Topics:

✓ (1) Confidence Interval → intuition → why? Applications what?

✓ (2) Bootstrapping ✓

(3) Central-Limit Theorem (CLT) ✓

Math ✓
intuition ✓
Case-study
Code

Uber Eats

ops:

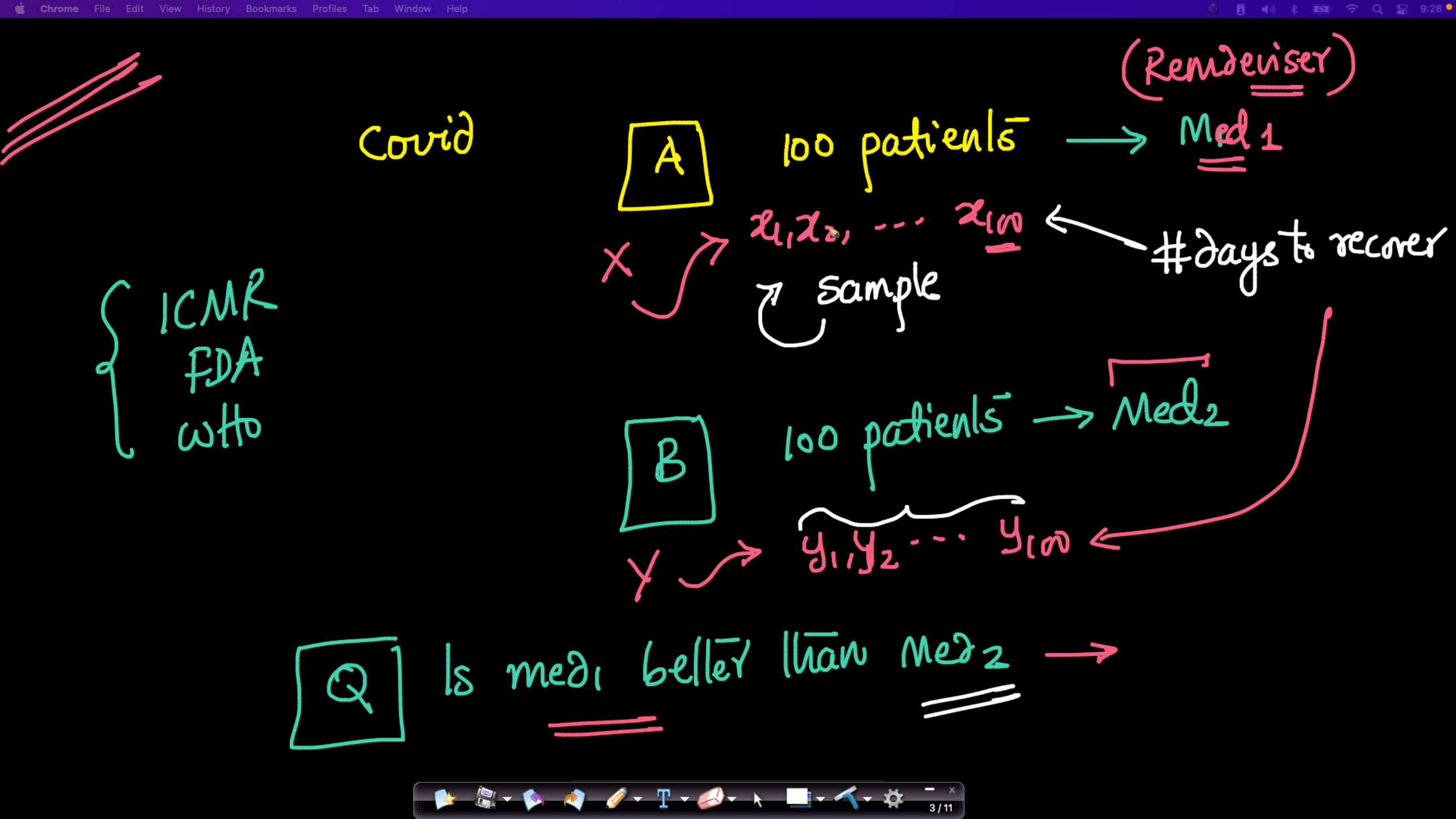
Speed:

checking

Ques → tab

" END: ----- "

[chat → interactivity
Y/N


(Remdesivir)
Covid
A
100 patients → Med 1
$x_1, x_2, \ldots x_{100}$
#days to recover
X
sample
ICMR
FDA
WHO
B
100 patients → Med 2
$y_1, y_2 \ldots y_{100}$
Y
Q
Is med 1 better than Med 2 →

Med 1

mean (x) → sample

4.7 days

Med 2

mean (Y)

4.9 days ← sample mean

Actually compare: μ_1 vs μ_2 ← $\neq$

$4.7 = m_1$

$n_1 = 100$

$M_2 = 4.9$

$n_2 = 100$

as $n_1 \to \infty$; $m_1 \to \mu_1$

as $n_2 \to \infty$; $m_2 \to \mu_2$

Imagine

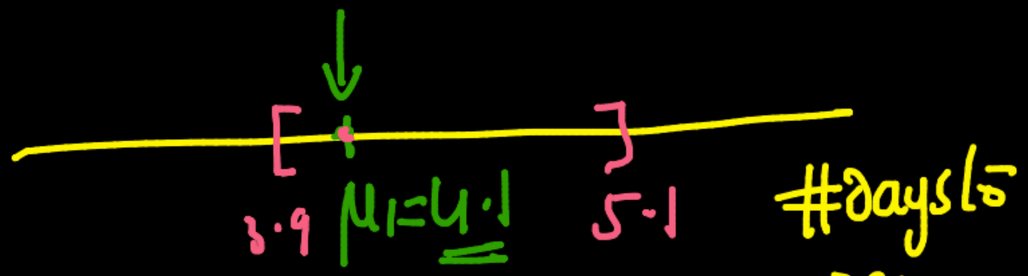
asy. confident

$n_1 = 100$

$\{x_1, x_2, \ldots x_{100}\}$ → $\mu_1 = [3.9, 5.1]$

point-estimate

$\{y_1, y_2 \ldots y_{100}\}$ $\mu_2 = [4.6, 6.0]$



C. interval (C.I)

med 1 ✓ or med 2

90%.

