Language Composition

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Talk aims

1. The programming language status quo limits us.

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2. Language composition might offer a way forward.

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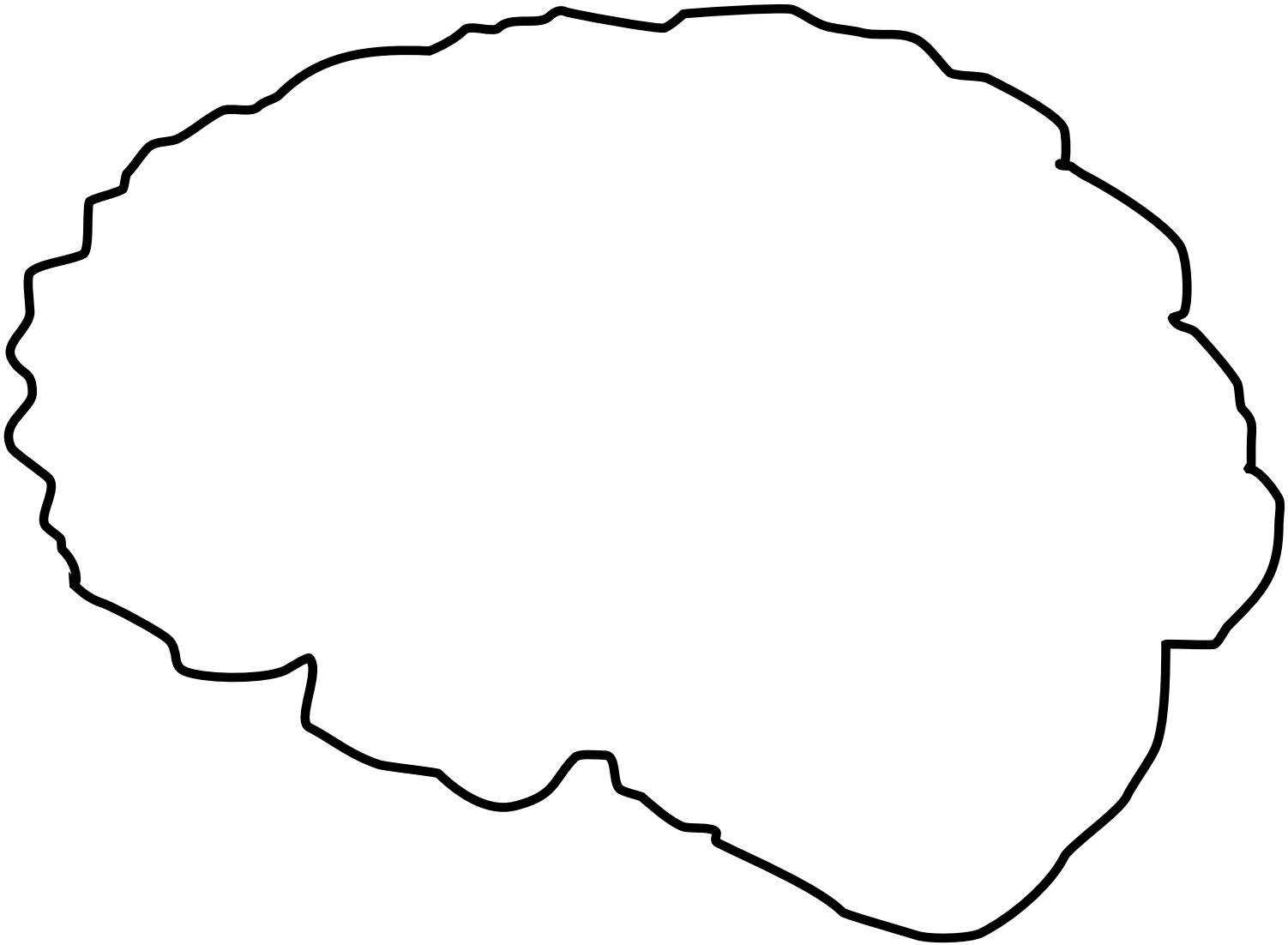
Talk aims

1. The programming language status quo limits us.
2. Language composition might offer a way forward.
3. We're not very good at it yet.
4. Possible future routes.

What's the problem with the status quo?

Languages conceptual size



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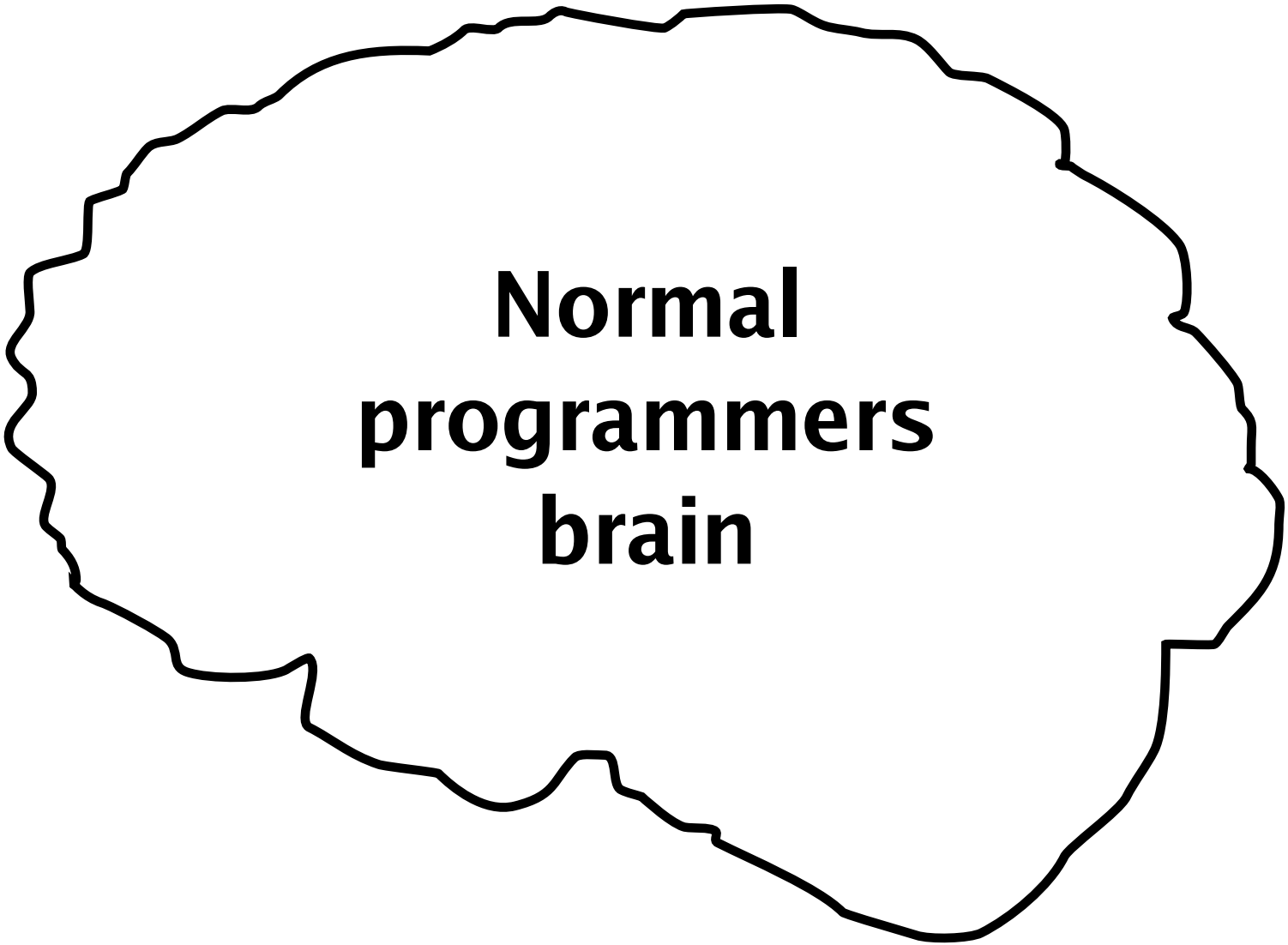

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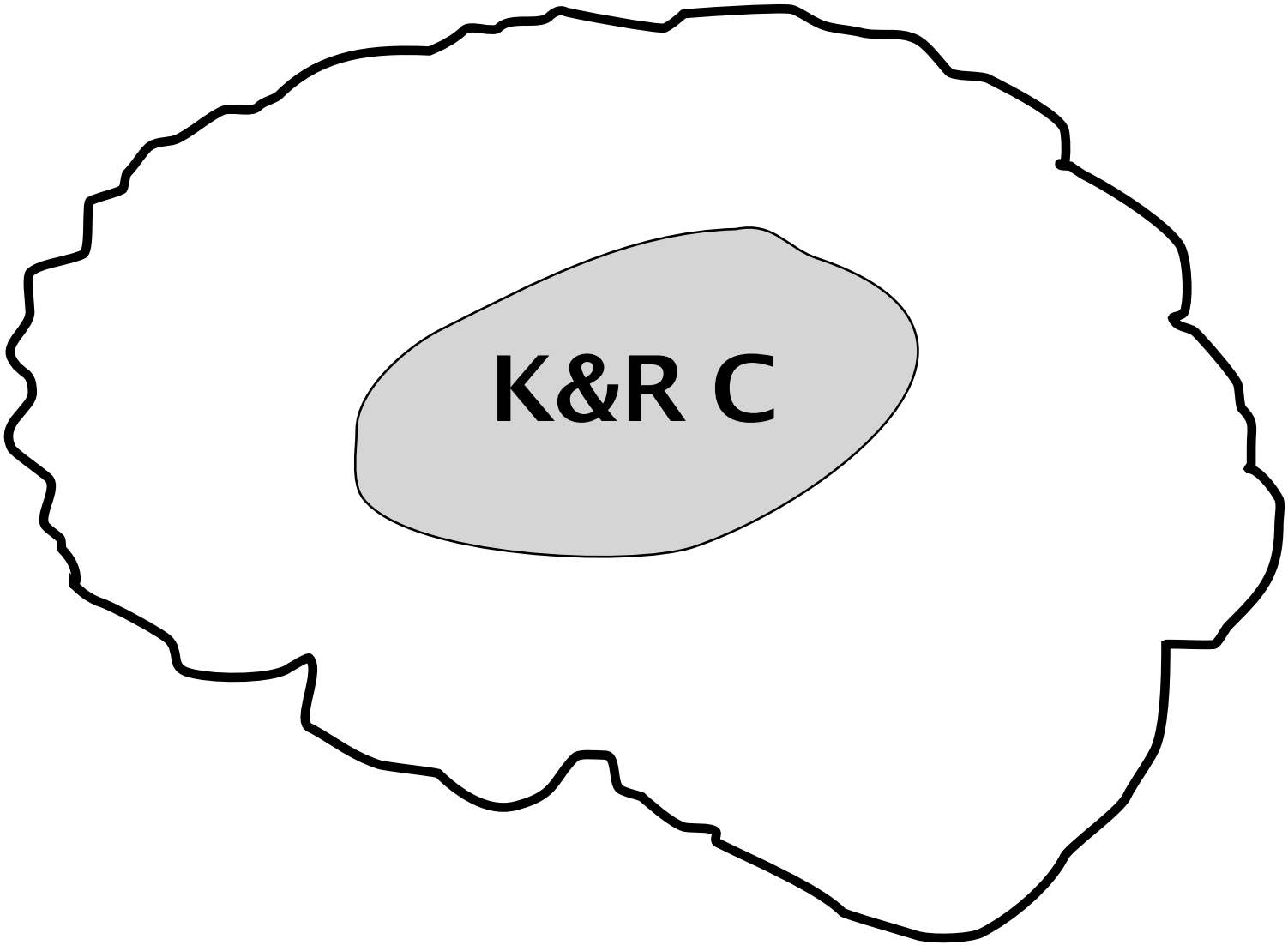

