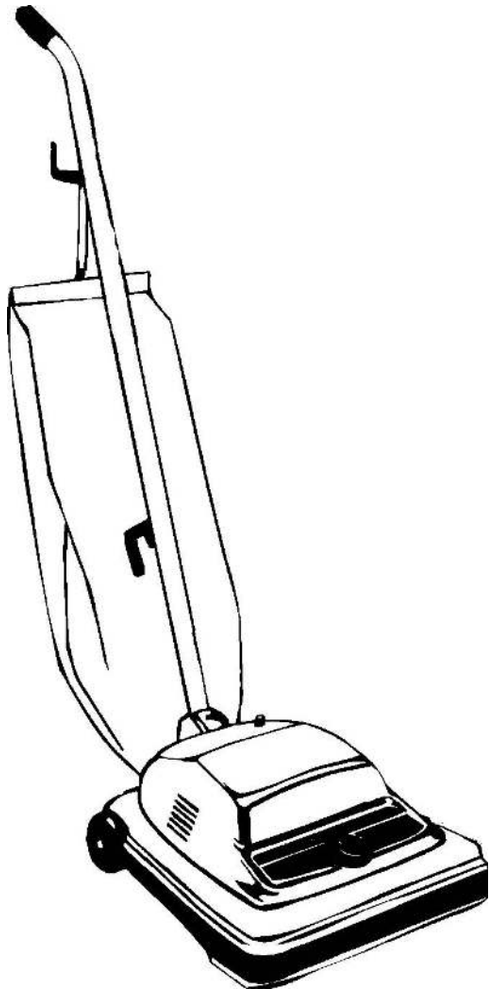
Valid programming with pragmatic program synthesis

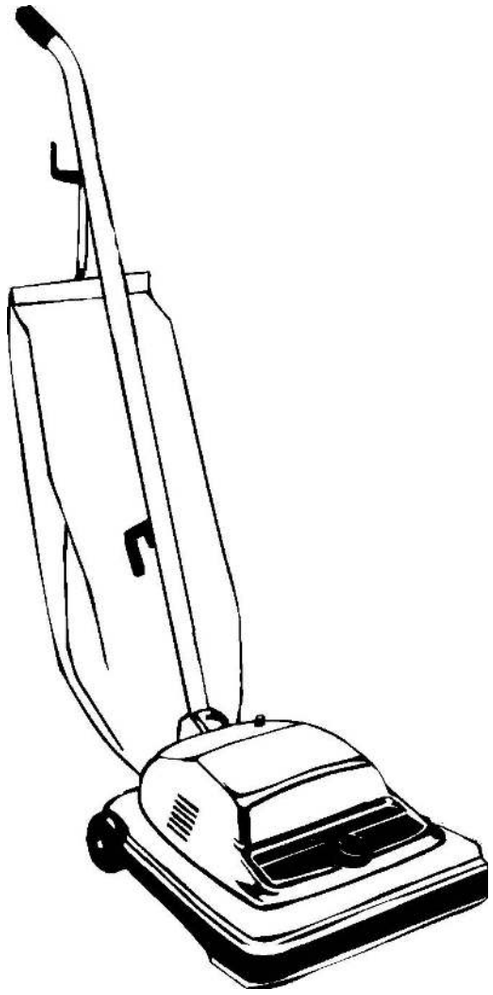
Long Ouyang

Validity: how to ensure that a system that meets its formal requirements does not have unwanted behaviors and consequences ("*Did I build the right system*?")

Validity: how to ensure that a system that meets its formal requirements does not have unwanted behaviors and consequences ("*Did I build the right system*?")

