CS492: Probabilistic Programming

Basics of Clojure and tiny bit of Anglican

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KAIST

Does anyone use Clojure, Scheme, or Lisp?

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What are the cons and pros of such a lang.?

Clojure

- Re-design of Scheme for Java virtual machine, with concurrency in mind.
- Untyped.
- Highly expressive.
- Cousin language for Anglican, the probabilistic programming language used in this course.

Learning outcome

- Can write simple Clojure programs with recursion, loop, sequence, and map.
- Can write simple Anglican programs with no conditioning, and perform inference.
- All by copy-past-modify programming.

Clojure in a nutshell

1. Prefix instead of infix notation:

(+ 3 3), not 3+3

2. Use let to bind variables to values.

```
(let [x (* 3 3) y (* 4 4)] (+ x y))
```

3. Anonymous function using fn:

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(let [f (fn [x] (* x x))] (+ (f 3) (f 4)))
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n^2

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4. Separate function definition:

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(defn f [n] …)
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E.g.

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(defn f [n]
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Clojure in a nutshell

Lecture2 — vi sum.clj — 48×14

...bProg17/Lectures/Lecture2 — vi sum.clj | ...g17/Lectures/Lecture2 — java ◂ lein repl

```
(ns lecture2)

(defn sq [x] (* x x))

(defn g [n]
  (if (= n 0)
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~
~
~
~
~
~
                                                    1,8           All
```

sion
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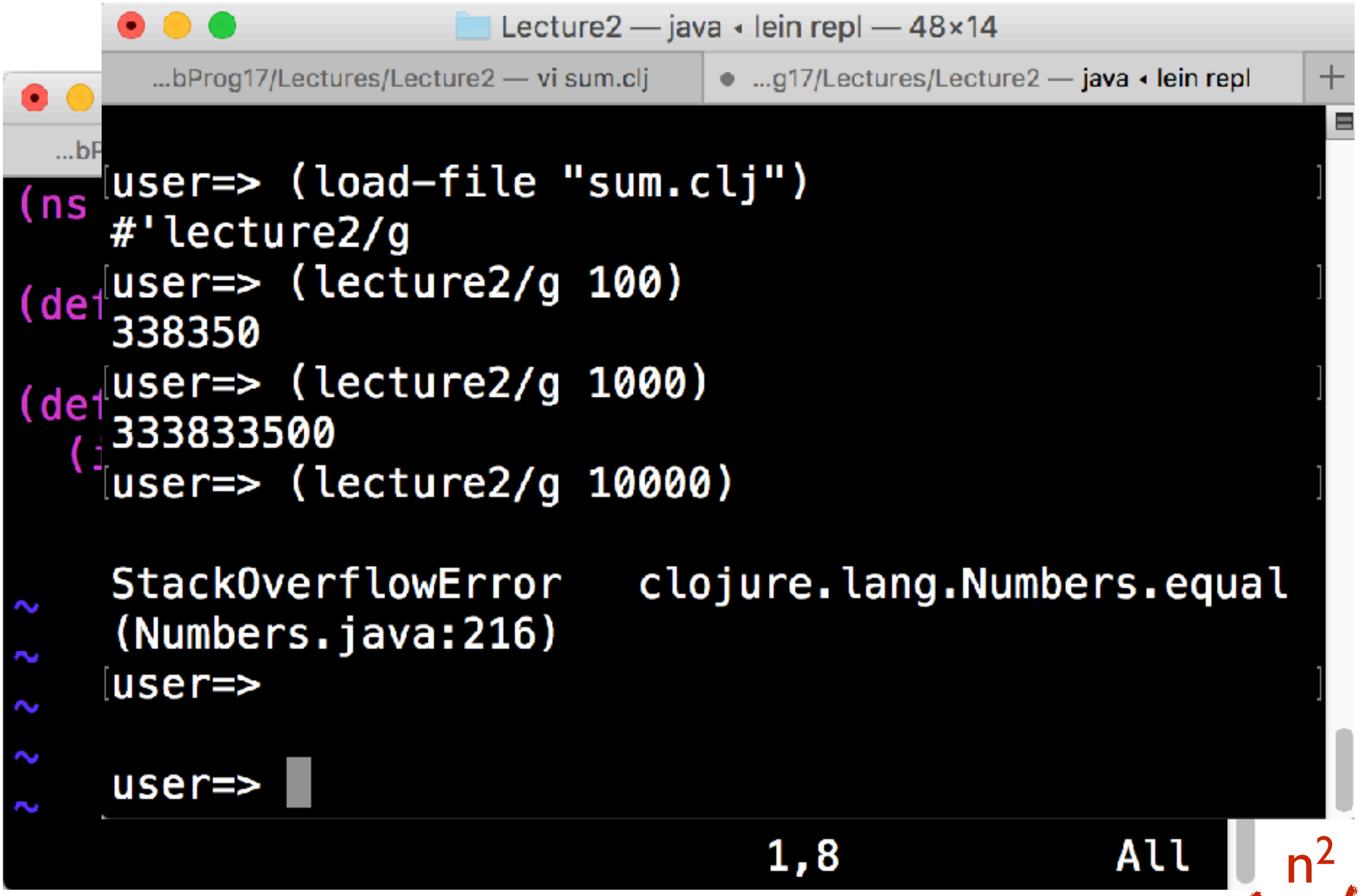
NB: I installed leiningen. Then, I ran "lein repl".