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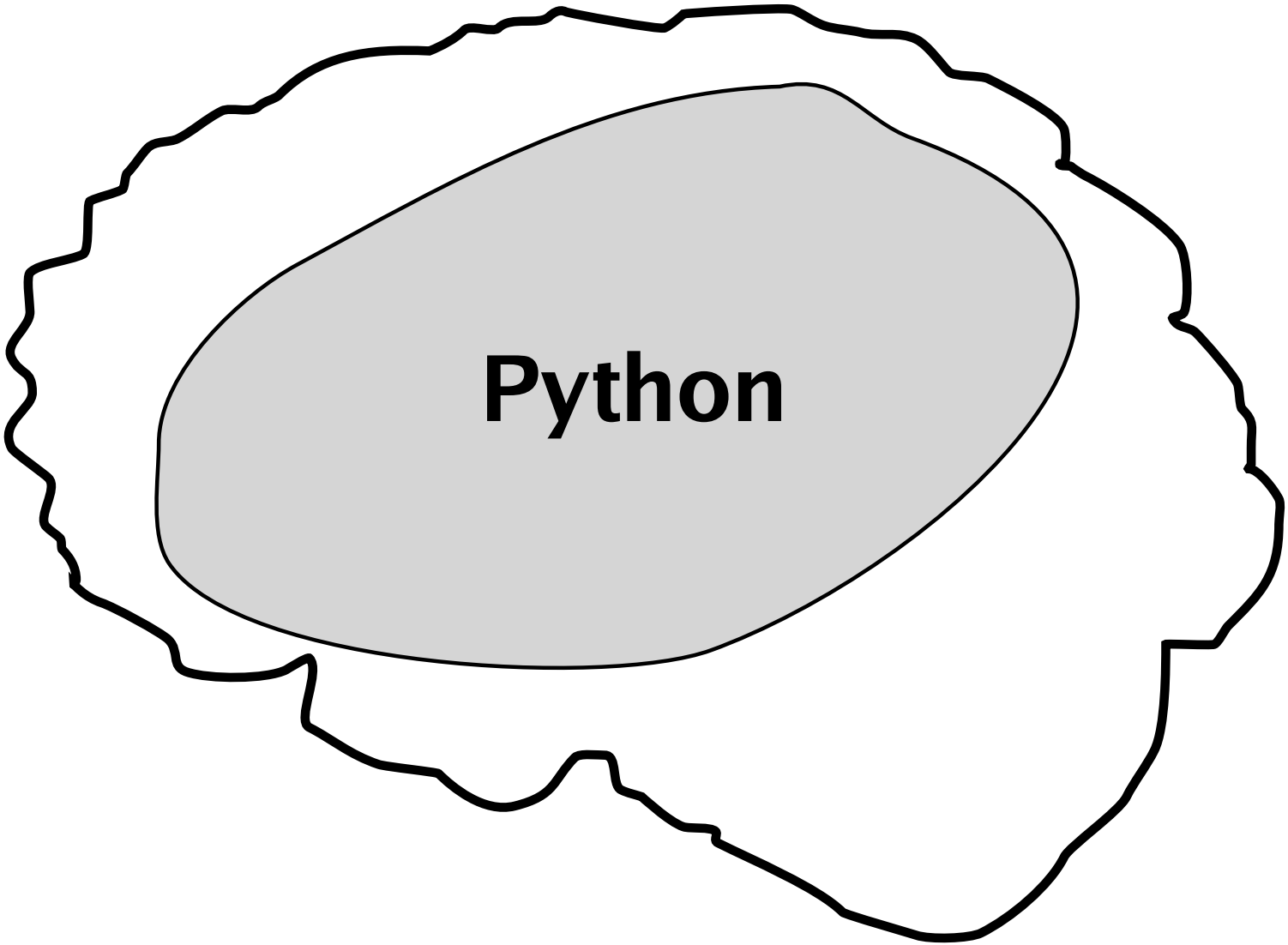

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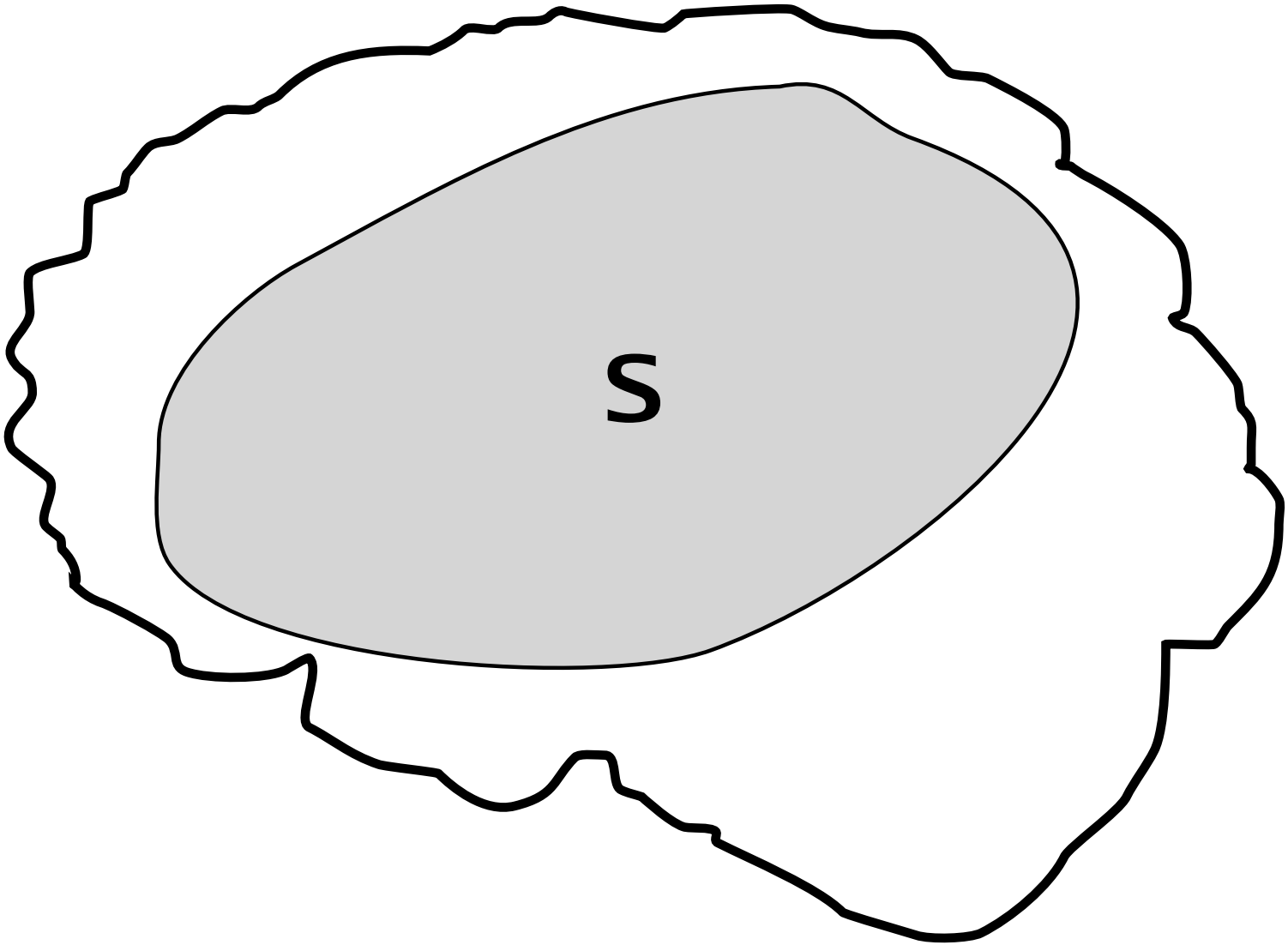
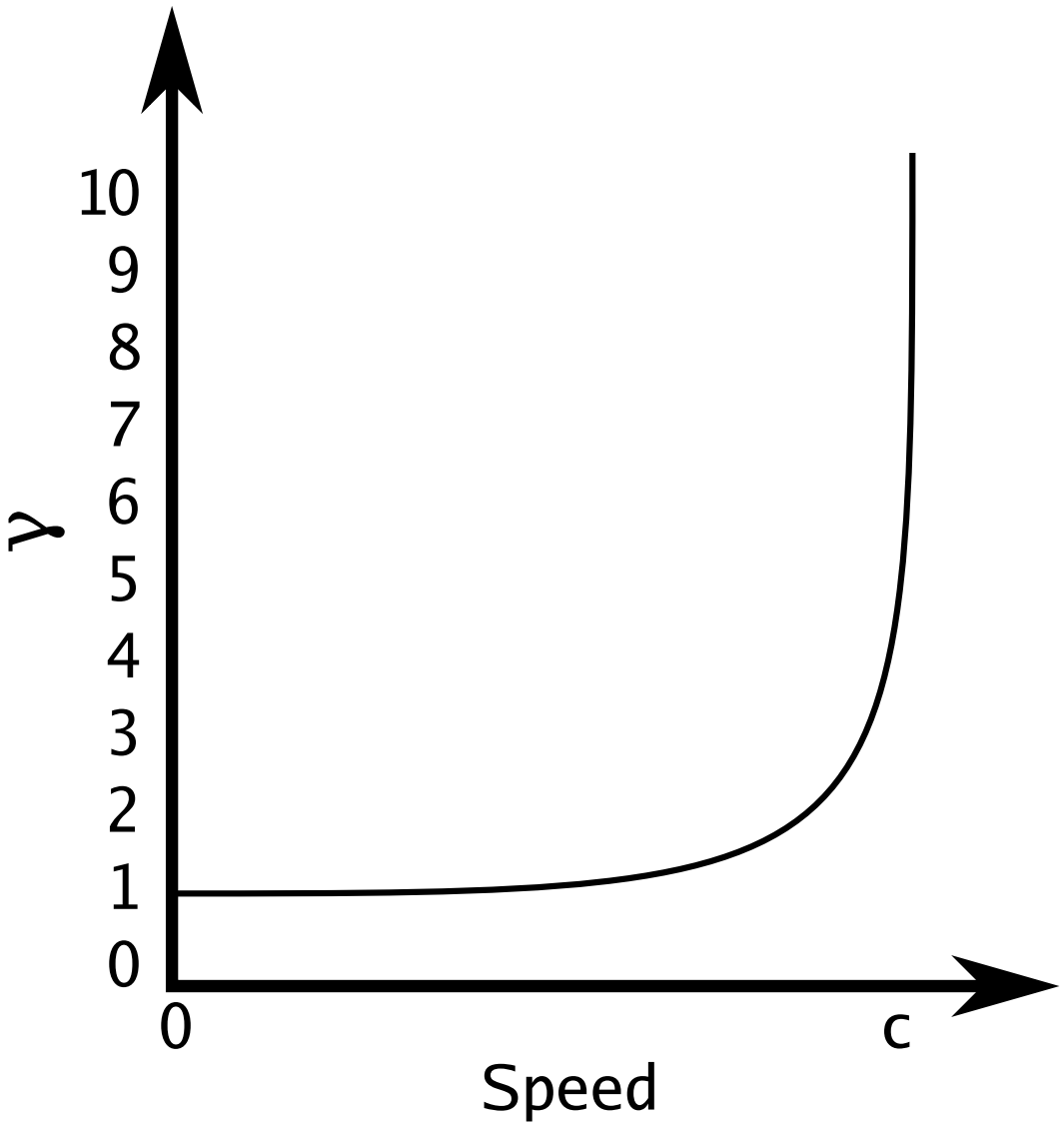


Programming languages' speed of light



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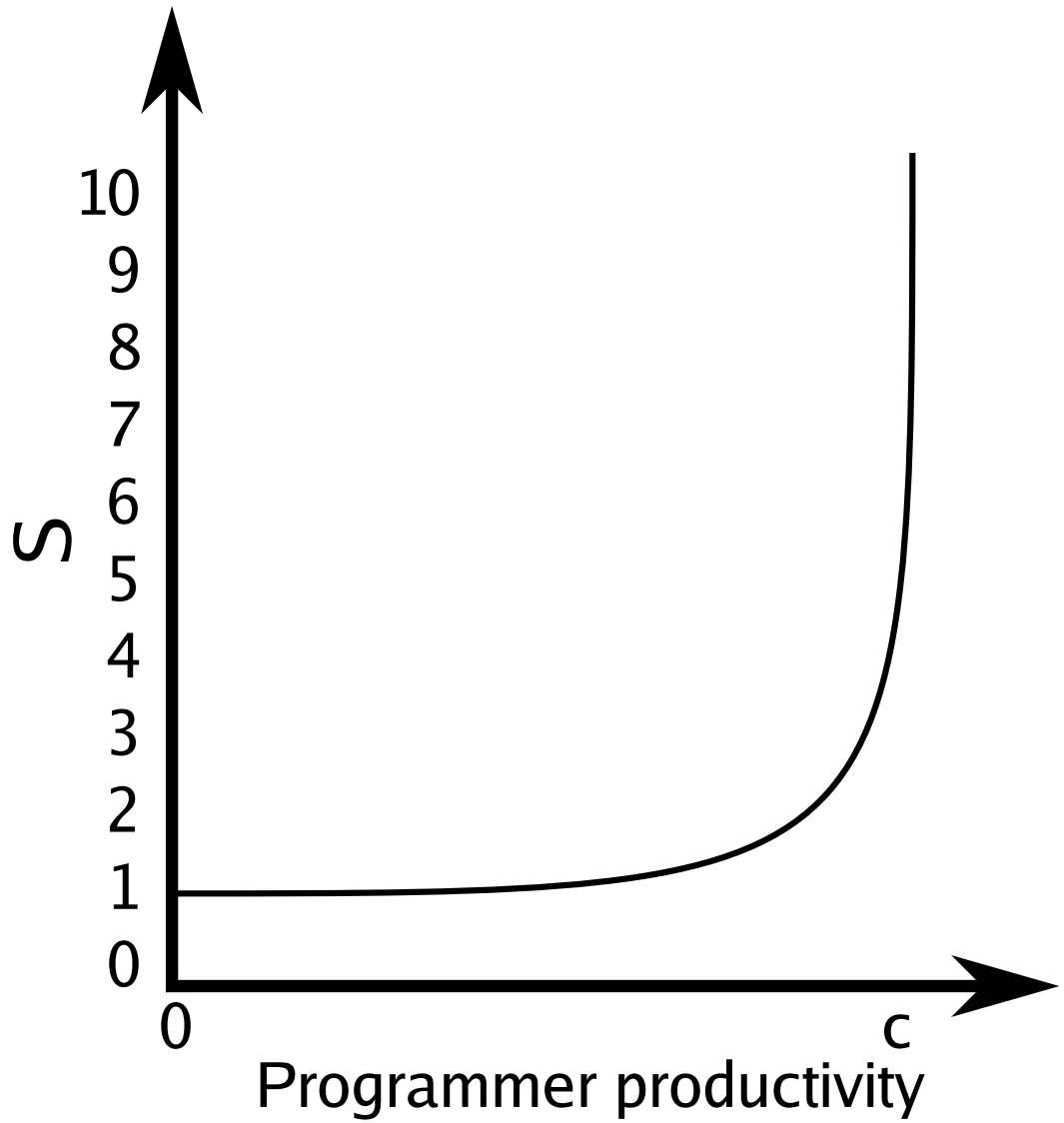