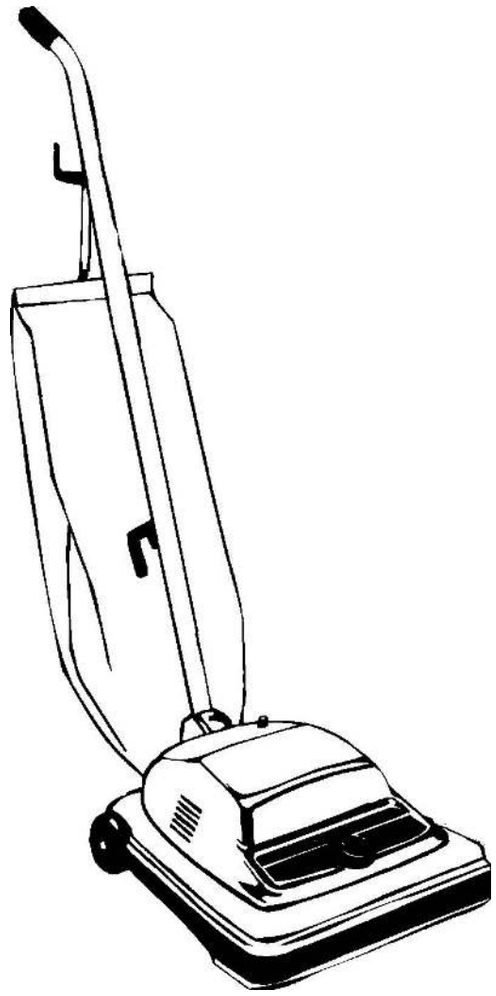


Validity: how to ensure that a system that meets its formal requirements does not have unwanted behaviors and consequences ("*Did I build the right system*?")



"clean up as much dirt as possible"

Validity: how to ensure that a system that meets its formal requirements does not have unwanted behaviors and consequences ("*Did I build the right system*?")



"clean up as much dirt as possible"

finds one patch of dirt, repeatedly picks it up and puts it down

Bad: Imperative specification *“how”*

Bad: Imperative specification *“how”*

```
# calculate a 15% tip
subtotal = 0
for i in items:
 subtotal += price[i]
tip = 0.15 * subtotal
```

Bad: Imperative specification *“how”*

```
# calculate a 15% tip
subtotal = 0
for i in items:
 subtotal += price[i]
tip = 0.15 * subtotal
```

Better: declarative specification *“what”*

Bad: Imperative specification *“how”*

```
# calculate a 15% tip
subtotal = 0
for i in items:
 subtotal += price[i]
tip = 0.15 * subtotal
```

Better: declarative specification *“what”*

```
tip([90,10])      = 15,
tip([50,50,100]) = 30,
…
```

Program synthesis

(programming by example)

```
tip([90,10])      = 15,
tip([50,50,100]) = 30,
…
```

Program synthesis

(programming by example)

“a” ✔

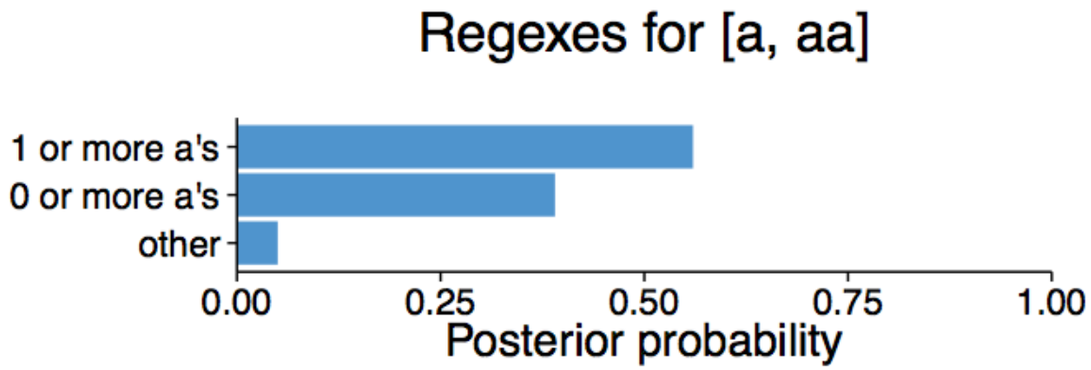
“aa” ✔

Program synthesis

(programming by example)

“a” ✔

“aa” ✔



Programming by example is good for validity

- Write tests, get code for free (ish)
- Reduce surface area for errors (e.g., syntax, type errors, mis-specification)
- Enables thinking at high (domain-specific) level of abstraction
- Empowers non-programmers to produce code