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Clojure in a nutshell

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No further work after recursive call.

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Tail recursive

in a nutshell

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n^2

Lecture2 — vi sum_loop.clj — 45×13

...es/Lecture2 — -bash | java ◂ lein repl | vi sum_loop.clj

```
(ns lecture2b)

(defn sq [x] (* x x))

(defn g [n]
  (loop [n0 n r0 0]
    (if (= n0 0)
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      (recur (- n0 1) (+ (sq n0) r0)))))
~
                                    11,0-1        All
```

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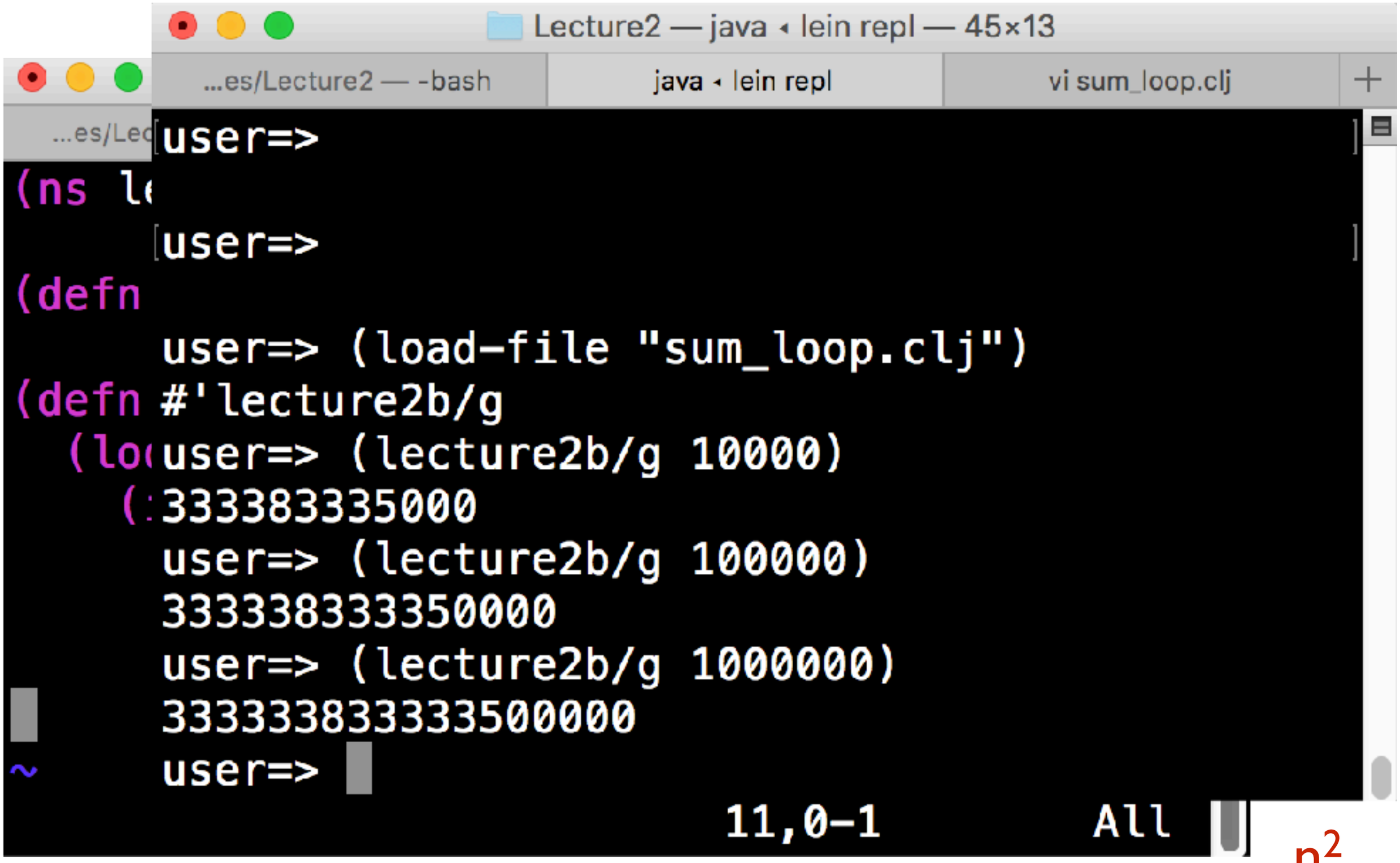