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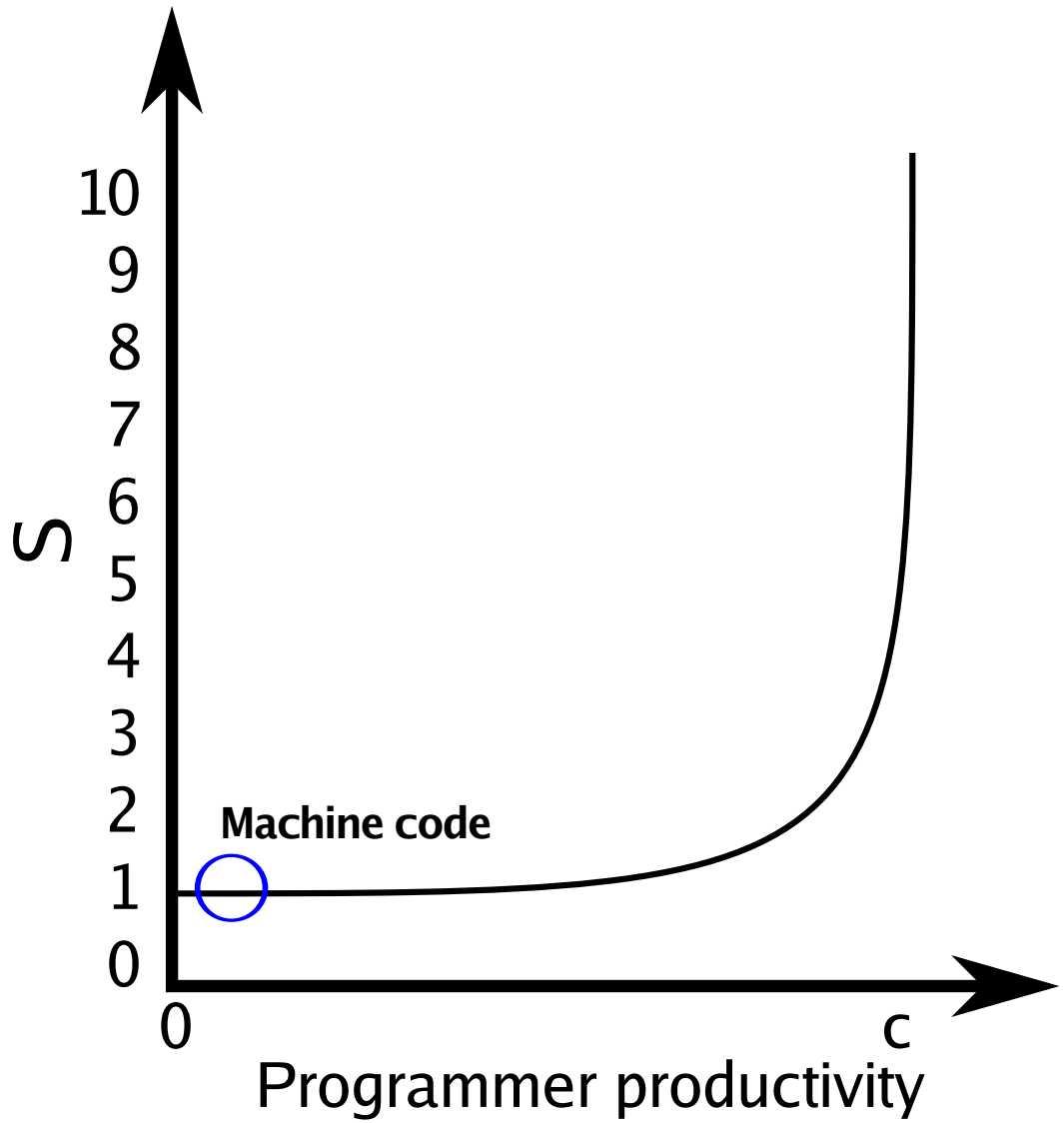

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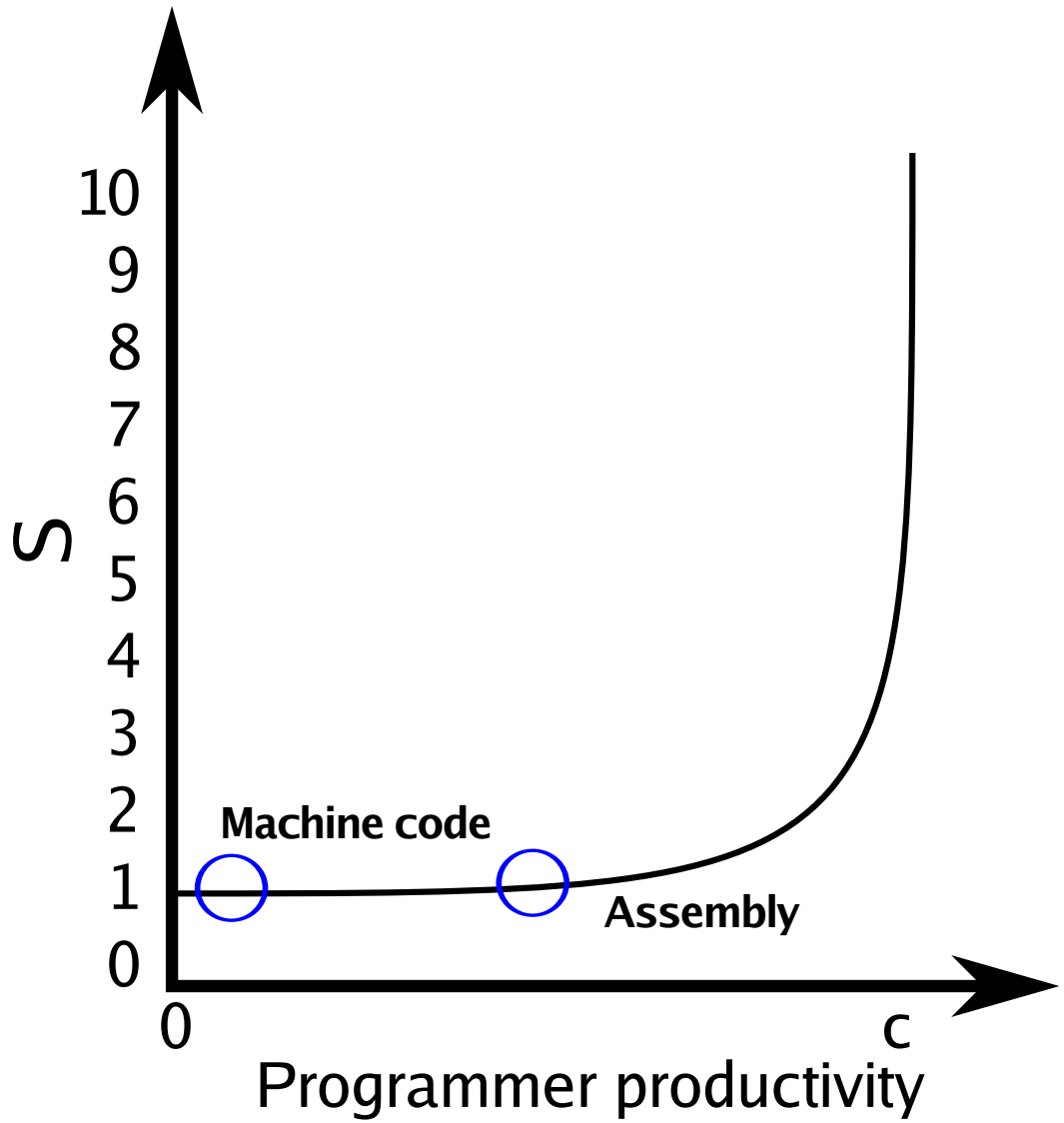

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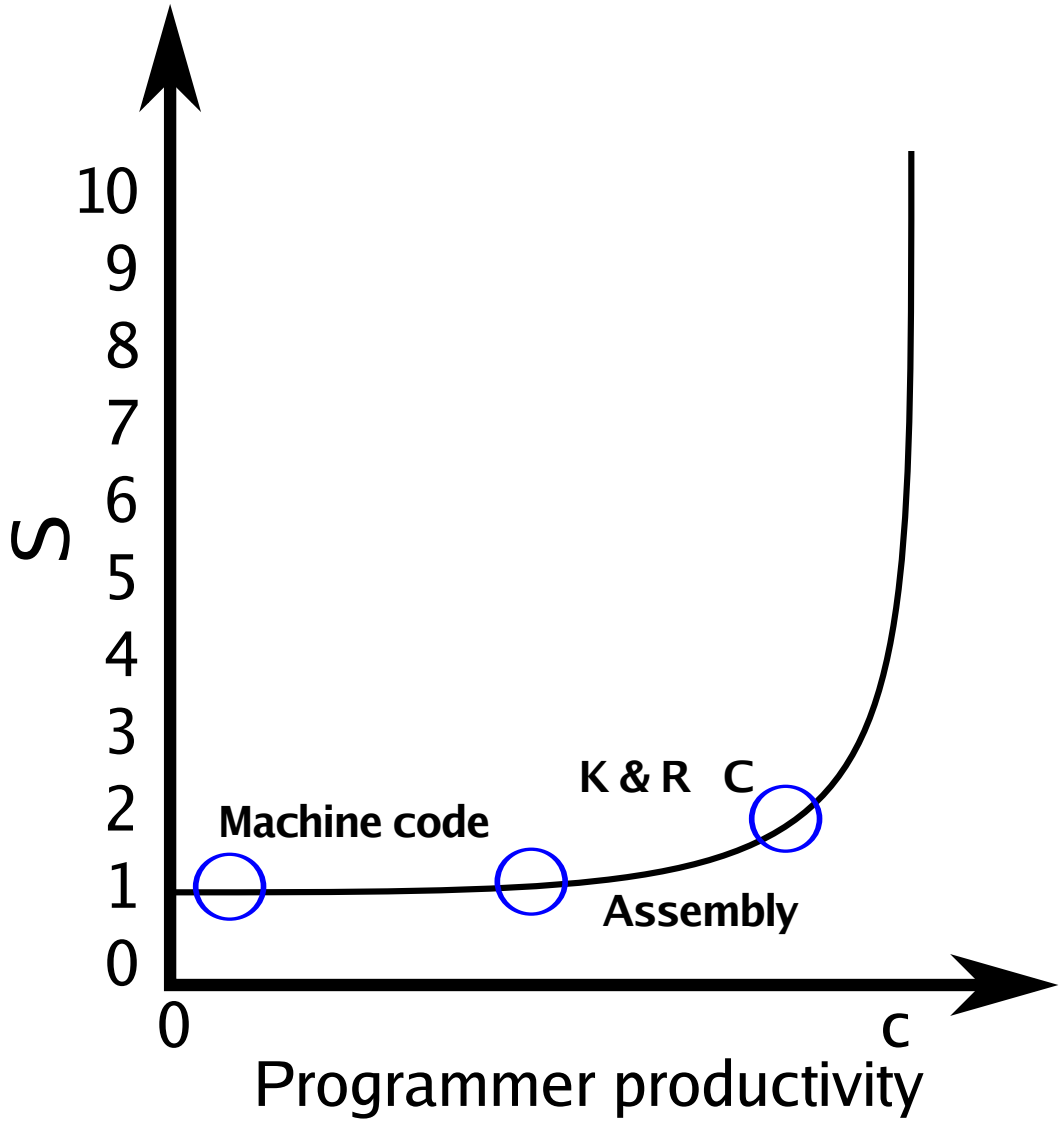

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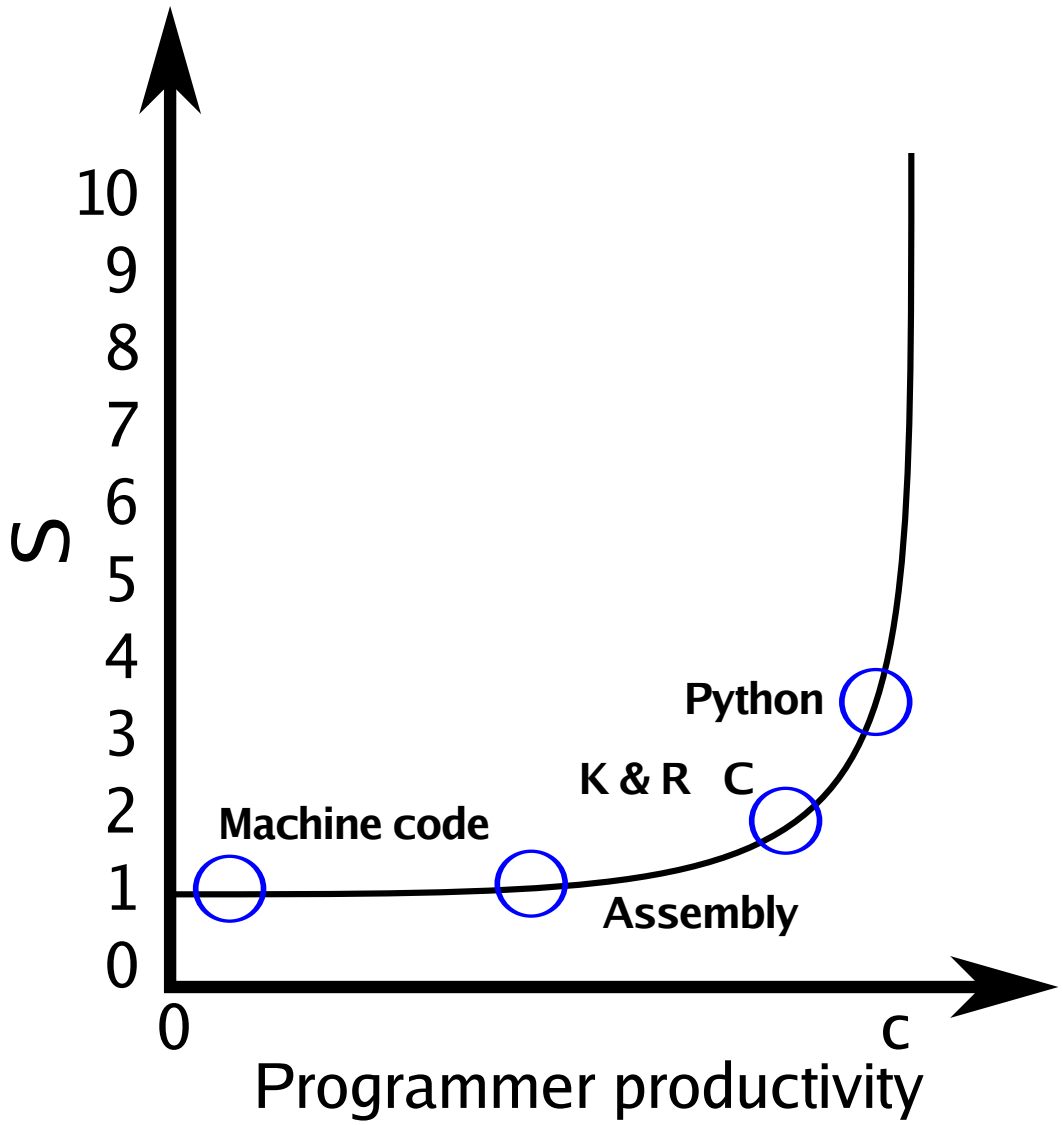