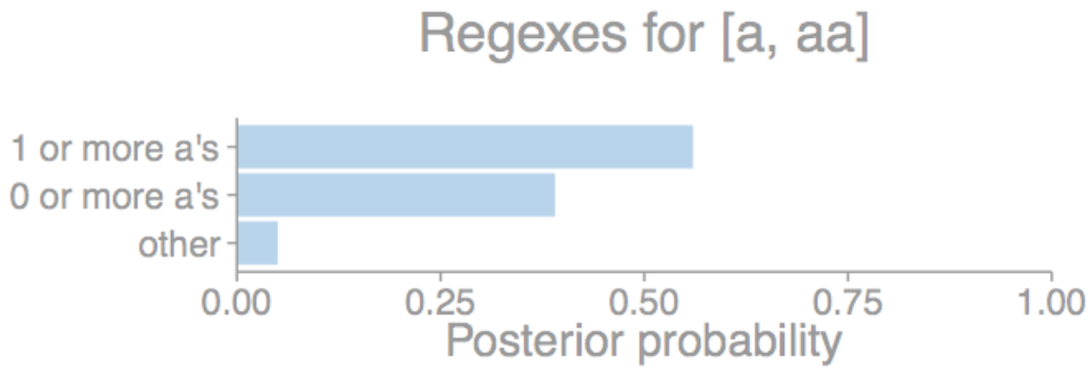
But.. PBE can be invalid

Program synthesis

(programming by example)

“a” ✔

“aa” ✔



“aa” ✔

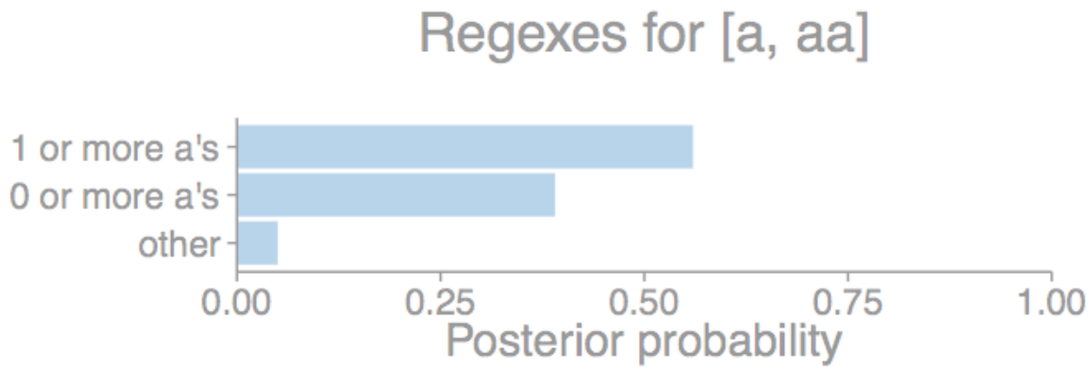
“aaa” ✔

Program synthesis

(programming by example)