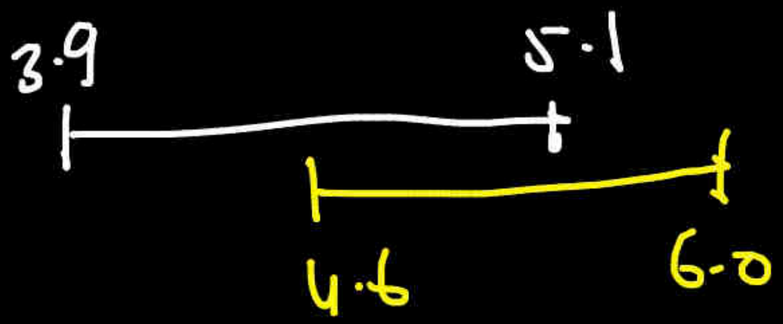
Commonly [95% C.I of $\mu_1 = [\cdot\ ,\ \cdot]$

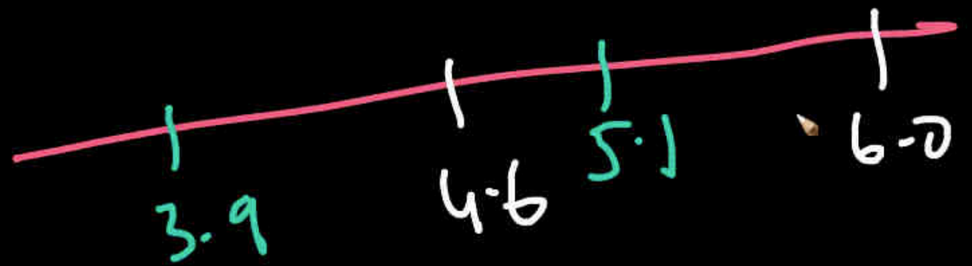
95% C.I of $\mu_2 = [\ \ ,\ \ ]$]

90%.

Med1 $\mu_1 = [3.9 \quad 5.1]$

$\mu_2 = [4.6, \quad 6.6]$





who were hospitalized with Covid-19 and had evidence of lower respiratory tract infection. Patients were randomly assigned to receive either remdesivir (200 mg loading dose on day 1, followed by 100 mg daily for up to 9 additional days) or placebo for up to 10 days. The primary outcome was the time to recovery, defined by either discharge from the hospital or hospitalization for infection-control purposes only.

RESULTS

A total of 1062 patients underwent randomization (with 541 assigned to remdesivir and 521 to placebo). Those who received remdesivir had a median recovery time of 10 days (95% confidence interval [CI], 9 to 11), as compared with 15 days (95% CI, 13 to 18) among those who received placebo (rate ratio for recovery, 1.29; 95% CI, 1.12 to 1.49; P<0.001, by a log-rank test). In an analysis that used a proportional-odds model with an eight-category ordinal scale, the patients who received remdesivir were found to be more likely than those who received placebo to have clinical improvement at day 15 (odds ratio, 1.5; 95% CI, 1.2 to 1.9, after adjustment for actual disease severity). The Kaplan–Meier estimates of mortality were 6.7% with remdesivir and 11.9% with placebo by day 15 and 11.4% with remdesivir and 15.2% with placebo by day 29 (hazard ratio, 0.73; 95% CI, 0.52 to 1.03). Serious adverse events were reported in 131 of the 532 patients who received remdesivir (24.6%) and in 163 of the 516 patients who received placebo (31.6%).

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Our data show that remdesivir was superior to placebo in shortening the time to recovery in adults who were hospitalized with Covid-19 and had evidence of lower respiratory tract infection. (Funded by the National Institute of Allergy and Infectious Diseases and others; ACTT-1 ClinicalTrials.gov number, NCT04280705.)

Remdesivir for 5 or 10 Days in Patients with Severe Covid-19

J.D. Goldman and Others

CORRESPONDENCE SEP 3, 2020

Remdesivir for the Treatment of Covid-19 — Preliminary Report

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Med 1

Med 2

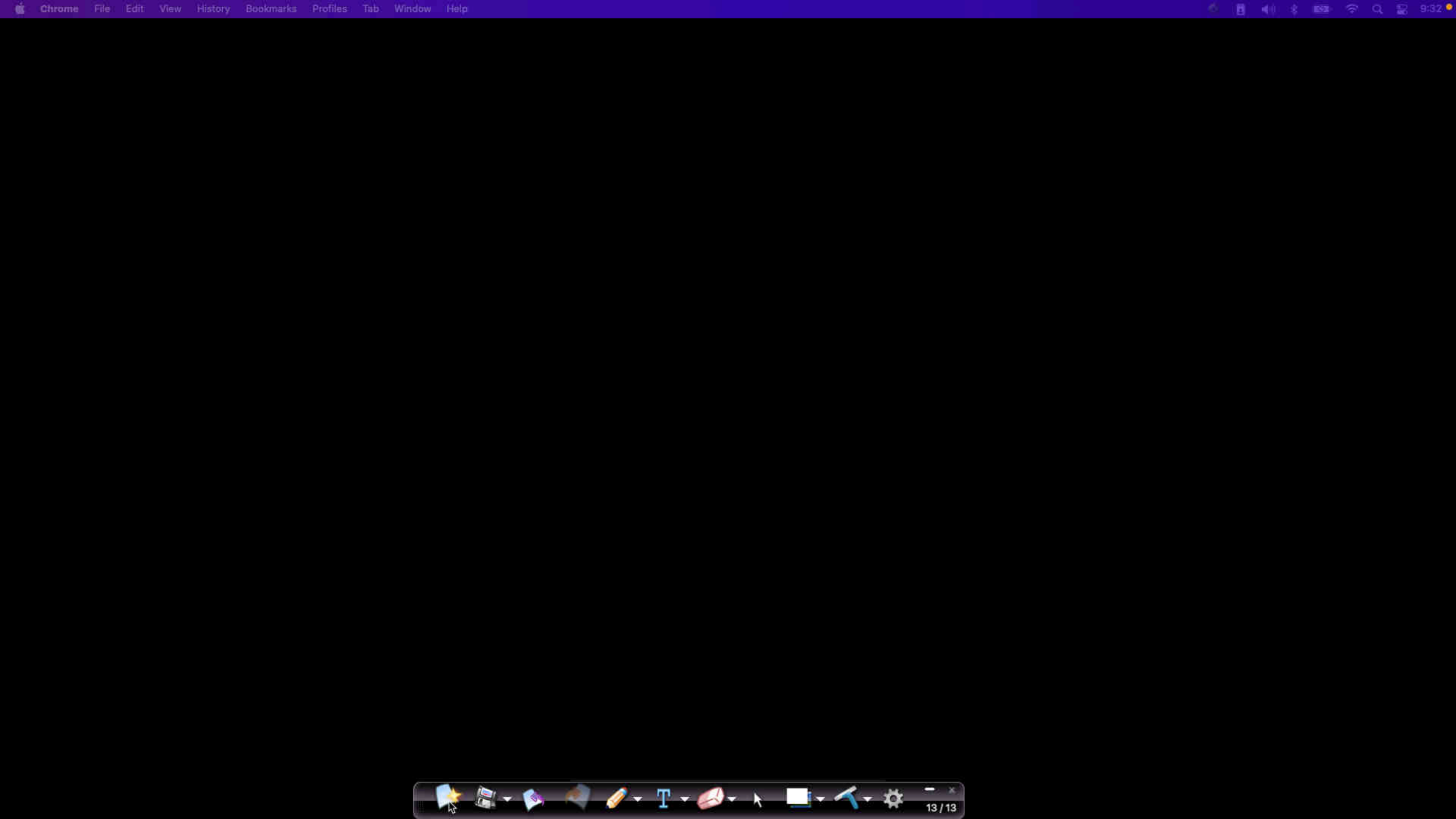
Sample mean:

5.6

25.1

$\mu_1 = [\ ,\ ]$

$\mu_2 = [\ ,\ ]$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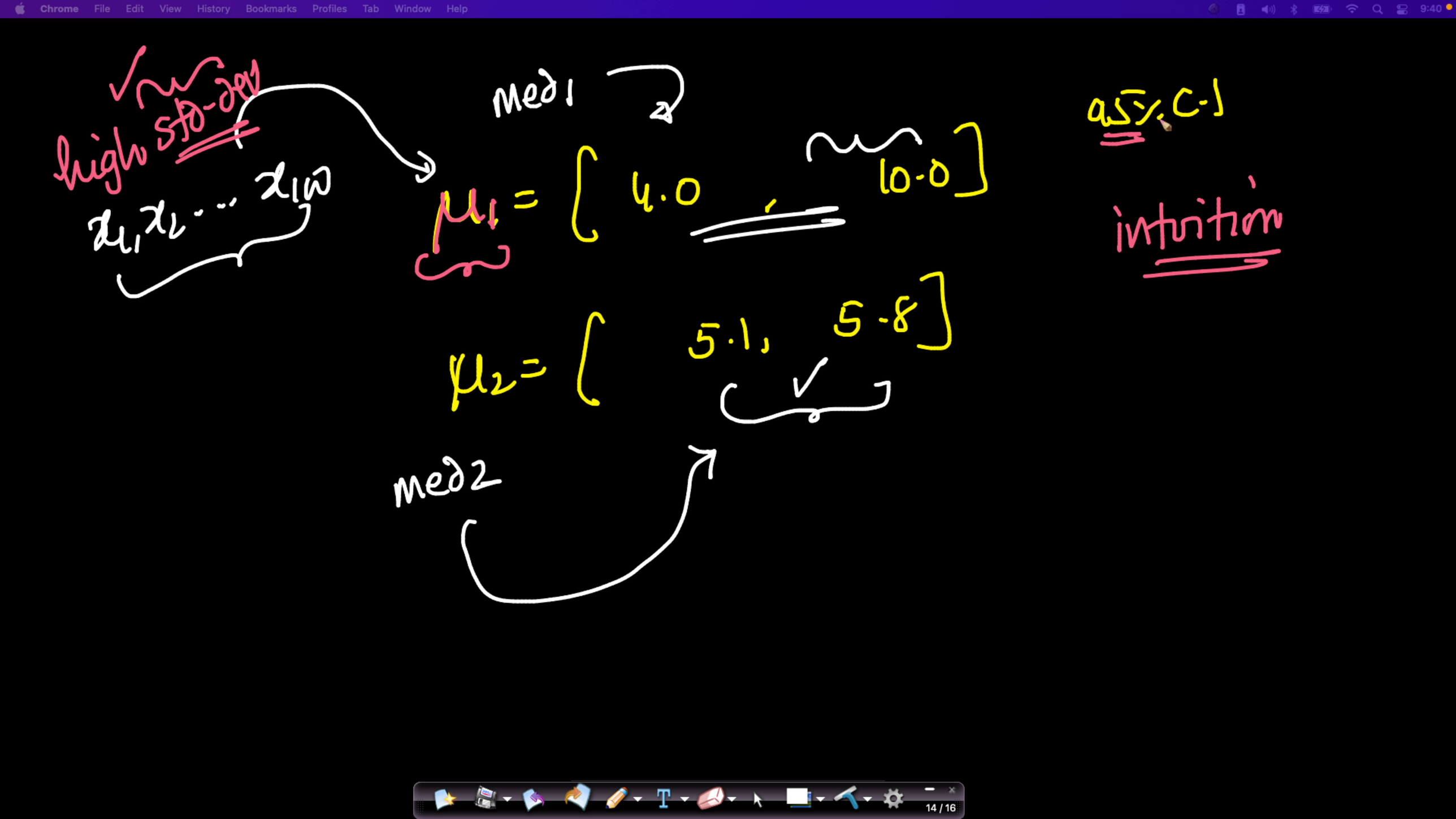
9:32
13 / 13

$E(X) =$ Mean of X

$E(X^2)$, $E(X+2)$, $E(X+Y)$


high sto-day
$x_1, x_2 \cdots x_{10}$
med 1
$\mu_1 = [\ 4.0 \quad \cdots \quad 10.0\ ]$
$\mu_2 = [\ 5.1, \quad 5.8\ ]$
med 2
assy. C-1
intuition

who were hospitalized with Covid-19 and had evidence of lower respiratory tract infection. Patients were randomly assigned to receive either remdesivir (200 mg loading dose on day 1, followed by 100 mg daily for up to 9 additional days) or placebo for up to 10 days. The primary outcome was the time to recovery, defined by either discharge from the hospital or hospitalization for infection-control purposes only.

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Med1

$n_1 = 100$

$\mu_1 = [\ 3.9 \quad 5.0\ ]$

$\mu_2 = [\ 4.1 \quad 5.2\ ]$

Med2

$n_2 = 100$

95% C.I

99%

Lots of data

critical

Med 1

sample Mean $_1$ = 4.7 ✓ (100)

sample Mean $_2$ = 4.9 (100) Med 2

95% C.I $\mu_1 = [\ 4.6 \quad 9.1\ ]$

" $\mu_2 = [\ 3.0 \quad 5.0\ ]$ ✓

Published in Netflix TechBlog

Netflix Technology Blog
Sep 22, 2021 · 9 min read · Listen

What is an A/B Test?

Martin Tingley with Wenjing Zheng, Simon Ejdemyr, Stephanie Lane, and Colin McFarland

This is the second post in a multi-part series on how Netflix uses A/B tests to inform decisions and continuously innovate on our products. See here for Part 1: Decision Making at Netflix. Subsequent posts will go into more details on the statistics of A/B tests, experimentation across Netflix, how Netflix has invested in infrastructure to support and scale experimentation, and the importance of the culture of experimentation within Netflix.

An A/B test is a simple controlled [illegible]'s say — this is a hypothetical! — we want to learn if a new

core idea was that surfacing titles that are popular in each country would benefit our members in two ways. First, by surfacing what's popular we can help members have shared experiences and connect with one another through conversations about popular titles. Second, we can help members choose some great content to watch by fulfilling the intrinsic human desire to be part of a shared conversation.