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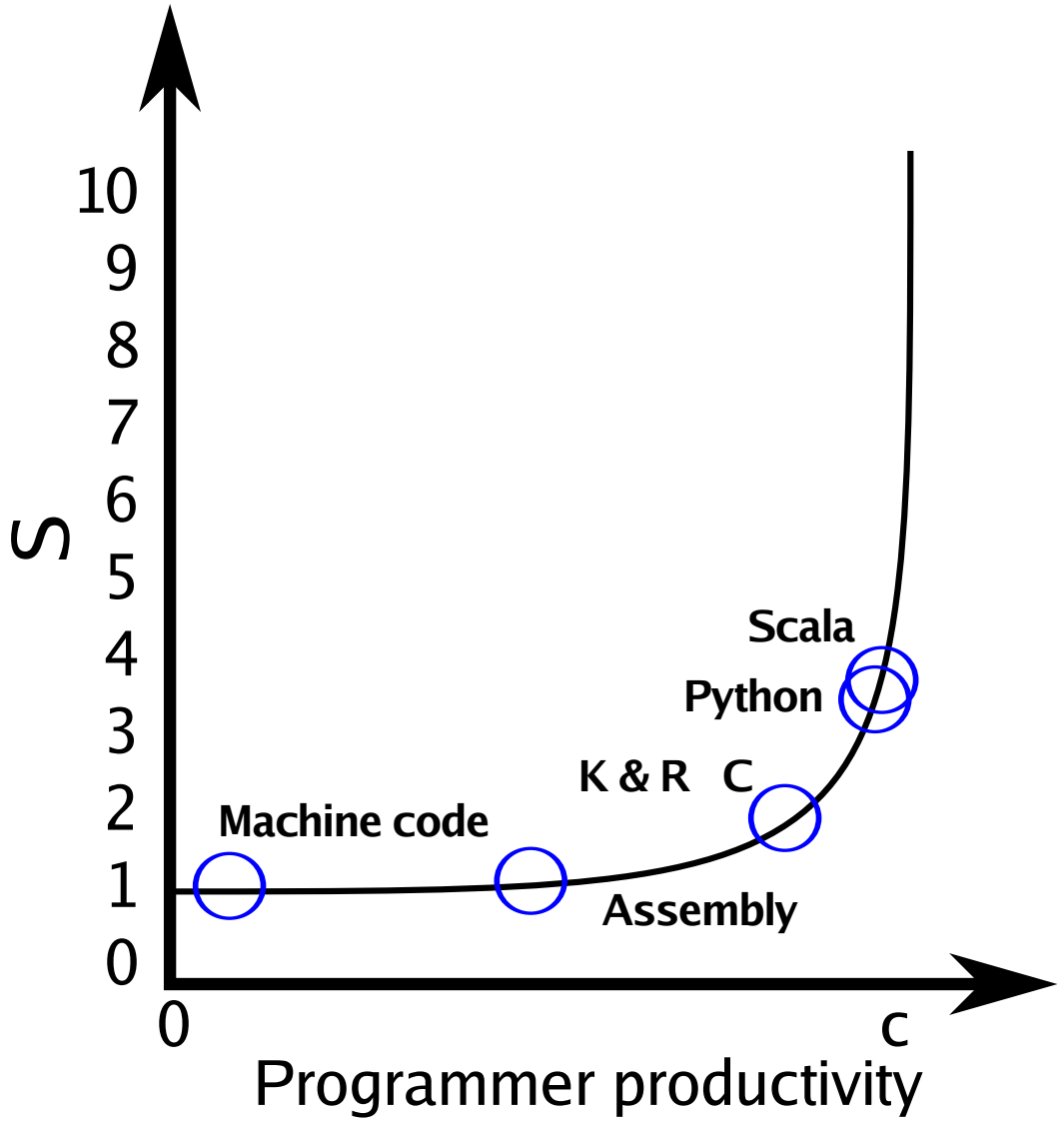

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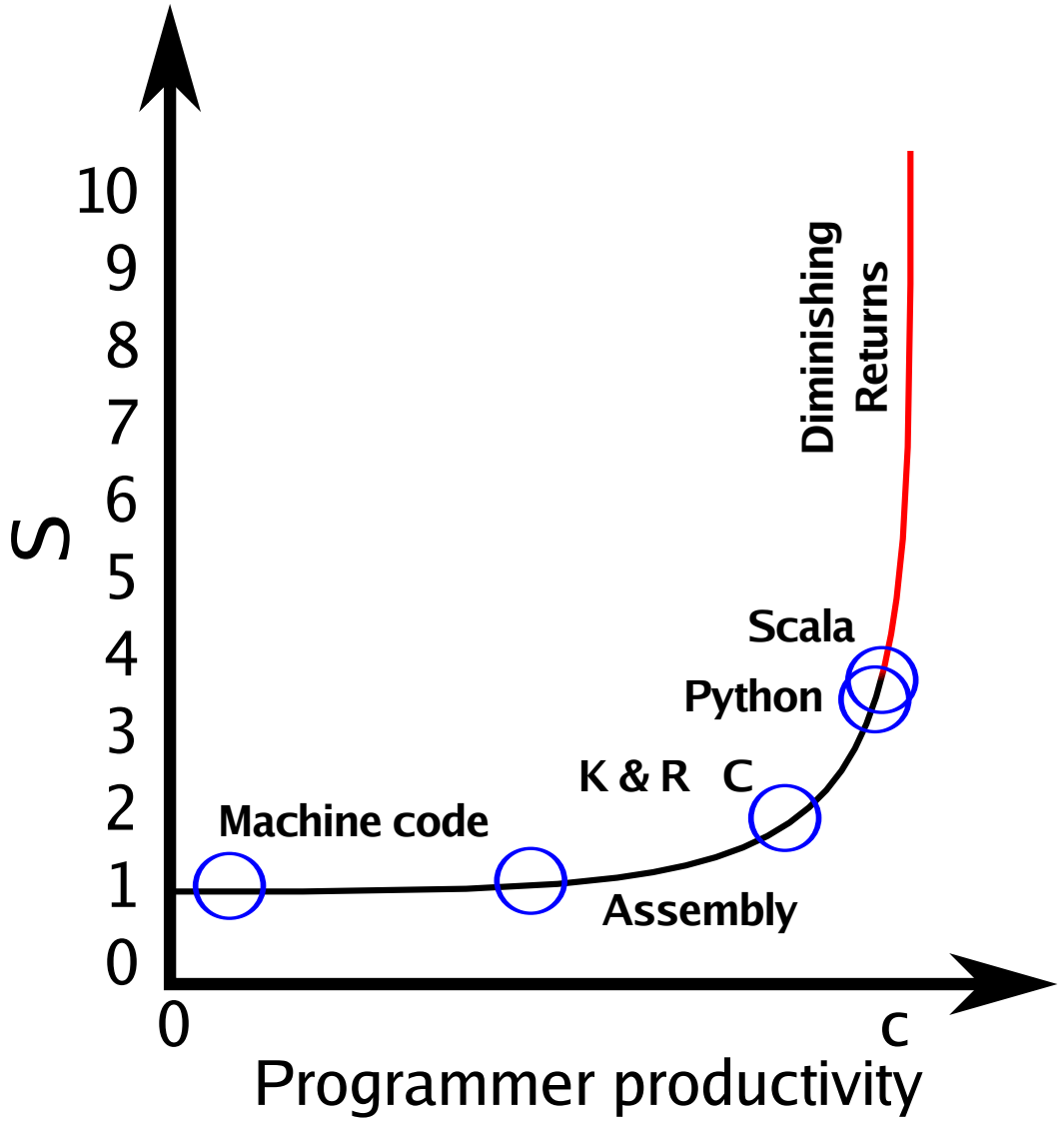
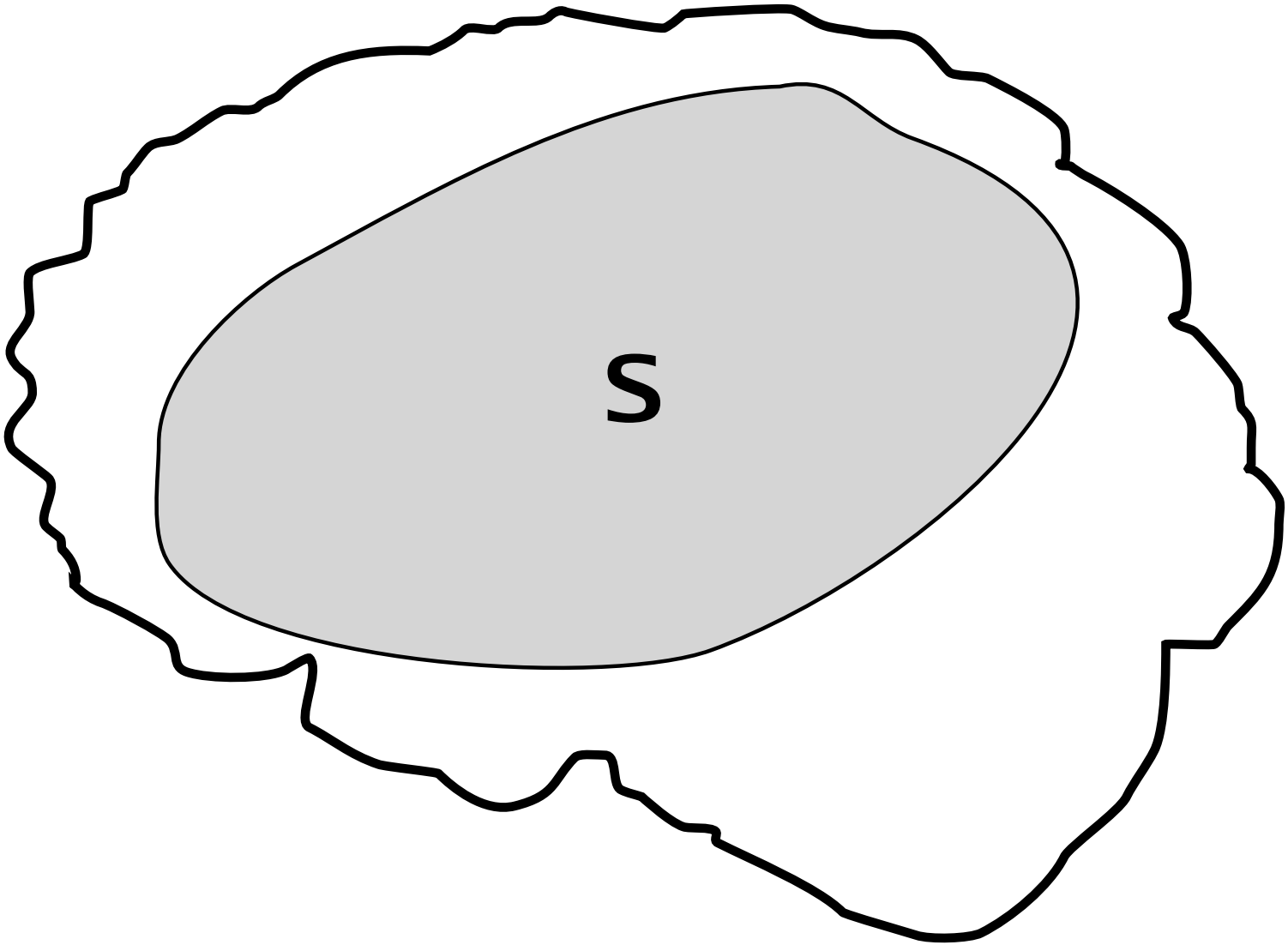


Can S become too big?