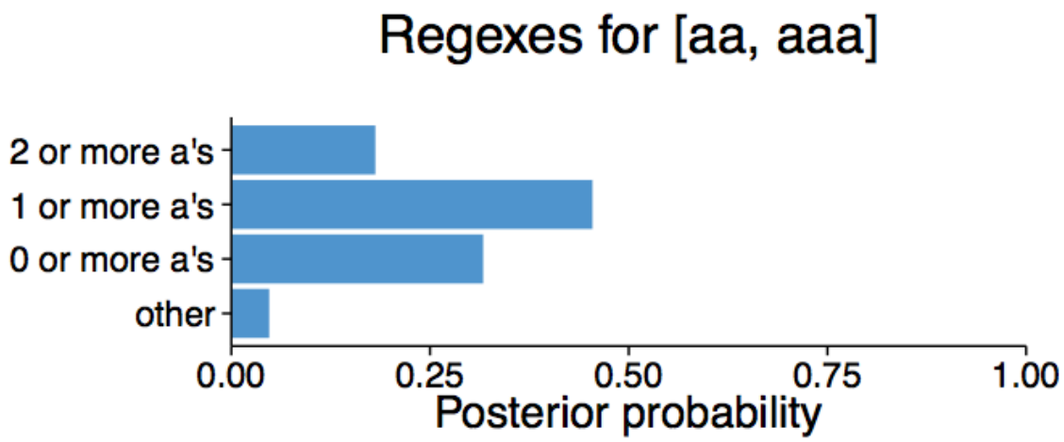
“a” ✔

“aa” ✔



“aa” ✔

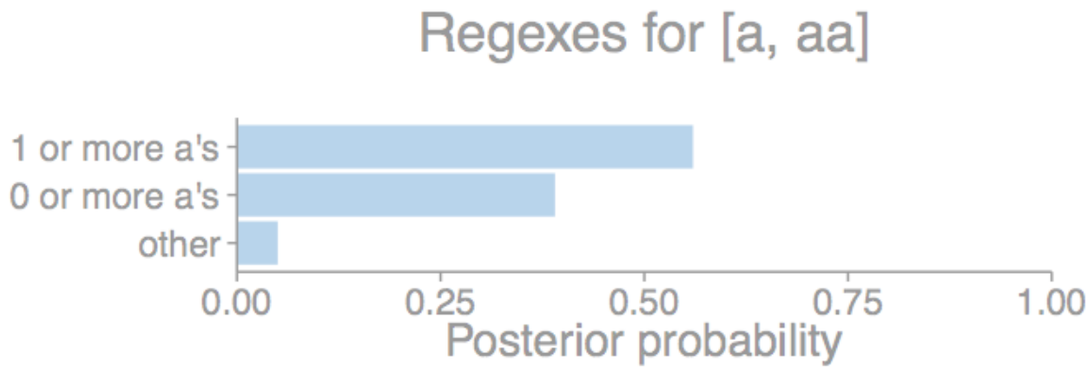
“aaa” ✔



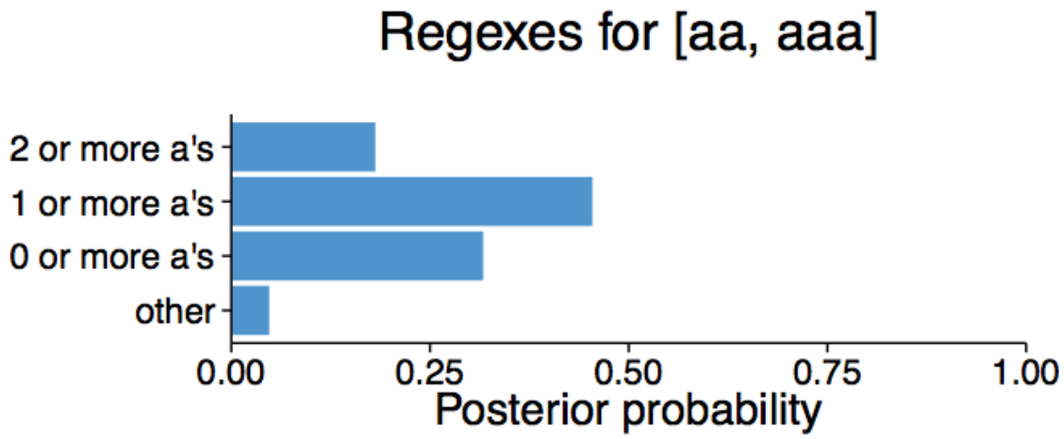
Program synthesis

(programming by example)

