11111111 00000000000000000000001 -> NaN (signaling)
0 11111111 00000000000000000000010 -> NaN (signaling, but different)
0 11111111 00000000000000000000011 -> NaN (we can start counting!)
```

How many NaNs are there, really?

$2^{24} - 2 = 16777214$

And that's just with a float32!

What about a double64?

2^52 - 2 =

4503599627370494

That's 4.5 * 10^15, or 4.5 quadrillion.

4.5 petabytes is about 10,000 years worth of music.

If there are so many different possible NaNs, then it only seems reasonable...

...that one NaN is unlikely to be the same as another NaN!

Thus, NaN !== NaN.

Some Related Links

- http://ariya.ofilabs.com/2014/05/the-curious-case-of-javascript-nan.html
- http://www.2ality.com/2012/02/nan-infinity.html
- https://en.wikipedia.org/wiki/NaN

Who are you and where can I find the slides?

- I'm Lewis J Ellis: @lewisjellis on Twitter and GitHub
- My website is LewisJEllis.com.
- Slides available at GitHub.com/LewisJEllis/nantalk