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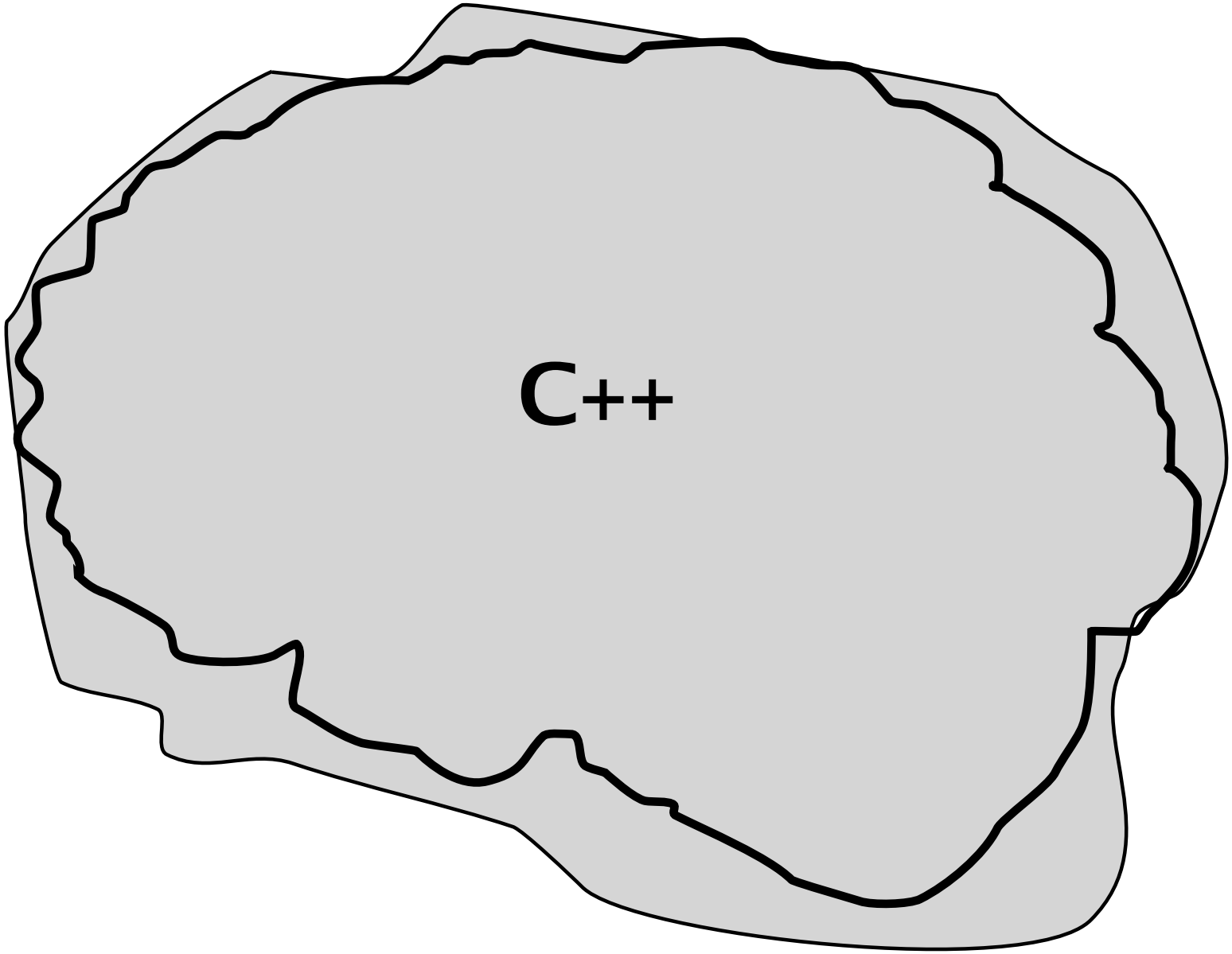
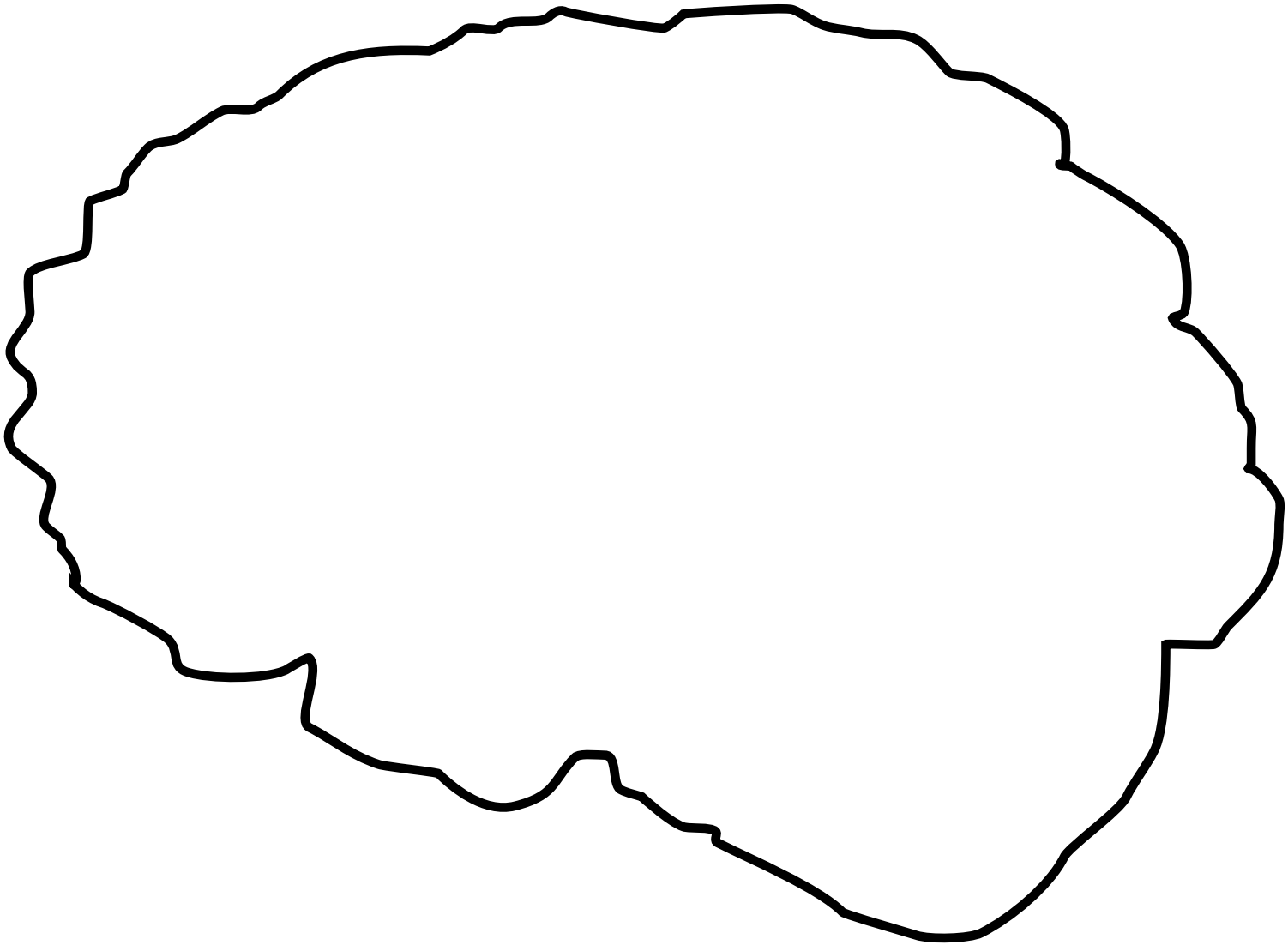


Wiggle room



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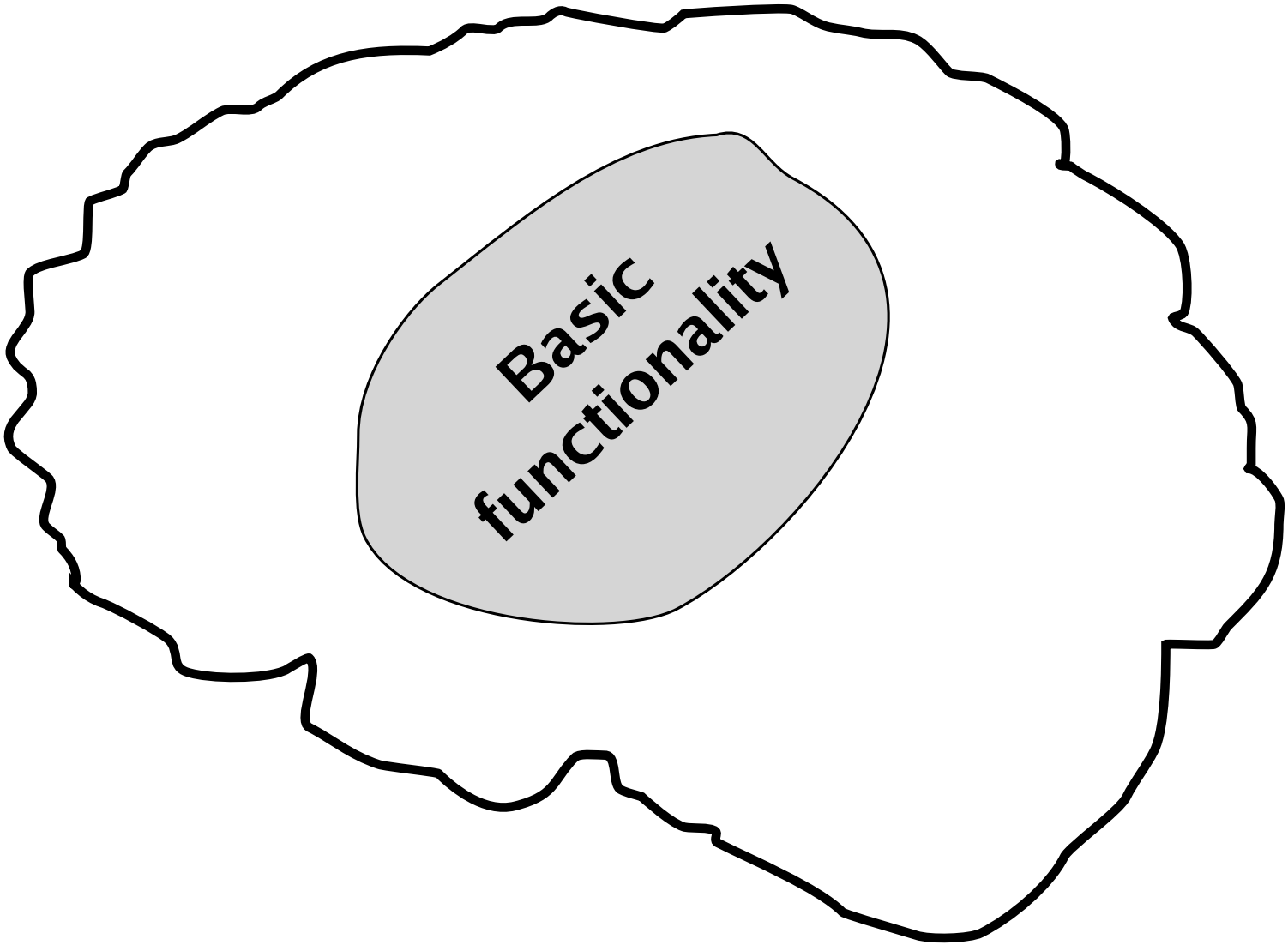