“a” ✔
“aa” ✔



“aa” ✔
“aaa” ✔

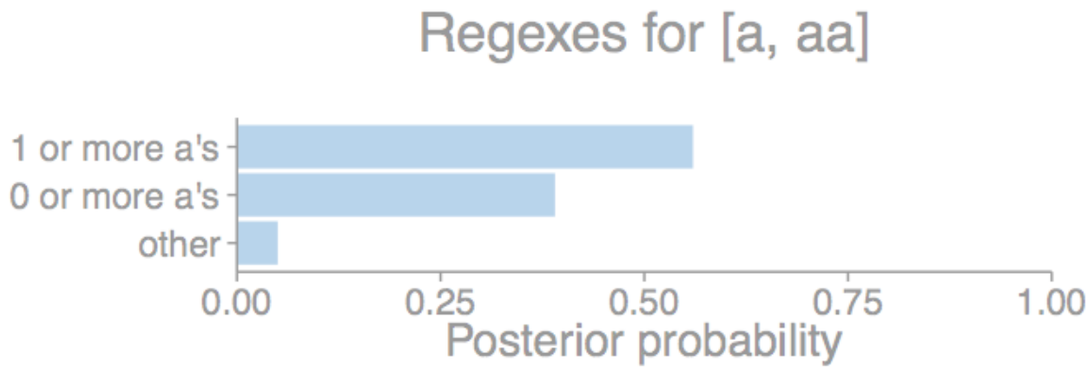


Current synthesis systems interpret examples *literally*

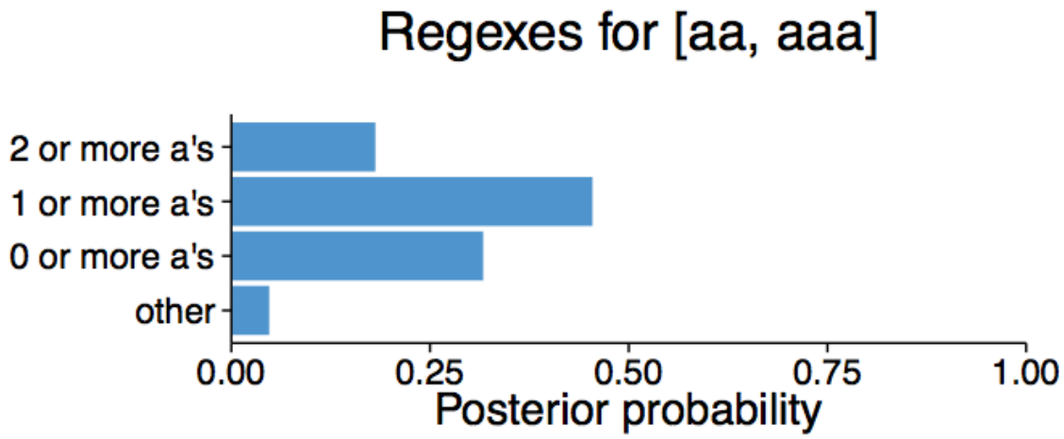
Program synthesis

(programming by example)

“a” ✔
“aa” ✔



“aa” ✔
“aaa” ✔



Current synthesis systems interpret examples *literally*

Goal: more sophisticated (*pragmatic*) interpretation

Literal vs. pragmatic

Literal vs. pragmatic

“The one with glasses”

Literal vs. pragmatic

“The one with glasses”

Literal:	0	0.5	0.5

Literal vs. pragmatic

“The one with glasses”

Literal:	0	0.5	0.5
Pragmatic:	0	0.9	0.1

Pragmatic program synthesis

“aa” ✔
“aaa” ✔

Literal:
search for programs that
satisfy these examples

Pragmatic:
search for programs that
would make a person
produce these examples

Generative models

$$P(r \mid x) \propto P(r) \times P(x \mid r)$$

Generative models

Literal:

interpret regexes as PCFGs, do Earley parsing

$$P(r \mid x) \propto P(r) \times P(x \mid r)$$

Generative models

$$P(r \mid x) \propto P(r) \times P(x \mid r)$$

Literal:

interpret regexes as PCFGs, do Earley parsing

Pragmatic:

need a model how people produce examples for particular regexes

So far

Collected data on how people generate examples

Work in progress on regex induction $P(r \mid x)$
  Collaboration: cognitive science research on language acquisition

Work on tooling: `webppl`
  Automated posterior visualization w/ static analysis (POPL ’17 PPS workshop)
  Automated inference?