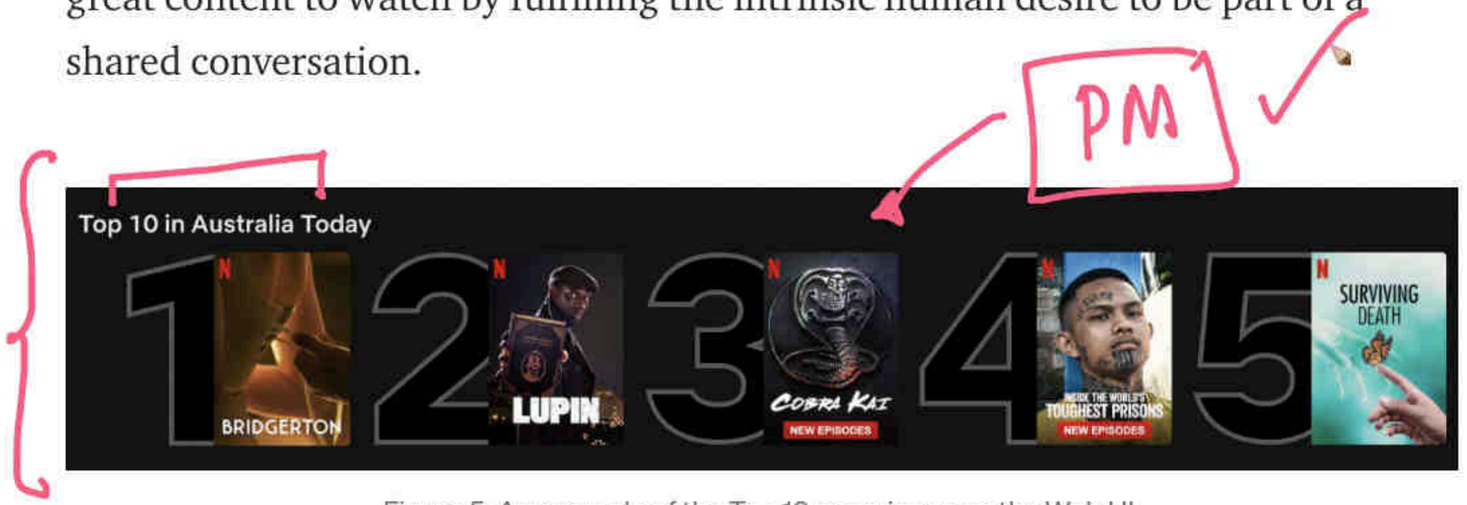
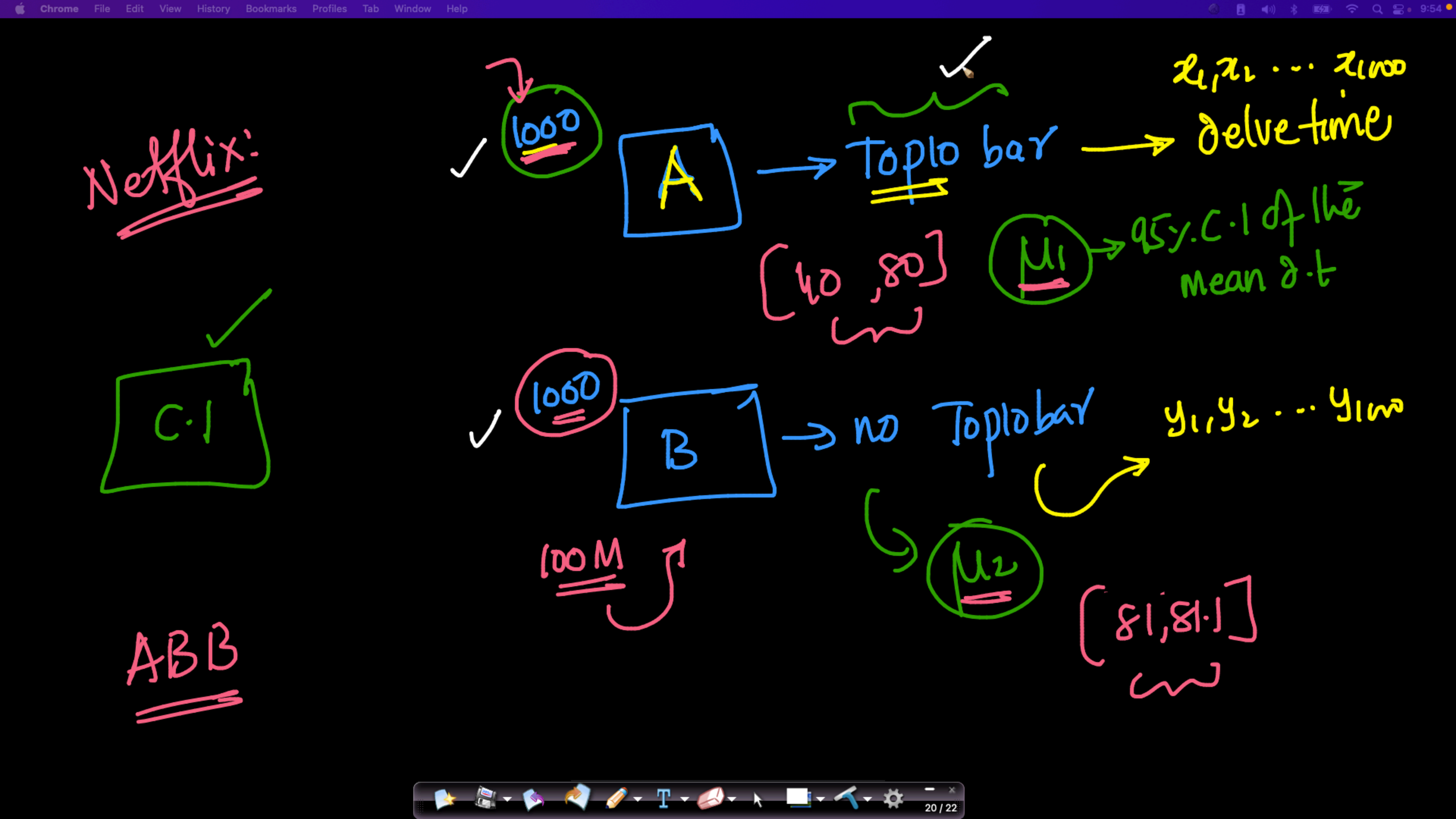