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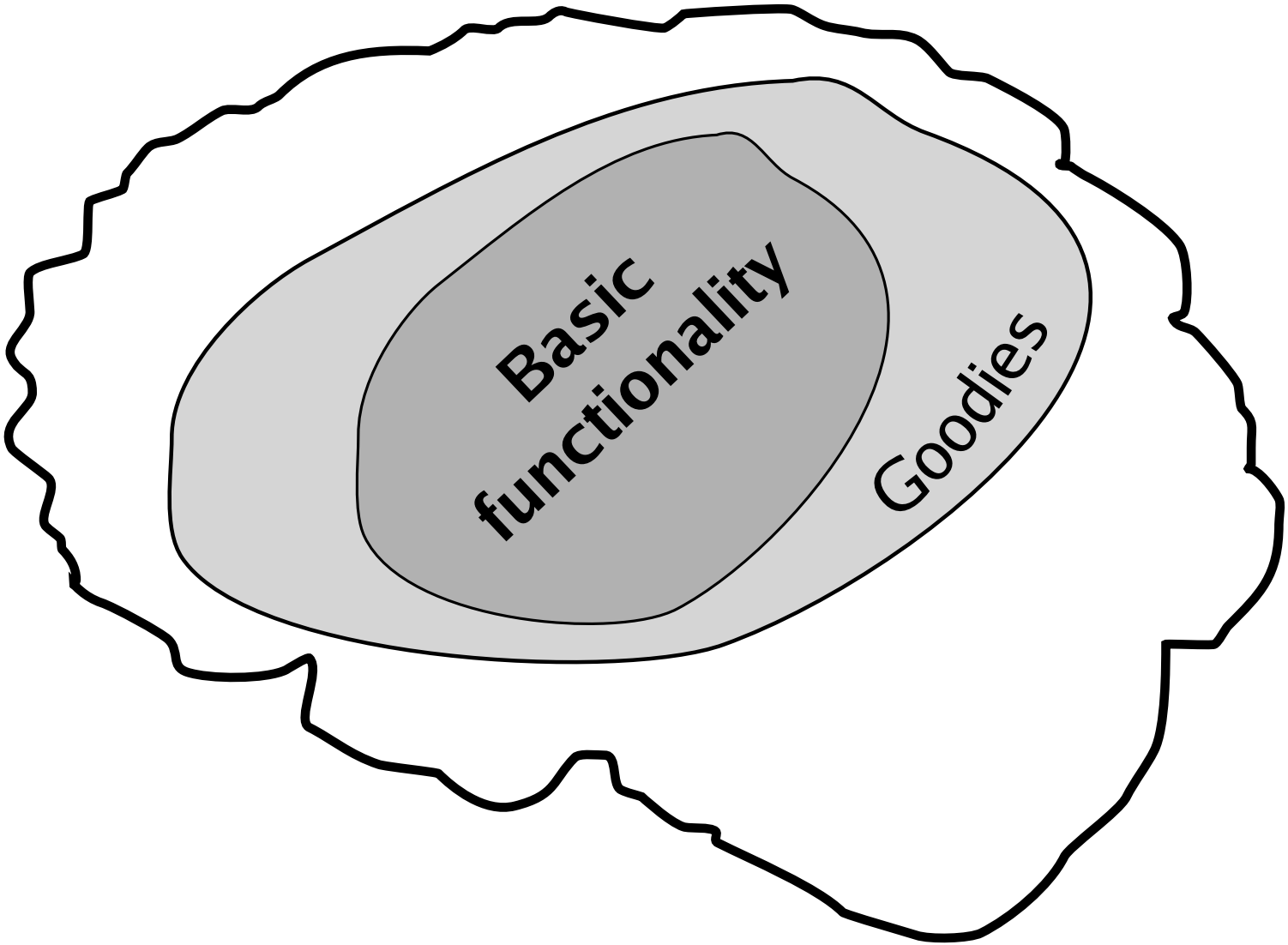
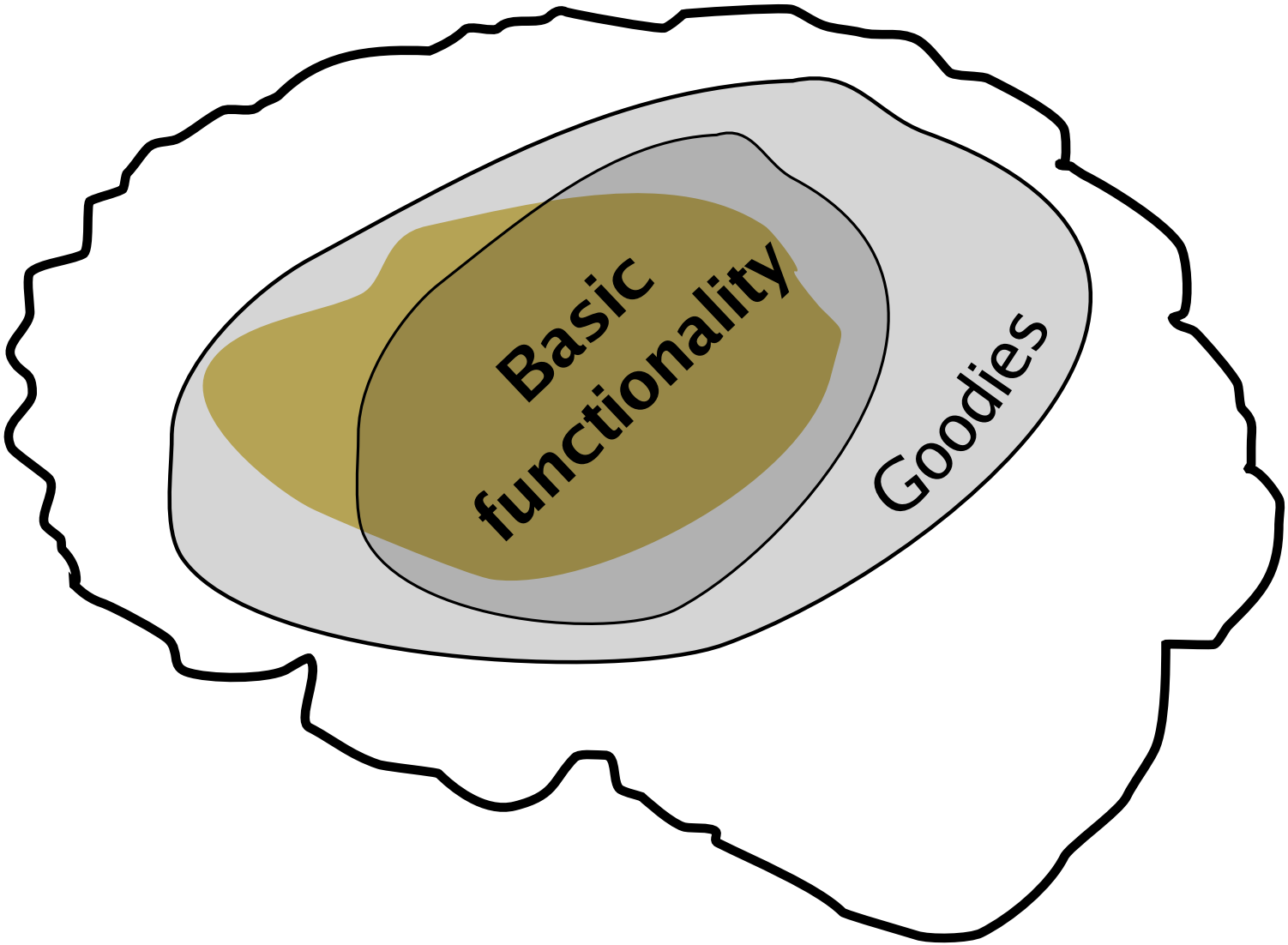


Even worse



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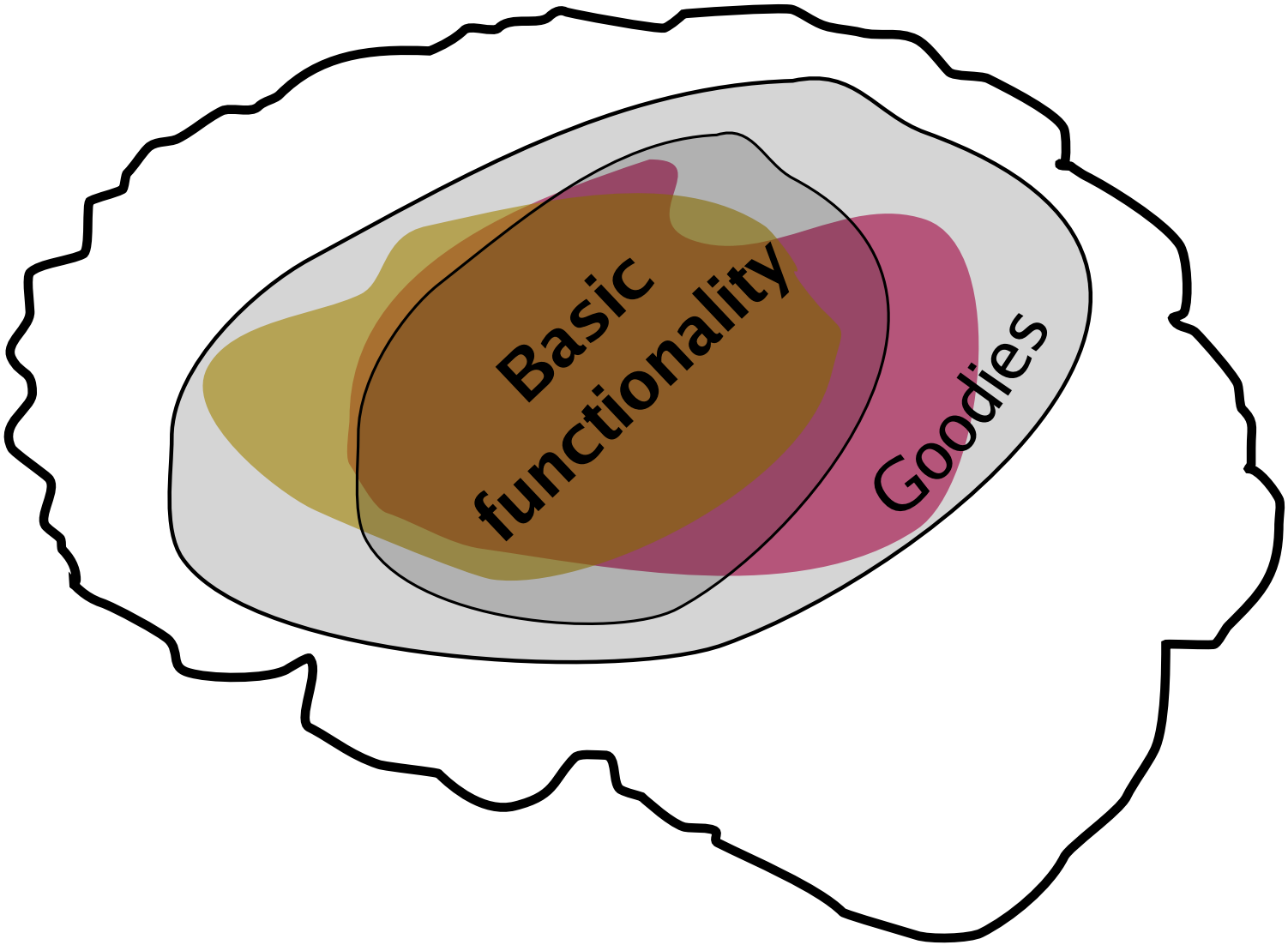

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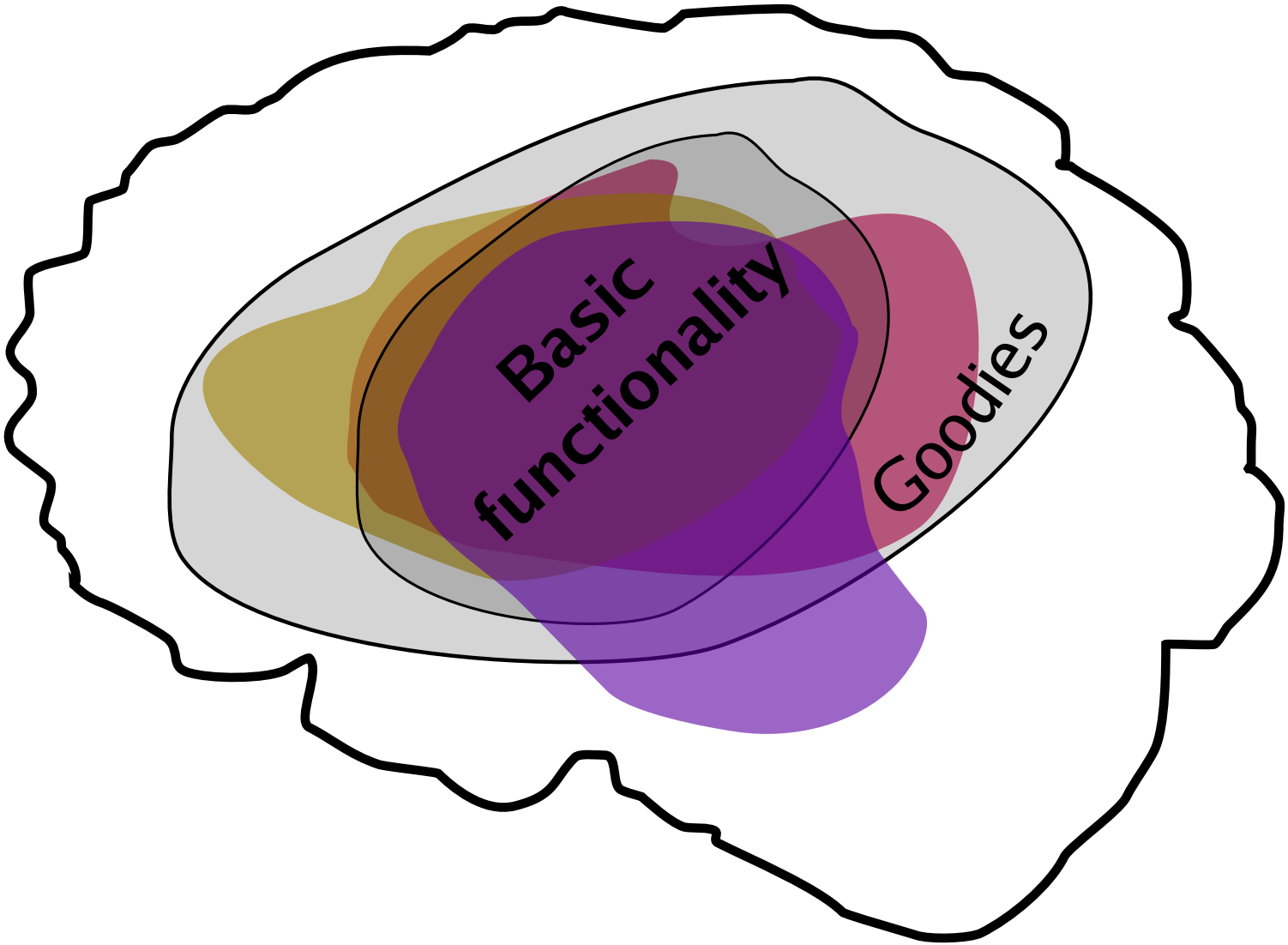