Initial experimental data

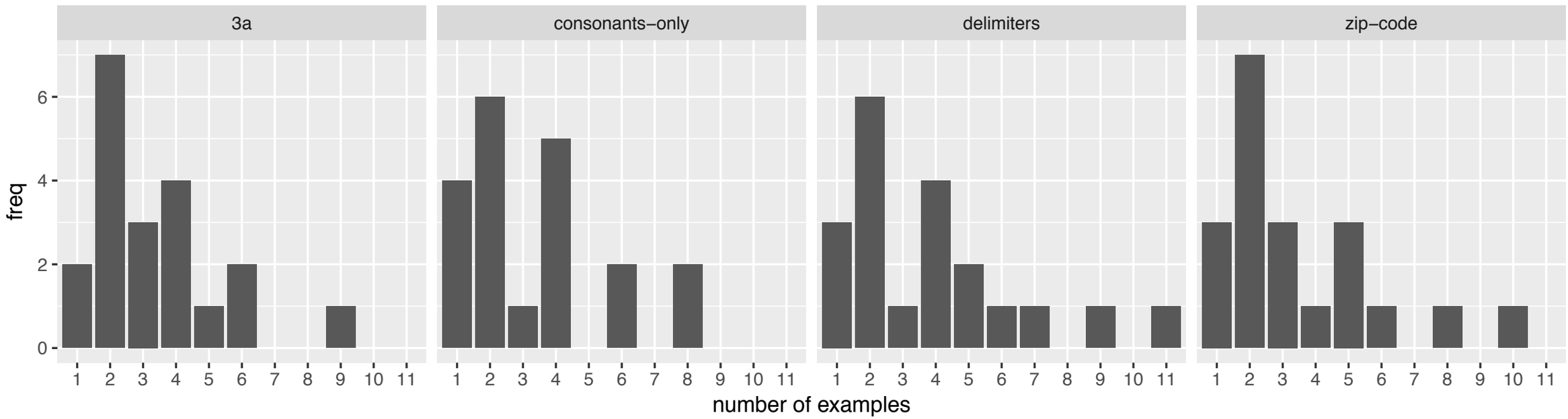
(plan to submit to CogSci ’17 but suggestions welcome)

Mechanical Turk subjects: mean age ~40, little to no programming experience

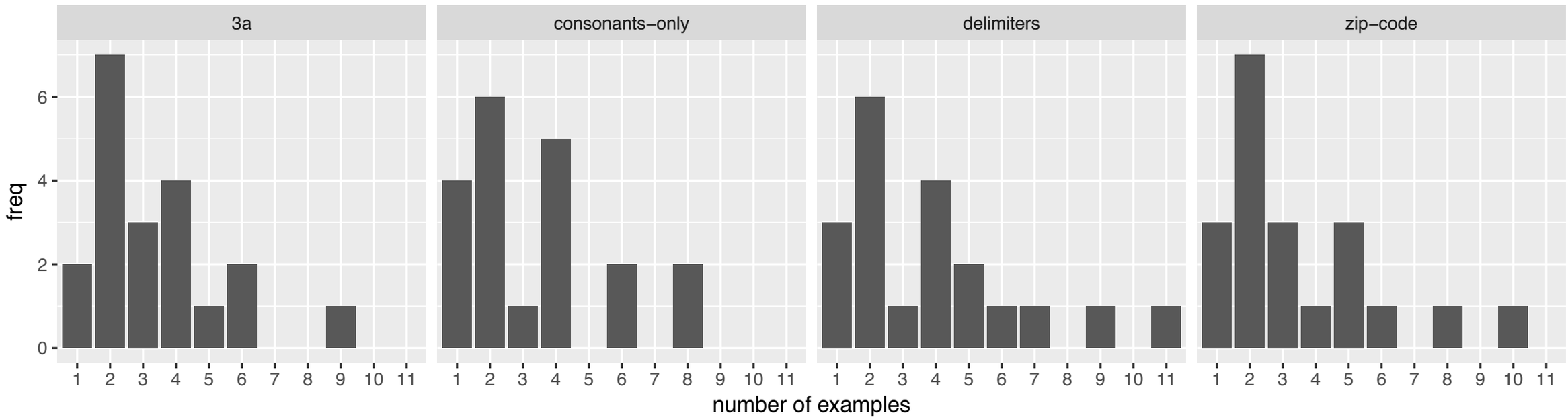
Demo

People give between 1 and 11 examples:

People give between 1 and 11 examples:

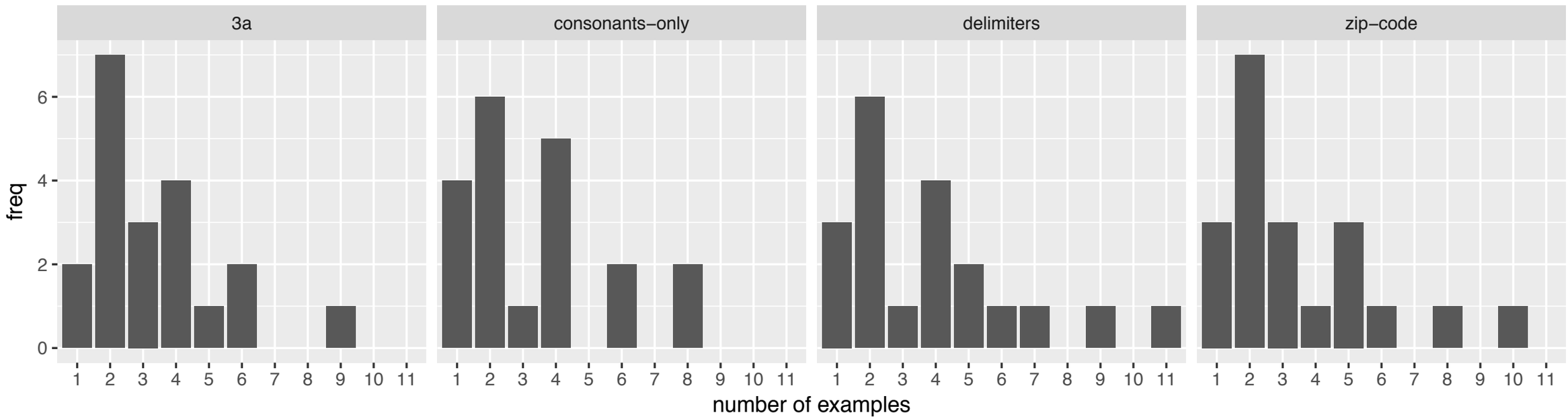


People give between 1 and 11 examples:

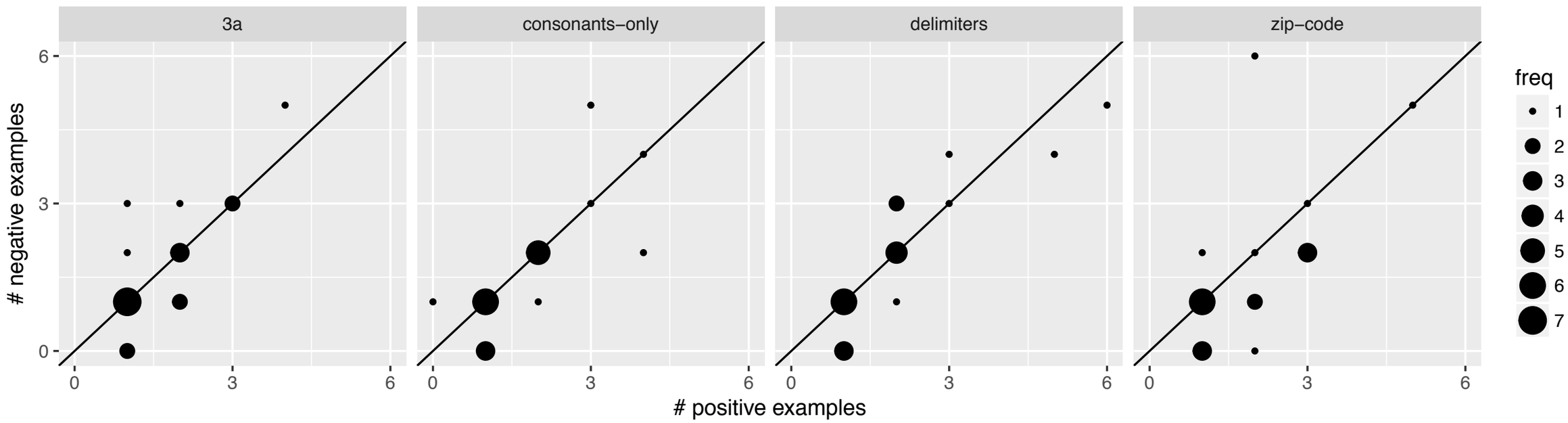


Examples are fairly balanced in polarity:

People give between 1 and 11 examples:



Examples are fairly balanced in polarity:



Examples tend to be related
e.g., **`[qwerty]`** and **`qwerty]`**, **`12521`** and **`125219`**

Examples tend to be related

e.g., **`[qwerty]`** and **`qwerty]`**, **`12521`** and **`125219`**

(near miss)

Examples tend to be related

e.g., **`[qwerty]`** and **`qwerty]`**, **`12521`** and **`125219`**

(near miss)

$p < 0.001$ by permutation test

Examples tend to be related

e.g., **[qwerty]** and **qwerty]**, **12521** and **125219**

(near miss)