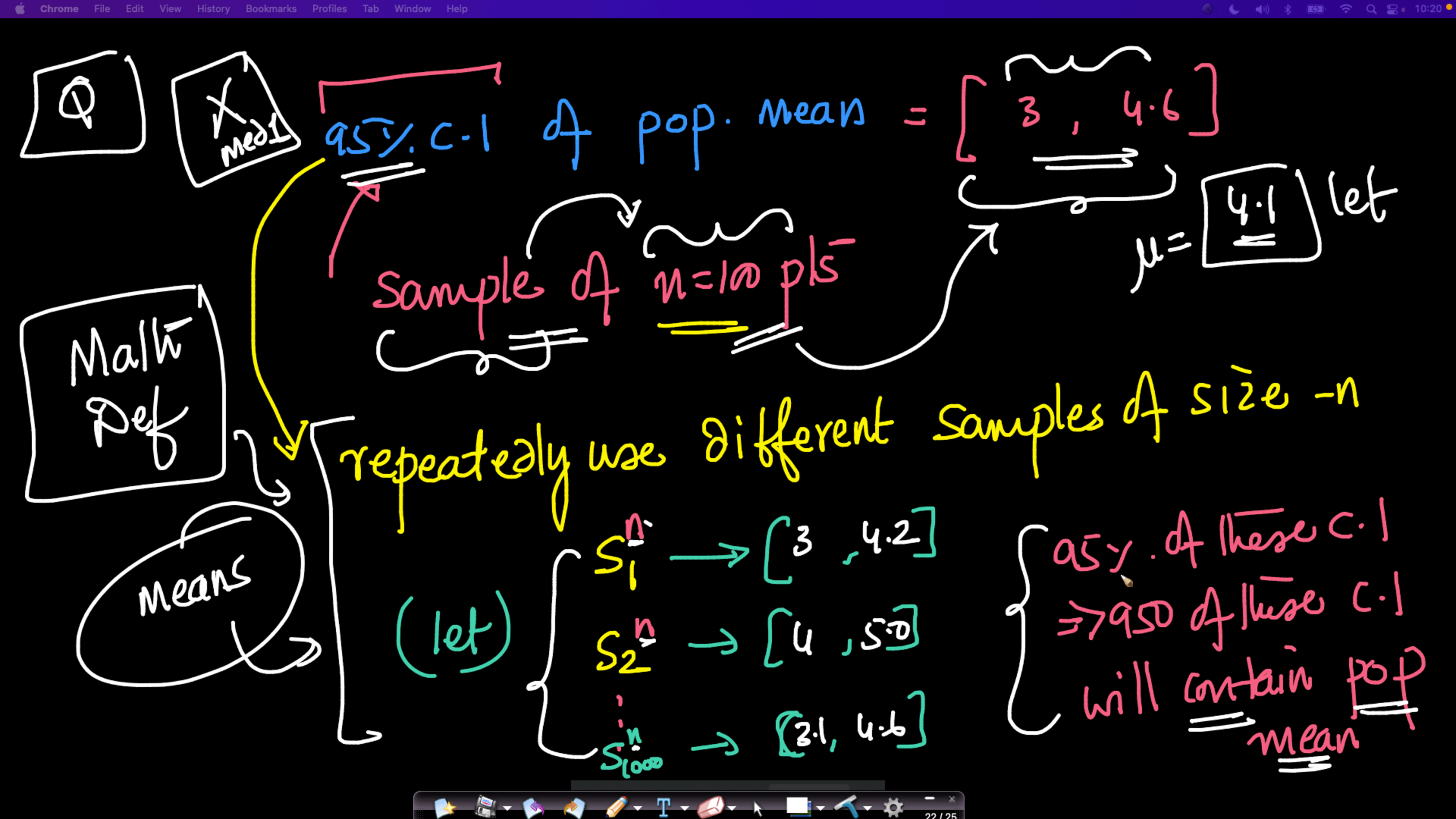
Figure 5: An example of the Top 10 experience on the Web UI.

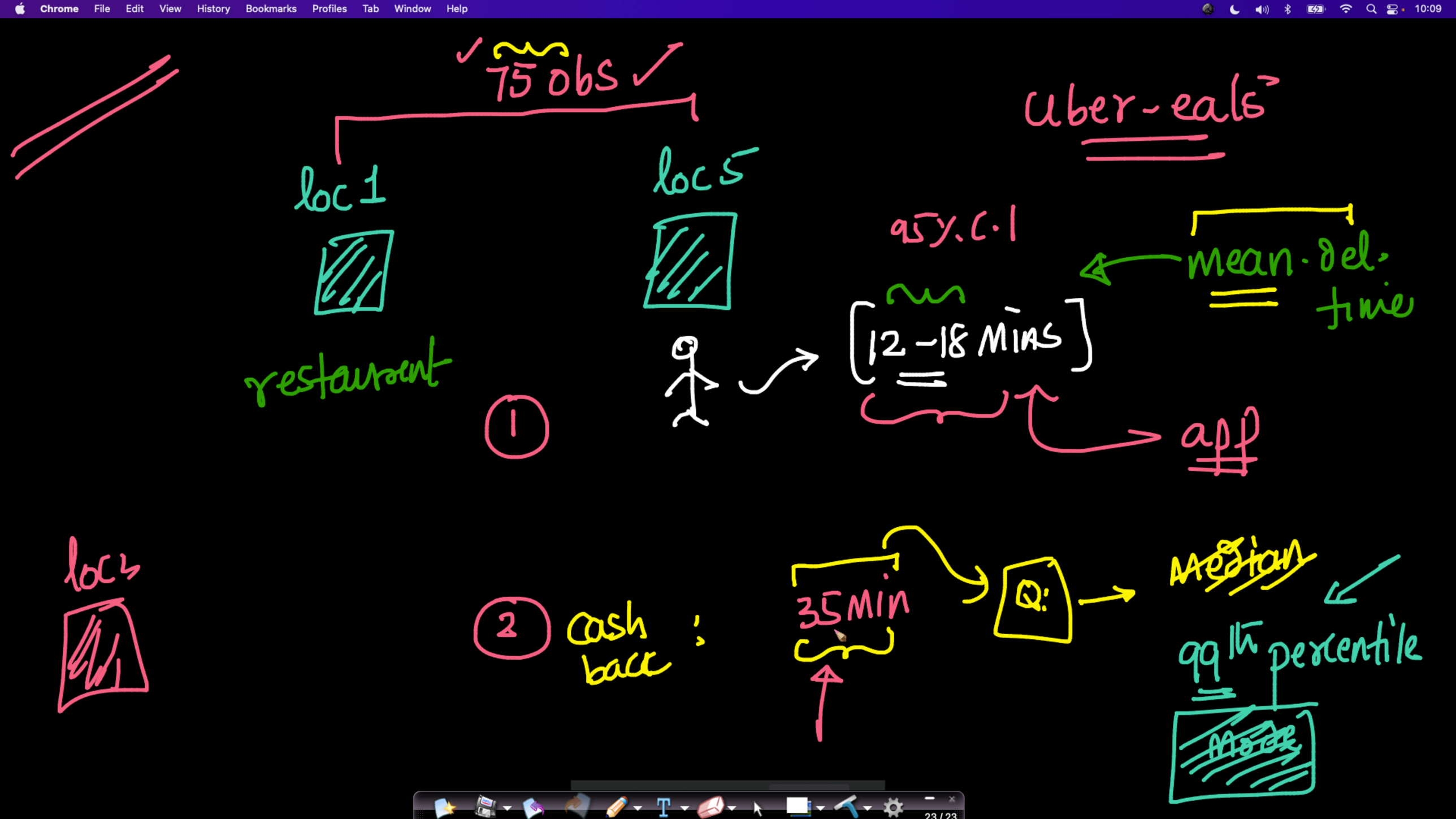
We next turn this idea into a testable hypothesis, a statement of the form "If we make change X, it will improve the member experience in a way that makes metric Y improve." With the Top 10 example, the hypothesis read: "*Showing members the Top 10 experience will help them find something to watch, increasing member joy and satisfaction.*" The primary decision metric for this test (and many others) is a measure of member


Netflix:
1000
A
Toplo bar
$x_1, x_2 \cdots x_{1000}$
delve time
[40, 80]
M1
95% C.I of the mean d.t
C.1
1000
B
no Toplobar
$y_1, y_2 \cdots y_{1000}$
100 M
M2
[81, 81.1]
ABB