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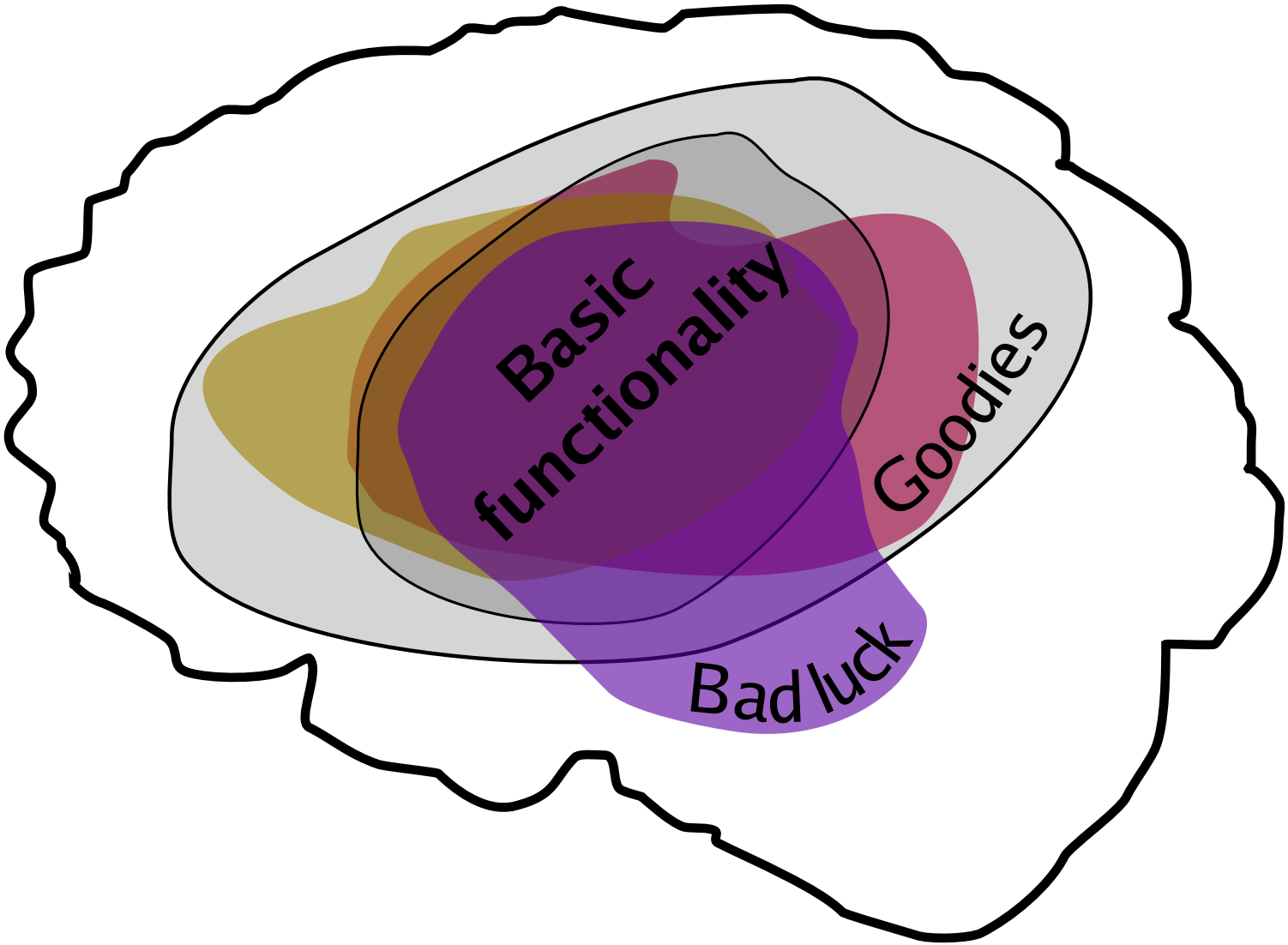
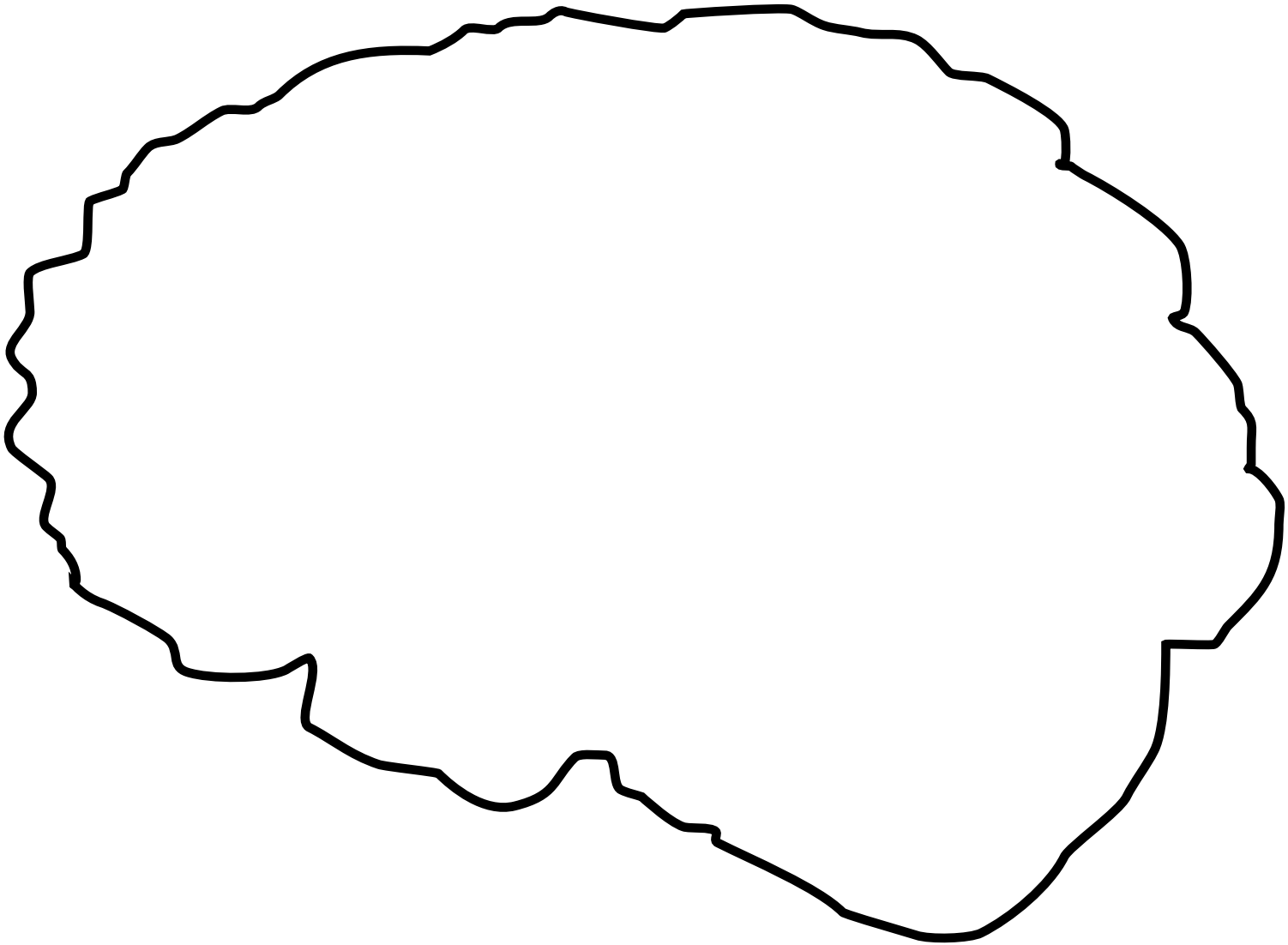


Is this about DSLs?



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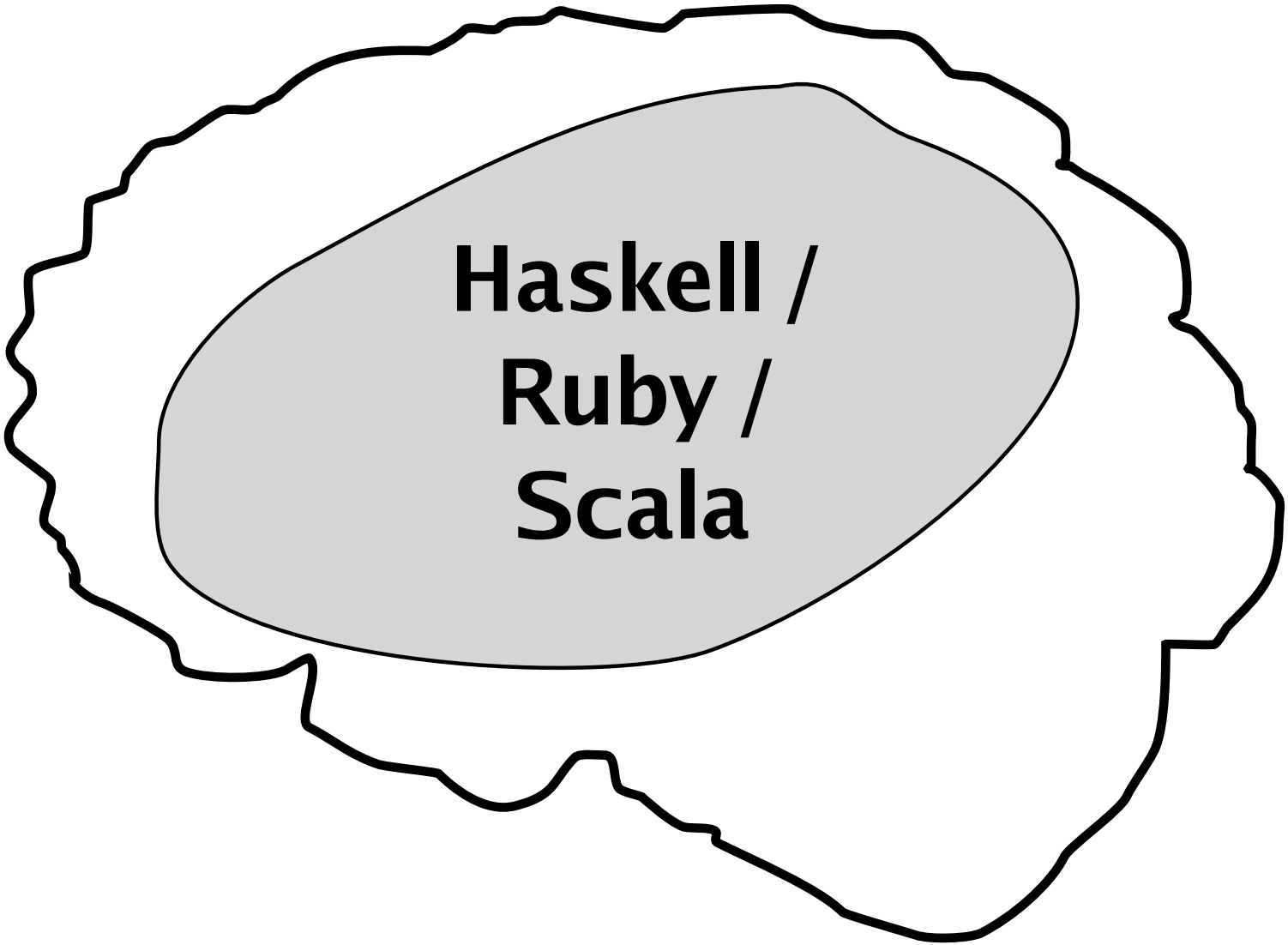

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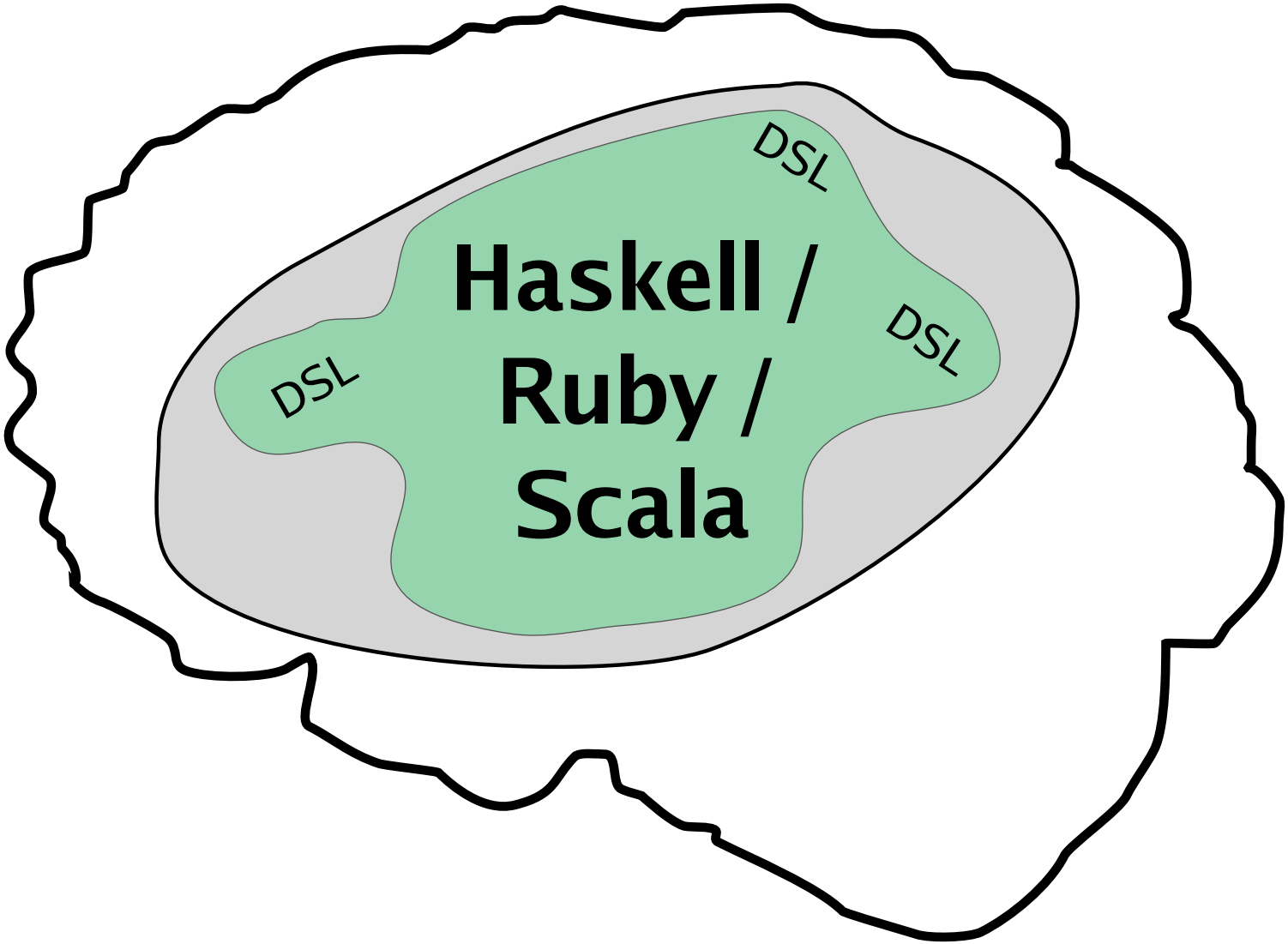