[Q] Write a program that computes $1^2 + 2^2 + \ldots + n^2$.

Exercise 1: Fibonacci sequence

[Q] Write a Clojure function that takes $n \geq 2$ and computes the n-th Fibonacci number F_n:

$$F_1 = 1, \quad F_2 = 1, \quad F_{n+2} = F_n + F_{n+1}$$

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[Hint]

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(defn fib [n]
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Exercise 2: Random Fibonacci sequence R_n

$R_1 = 1, \quad R_2 = 1,$

$R_{n+2} = R_n + R_{n+1}$ or $R_{n+1} - R_n$, each with prob. 1/2

[Q] What does the distribution of R_n look like?

Anglican in a nutshell

1. Define a Anglican query using defquery.

```
(defquery baby-rfib [n]
  (let [b (sample (flip 0.5))
        new-n (if b n (+ n 1))]
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Anglican in a nutshell

Creating and sampling from distribution object

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Clojure keyword.
Chooses an inference algorithm.

Returns a lazy infinite sequence of samples.
Only a finite prefix used.

Anglican in a nutshell

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Anglican in a nutshell

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Sequence

Anglican in a nutshell

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of maps

Anglican in a nutshell

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- To move on, we need to understand map and sequence datatypes of Clojure.

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- Two key questions:

1. How to construct a datatype?

2. How to destruct (or decompose) it?

Map in Clojure

1. Constructed using {..} or assoc typically.

```
{:a 0, :b 1, 3 10},
```

```
(assoc {:a 0, :b 1} 3 10)
```

2. Accessed (or destructed) by get & keyword.

```
(get {:a 0, :b 1, 3 10} 3)
```

```
(get {:a 0, :b 1, 3 10} :a)
```

```
(:a {:a 0, :b 1, 3 10})
```

Sequence in Clojure

1. Created using list and conj typically.

```
(list 1 2 3), (conj (list 2 3) 1)
```

2. Destructed by first, rest, take and reduce.

```
(first (list 1 2 3)),
(rest (list 1 2 3)),
(take 2 (list 1 2 3)),
(reduce + (list 1 2 3))
```

Sequence in Clojure

3. Changed using map and filter.