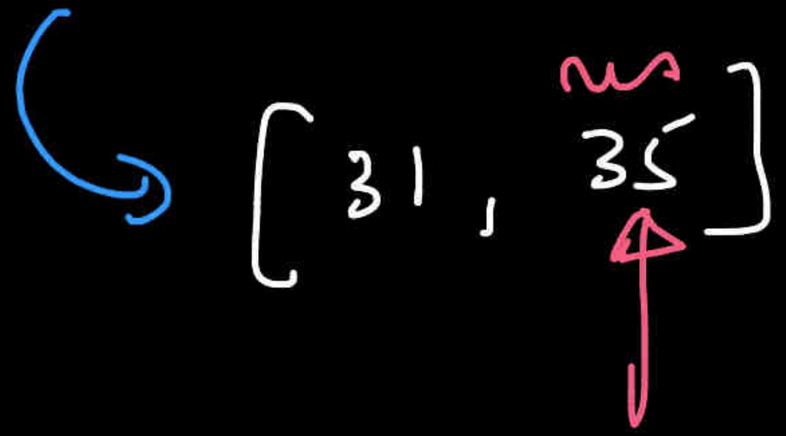
Amazon:

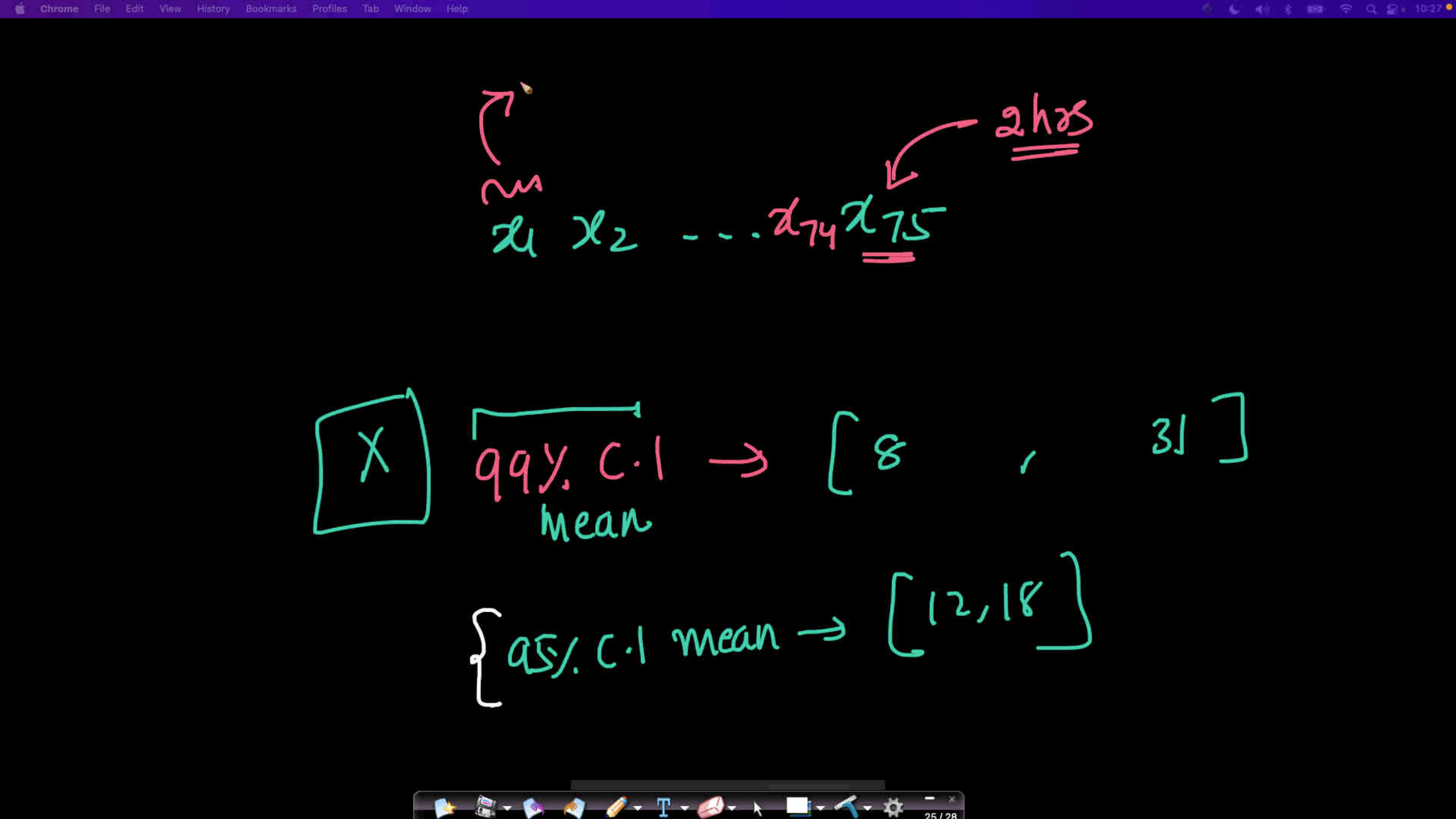
1000's A A|B


Q
X med1
95% C.I of pop. mean = [3, 4.6]
Sample of n=100 pls
μ = 4.1 let
Malik Def
repeatedly use different samples of size -n
Means
(let)
$S_1^n \rightarrow [3, 4.2]$
$S_2^n \rightarrow [4, 5.0]$
$S_{1000}^n \rightarrow [3.1, 4.6]$
95% of these C.I
⇒ 950 of these C.I
will contain pop mean


Chrome File Edit View History Bookmarks Profiles Tab Window Help
10:09
75 obs
loc 1
loc 5
restaurant
1
asy.c.1
[12-18 MINS]
mean.del.time
app
Uber-eats
loc 2
2 cash back :
35 MIN
Q:
AAEtion
99 th percentile

95% C.I of the tpq of del.time loc, & locs




2hrs
x_1 x_2 ... x_{74} x_{75}
X
99% C.I
mean
→ [8 , 31]
{ 95% C.I mean → [12, 18]