$p < 0.001$ by permutation test

Rich sequencing structure

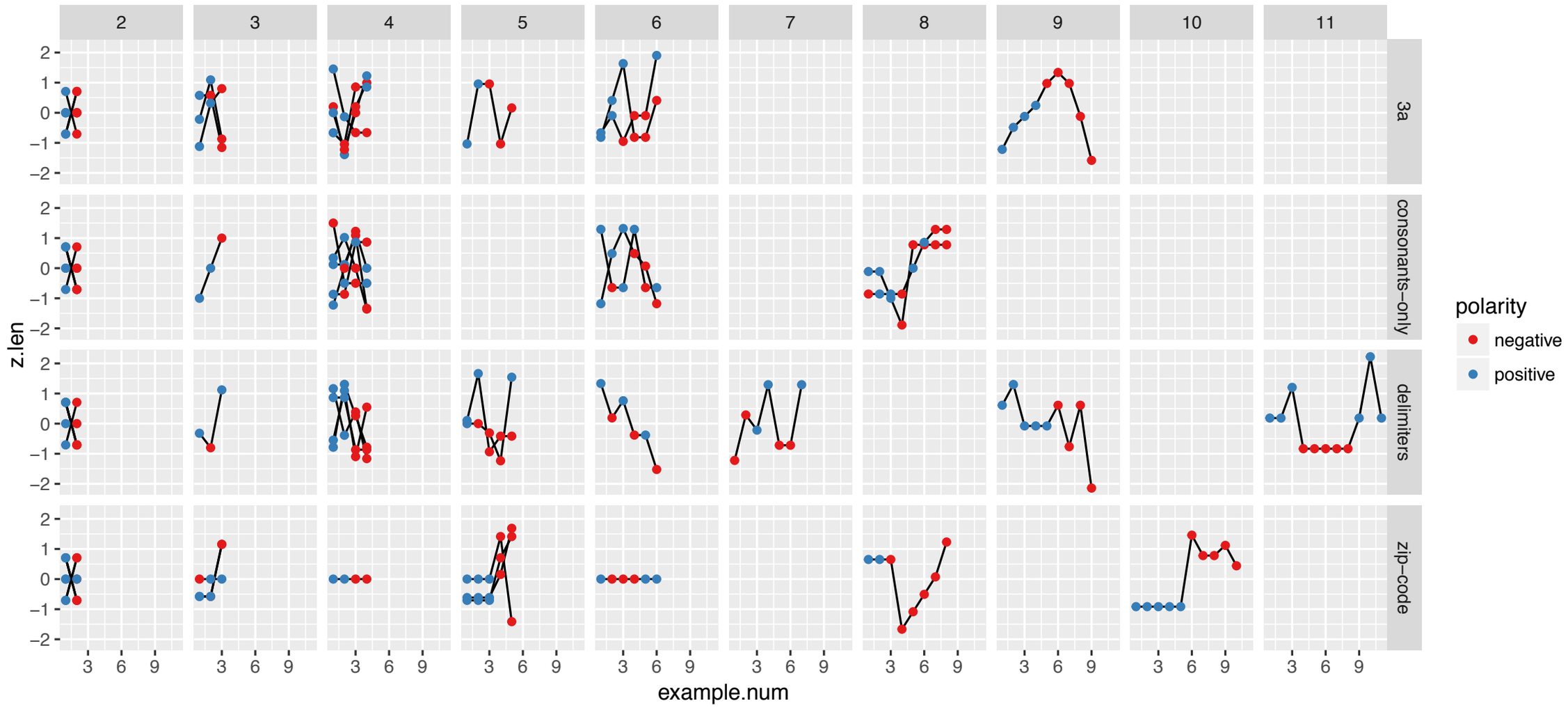
Examples tend to be related

e.g., **[qwerty]** and **qwerty]**, **12521** and **125219**

(near miss)

$p < 0.001$ by permutation test

Rich sequencing structure



Ahead

Collect more data, experiment with different stimuli, subjects, prompts, interfaces for example generation

Build pragmatic synthesis system for regular expressions, string transformations

Other domains: data transformation, data extraction, gesture, planning

Work on efficient inference (PPLs? deep learning?)

Analyze benefits of pragmatic versus literal synthesis