```
(map inc (list 1 2 3)),
(filter (fn [x] (>= x 2)) (list 1 2 3))
```

Summary

- Map: {..}, assoc, get, and access by keyword.
- List: list, conj, first, rest, take, reduce, map, filter.

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Core functions

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Core functions

Masters' tools.
reduce is a variant
of fold left.

Anglican in a nutshell

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2. Perform inference using doquery.

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3. Pick :result entries and analyse them.

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(let [s (doquery :importance rfib [20])
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(let [s (doquery :importance rfib [20])
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  (plot/histogram r
                  :bins 50
                  :normalize :probability))
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Anglican in a nutshell

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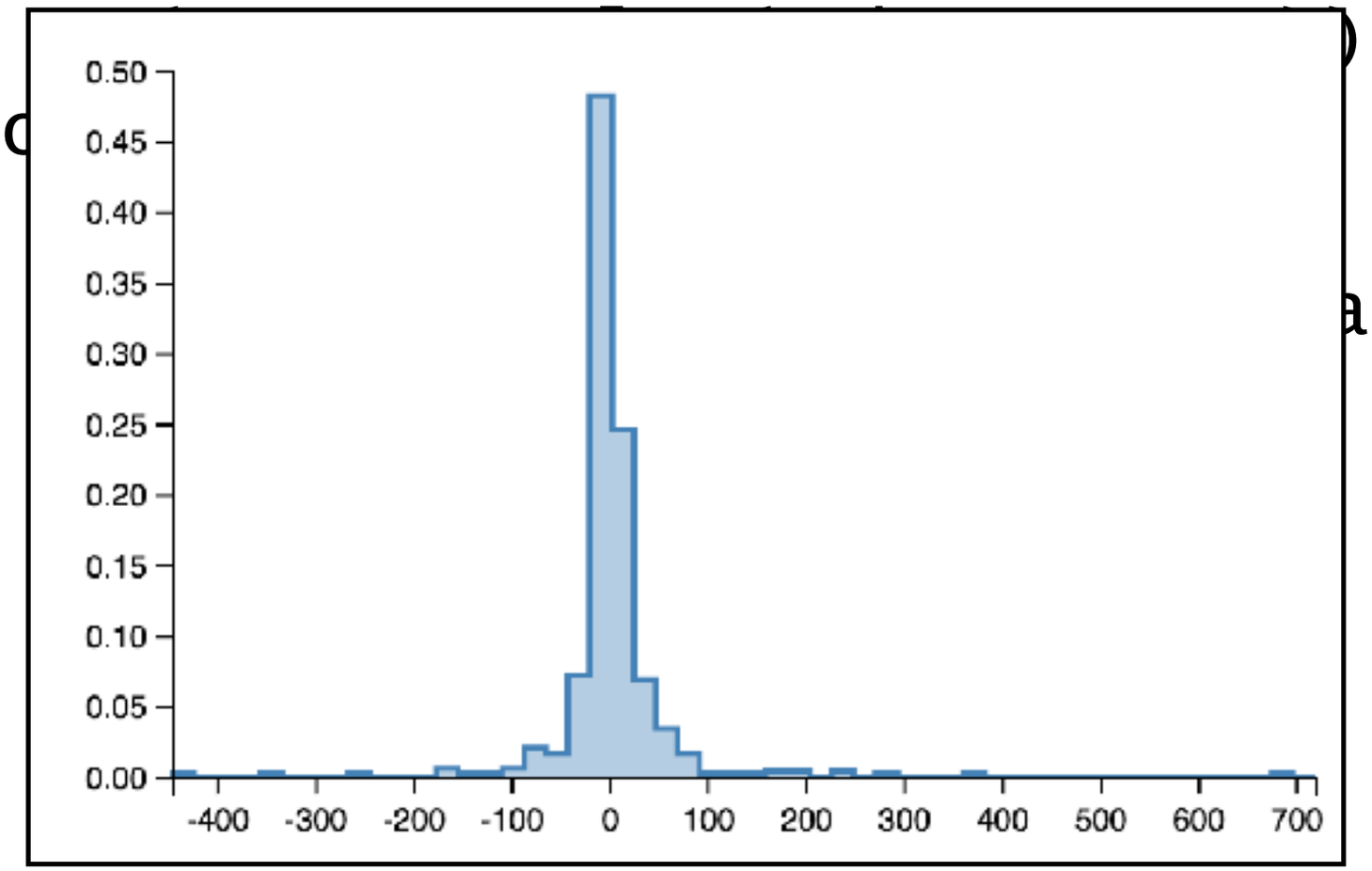

Anglican in a nutshell

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[Q1] Compute the average of generated R_{20} using 1000 samples. This is called empirical mean.

Anglican in a nutshell

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```
(let [s (doquery :importance rfib [20])
      r (map :result (take 1000 s))]
  (/ (reduce + r) 1000))
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[Q1] Compute the average of generated R_{20} using 1000 samples. This is called empirical mean.

Anglican in a nutshell

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[Q1] Compute the average of generated R_{20} using 1000 samples. This is called empirical mean.

[Q2] Compute the variance of generated R_{20}.

Anglican in a nutshell

3. Pick :result entries and analyse them.

```
(let [s (doquery :importance rfib [20])
      r (map :result (take 1000 s))
      m (/ (reduce + r) 1000)
      f (fn [x] (Math/pow (- x m) 2))]
  (/ (reduce + (map f r)) 1000))
```

[Q1] Compute the average of generated R_{20} using 1000 samples. This is called empirical mean.

[Q2] Compute the variance of generated R_{20}.

Topics covered

- Functions, recursion, loop, sequence, and map in Clojure.
- defquery, and doquery in Anglican.

Announcement

1. Homework 0 in the course webpage.
    - It will teach you how to use Gorilla and to try examples in the web browser.
2. ~~No lectures on 4 & 6 September 2017.~~
3. Form a group and tell us by the midnight of September 11 2017 (Monday).