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n1 =541

n2

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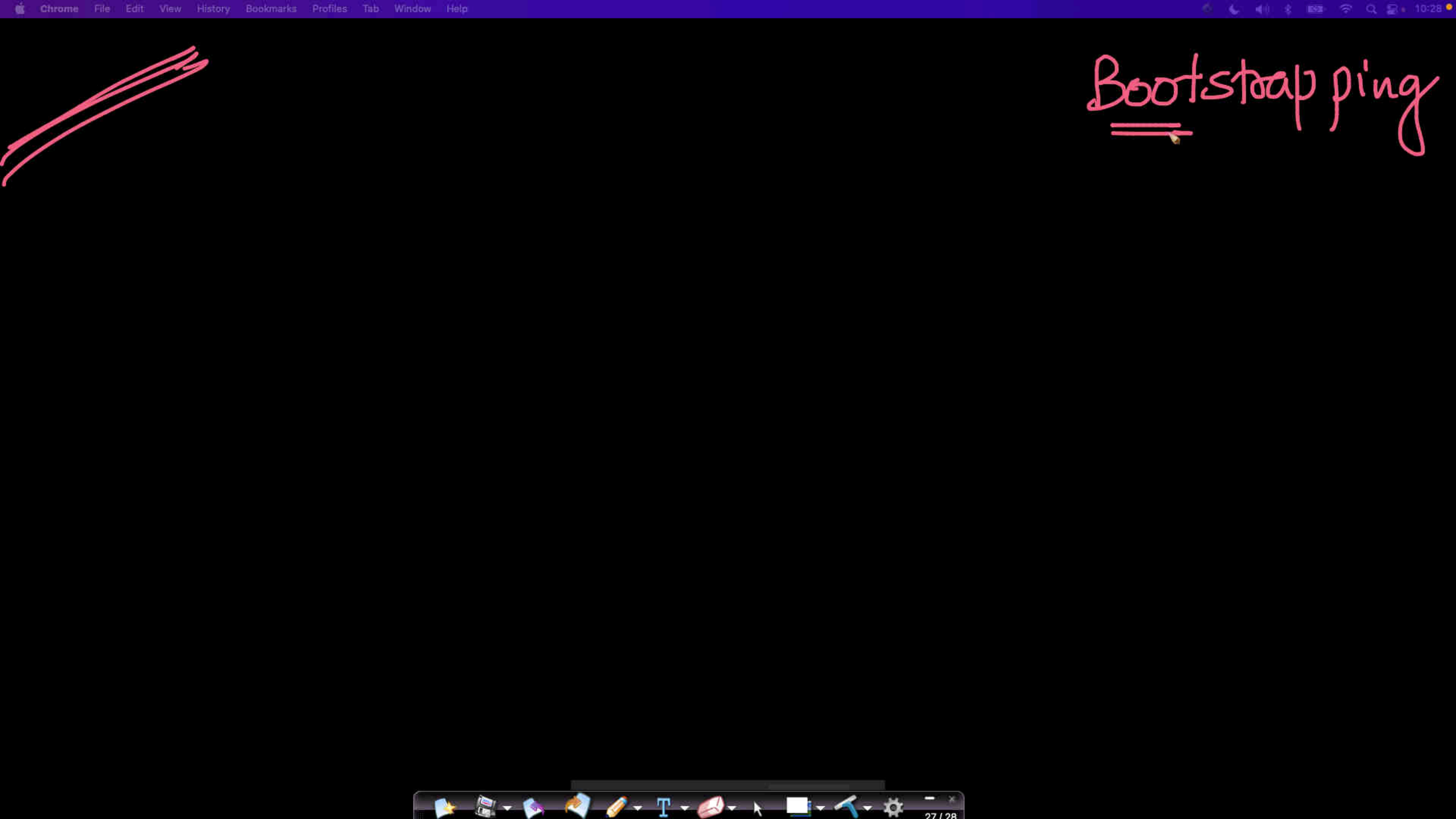
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10:28
Bootstoap ping
27 / 28

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Update

+ Code + Text Connect

```
[ ] from scipy import stats
    import seaborn as sns
    import  numpy as np
    import matplotlib.pyplot as plt
```

Uber Data

```
[ ] id = "1NokZy4YzavFdTZlWcIUs47WW5M2A4ElE"
    print("https://drive.google.com/uc?export=download&id=" + id)
```

https://drive.google.com/uc?export=download&id=1NokZy4YzavFdTZlWcIUs47WW5M2A4ElE

```
[ ] !wget "https://drive.google.com/uc?export=download&id=1NokZy4YzavFdTZlWcIUs47WW5M2A4ElE" -O Uber_da
```

```
--2022-07-01 13:34:47--  https://drive.google.com/uc?export=download&id=1NokZy4YzavFdTZlWcIUs47WW5M2
Resolving drive.google.com (drive.google.com)... 74.125.142.100, 74.125.142.102, 74.125.142.101, ...
Connecting to drive.google.com (drive.google.com)|74.125.142.100|:443... connected.
```

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Update

+ Code + Text

Connect

```
import matplotlib.pyplot as plt
```

[ ]

Uber Data

[ ]
```
id = "1NokZy4YzavFdTZlWcIUs47WW5M2A4ElE"
print("https://drive.google.com/uc?export=download&id=" + id)
```

```
https://drive.google.com/uc?export=download&id=1NokZy4YzavFdTZlWcIUs47WW5M2A4ElE
```

[ ]
```
!wget "https://drive.google.com/uc?export=download&id=1NokZy4YzavFdTZlWcIUs47WW5M2A4ElE" -O Uber_da
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--2022-07-01 13:34:47--  https://drive.google.com/uc?export=download&id=1NokZy4YzavFdTZlWcIUs47WW5M2
Resolving drive.google.com (drive.google.com)... 74.125.142.100, 74.125.142.102, 74.125.142.101, ...
Connecting to drive.google.com (drive.google.com)|74.125.142.100|:443... connected.
HTTP request sent, awaiting response... 303 See Other
Location: https://doc-0c-ag-docs.googleusercontent.com/docs/securesc/ha0ro937gcuc717deffksulhg5h7mbp
Warning: wildcards not supported in HTTP.
--2022-07-01 13:34:48--  https://doc-0c-ag-docs.googleusercontent.com/docs/securesc/ha0ro937gcuc717d
Resolving doc-0c-ag-docs.googleusercontent.com (doc-0c-ag-docs.googleusercontent.com)... 74.125.142.
Connecting to doc-0c-ag-docs.googleusercontent.com (doc-0c-ag-docs.googleusercontent.com)|74.125.142
```

```
Uber_dataset.zip    100%[===================>]  17.41M  48.6MB/s    in 0.

2022-07-01 13:34:49 (48.6 MB/s) - 'Uber_dataset.zip' saved [18251707/18251707]
```

```
[ ] !unzip Uber_dataset.zip
```

```
Archive:  Uber_dataset.zip
  inflating: uber_travel_data.csv
  inflating: __MACOSX/._uber_travel_data.csv
```

```
[ ] !ls -lrt
```

```
total 525784
-rw-r--r-- 1 root root 520141836 May 12 14:30 uber_travel_data.csv
drwxr-xr-x 1 root root      4096 Jun 29 13:44 sample_data
-rw-r--r-- 1 root root  18251707 Jul  1 13:34 Uber_dataset.zip
drwxr-xr-x 2 root root      4096 Jul  1 13:34 __MACOSX
```

```
[ ] import pandas as pd
```

```
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```

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total 525784
-rw-r--r-- 1 root root 520141836 May 12 14:30 uber_travel_data.csv
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drwxr-xr-x 2 root root      4096 Jul  1 13:34 __MACOSX
```

```
import pandas as pd

df = pd.read_csv("./uber_travel_data.csv")
df.sample(100).head()
```

	sourceid	source	dstid	destination	travel_time
3699703	234	113, Press Colony, Press Colony, Mayapuri, New...	76	124, SPG Quarters, Sector 4, Pushp Vihar, New ...	2695
2441504	156	Doctor Satpal Sachdeva Marg, Keshav Puram, Tri...	230	N494, Block N, Raghubir Nagar, Tagore Garden E...	958
1824456	119	81, Zulfe Bengal, Dilshad Garden, Delhi	58	Pushta Road, Block A, Rajiv Nagar, Sonia Vihar...	1401