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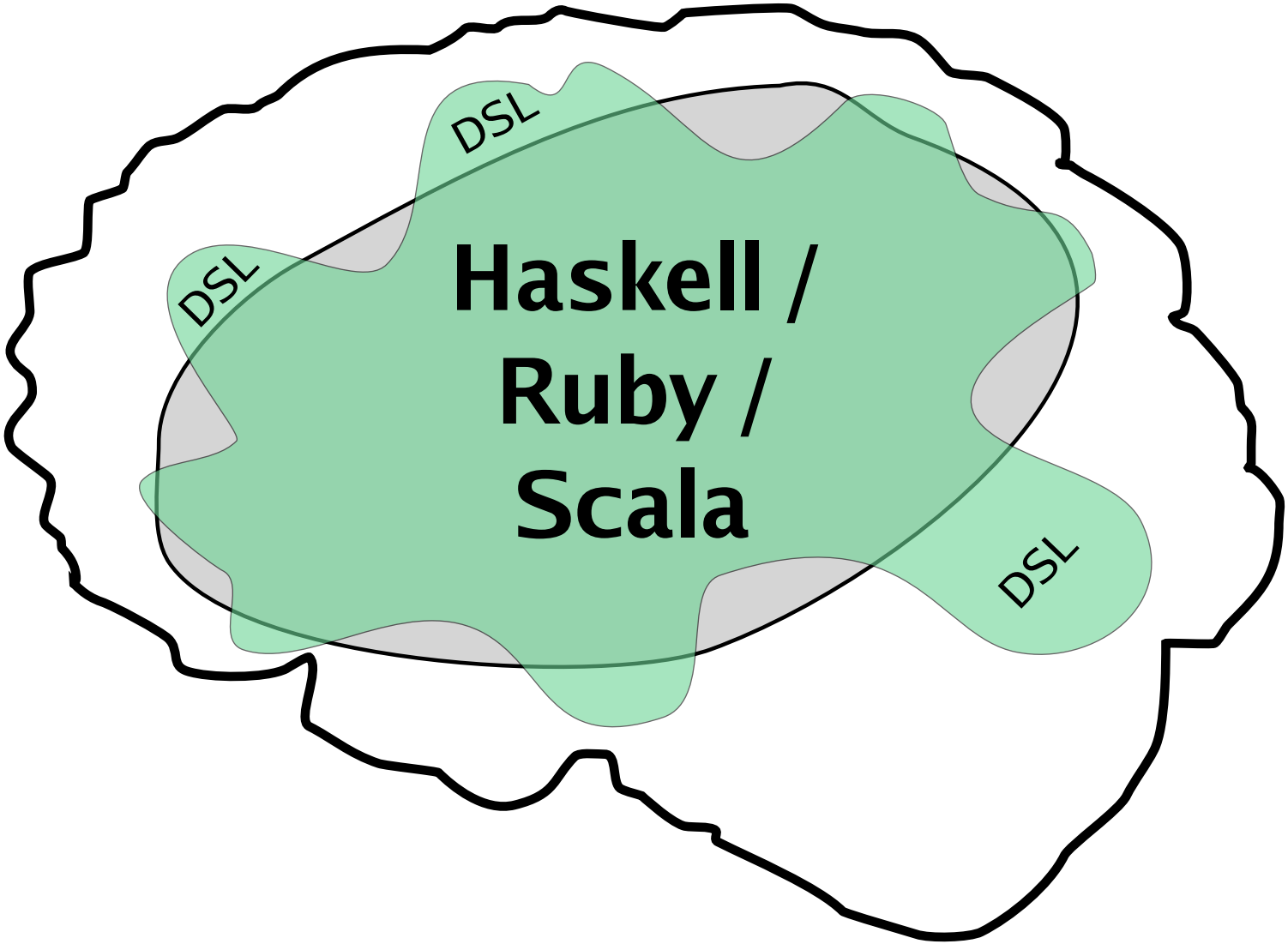

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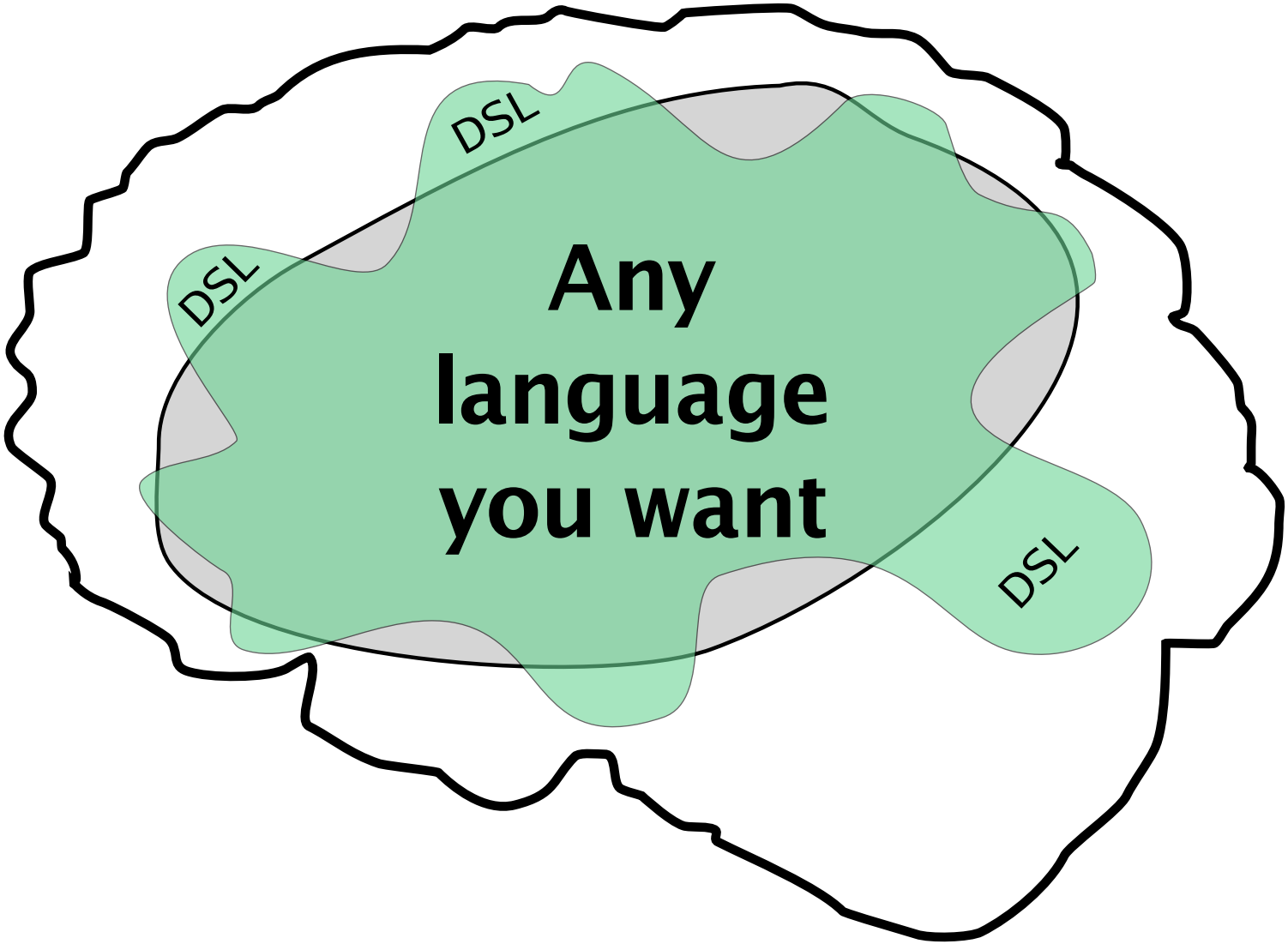

A way forward?

Idea: allow users to *compose* languages.

What does composition mean?

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$$\text{Language} \triangleq$$
$$\text{syntax} + \text{semantics}$$

What does composition mean?

$$\text{Language implementation} \triangleq \text{compiler} + \text{runtime}$$

What does composition mean?

$$\text{Language implementation} \triangleq \text{compiler} + \text{virtual machine}$$

What does composition mean?

$$\text{Compiler} \triangleq$$
$$\text{parser} + \text{code generator}$$

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$$\text{Compiler} \triangleq$$
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What does composition mean?

Compose:

- parsers
- virtual machines

Example (1)

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SQL and Java

```
for (pid : SELECT pid FROM personnel WHERE salary > 100000) {
   if (!is_worth_it(pid))
     UPDATE personnel SET salary=0 WHERE pid=pid;
}
```

Example (2)

Example (2)

Tax code

```
income tax {
  2010-2011 {
    allowance {
      age < 65: £6,475
      age >= 65 and age <= 74: £9,490
      age > 74: £9,640

      reduction: if income > £100,000 then
        max(0, allowance - ((income - £100,000) / 2))
    }
  }
}
```

Part III

Why aren't we (me?) very good at it yet?

Converge

Converge

$$\text{Converge} \triangleq \text{Python} + \text{macros}$$

Converge

$$\text{Converge} \triangleq \text{Python} + \text{compile-time meta-programming}$$

Compile-time meta-programming

Code (as trees, not text) is programmatically generated.

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Expression	`2 + 3`	evaluates to `5`.
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Quasi-quote	`[| 2 + 3 |]`	evaluates to a *hygienic* AST representing `2 + 3`.
Insertion	`[| 2 + ${x} |]`	'inserts' the AST `x` into the AST being created by the quasi-quotes.

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DSL Block	`$«x»: ...`	passes the text '...' to the function `x` at compile-time.

An example

Where it falls apart

- Parser composition: a mess.

Where it falls apart

- Parser composition: a mess.
- Extension languages second-class citizens.

Parsing composition

Should be easy

Parsing composition

- **LR**
- **Earley**
- **PEG**

Parsing composition

- **LR** composition undefined (in general).
- **Earley**
- **PEG**

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Parsing composition

- **LR** composition undefined (in general).
- **Earley** composition ambiguous (in general).
- **PEG** composition can shadow (in general).

Where it falls apart (2)

- Parser composition: a mess.
- Extension languages second-class citizens.

Where it falls apart (2)

- Parser composition: a mess.
- Extension languages second-class citizens.
- Text only.

Example (3)

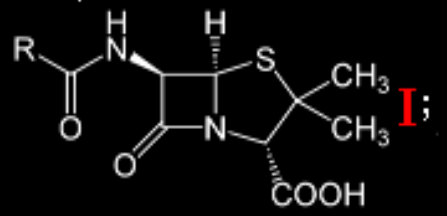
Example (3)

example.fnd - /home/ltratt/

File Edit Search Preferences Shell Macro Windows Help

/home/ltratt/example.fnd L: 24

```
func custom_prescription(Patient p) : Medicine
{
    if (p.penicillin_allergy())
        return NULL;

    Medicine m =  

;

    candidate = generate(P, m);
    if (!check_with_doctor(candidate))
        return NULL;
    m.set_variable(R, candidate);

    return m;
}
```

Example (4)

example.fnd - /home/ltratt/

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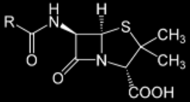
/home/ltratt/example.fnd L:224

```
func check_all_suitabile(trial_id):
  for patient_id in SELECT pid FROM trial WHERE id=${trial_id}:
    if | SELECT * FROM prescribed                            | > 0:
       | WHERE contains(drug,
```




```
                                                          )|
      warn("Patient ${patient_id} currently prescribed a "
        "penicillin derived anti-biotic and must be "
        "seen by a specialist before trial begins.")
```

What are our options?

Abandon parsing...

Parsing

Abandon parsing...

...for SDE?

Example

Boil down to the JVM

VM composition

~~Boil down to the JVM~~

Meta-tracing to the rescue

Put it together

Compose:

- parsers
- virtual machines

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- parsers *Incremental parsing*
- virtual machines

Put it together

Compose:

- parsers *Incremental parsing*
- virtual machines *Meta-tracing*

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Summary

- The status quo needn't be so.
- Language composition might offer a way forward.
- We're not very good at it yet.
- Incremental parsing and meta-tracing *might* save us.

Further reading

- *Parsing: the solved problem that isn't*, Tratt
- Converge: http://convergepl.org/

Thank you for listening