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+ Code + Text Connect

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1824456	119	81, Zulfe Bengal, Dilshad Garden, Delhi	58	Pushta Road, Block A, Rajiv Nagar, Sonia Vihar...	1401
198463	11	Mother Teresa Crescent, Talkatora Garden, Cent...	283	NaN	957
488666	29	Street Number 14, Block C, Sitapuri Part 1, Ja...	60	NaN	3026

[ ]

```
df.shape
```

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+ Code + Text Connect

1824456	119	Delhi	58	Sonia Vihar...	1401
198463	11	Mother Teresa Crescent, Talkatora Garden, Cent...	283	NaN	957
488666	29	Street Number 14, Block G, Sitapuri Part 1, Ja...	60	NaN	3026

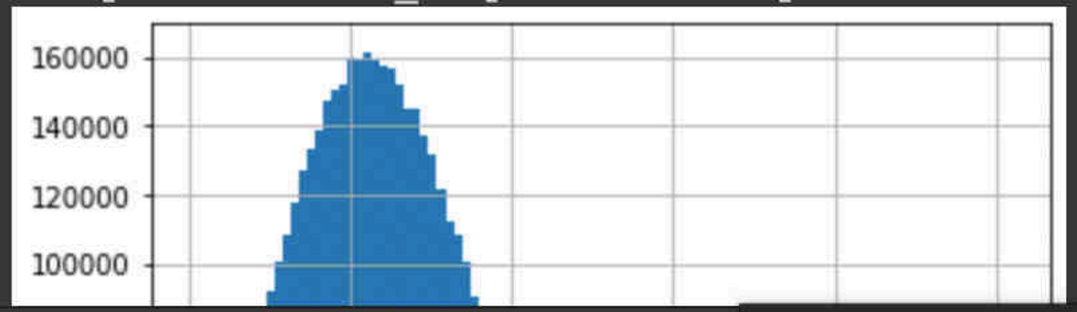
[ ] df.shape

Src dest time

(4542026, 5)

```
# histogram of travel_times
df["travel_time"].hist(bins = 100)
```

<matplotlib.axes._subplots.AxesSubplot at 0x7fde4ea25dd0>



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colab.research.google.com/drive/14XXagrZxnpzYGe_dHUZxE0xqRCngh9F1#scrollTo=dwbToyJk8E3V

Update

+ Code + Text Connect

```
(4542026, 5)
```

```
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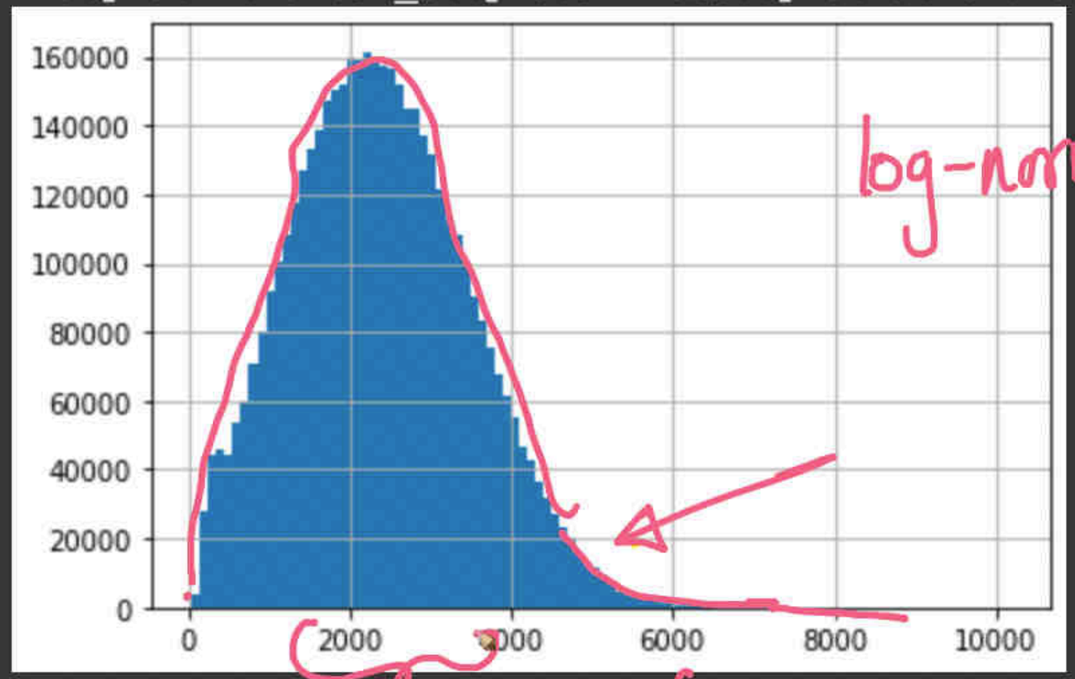
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fde4ea25dd0>
```

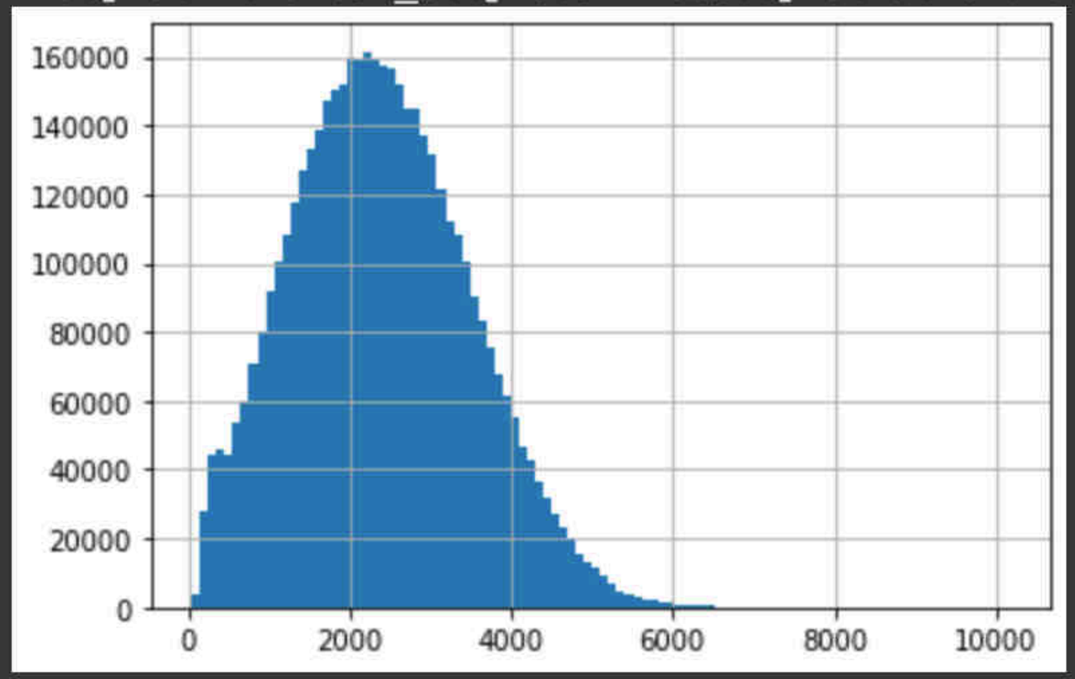


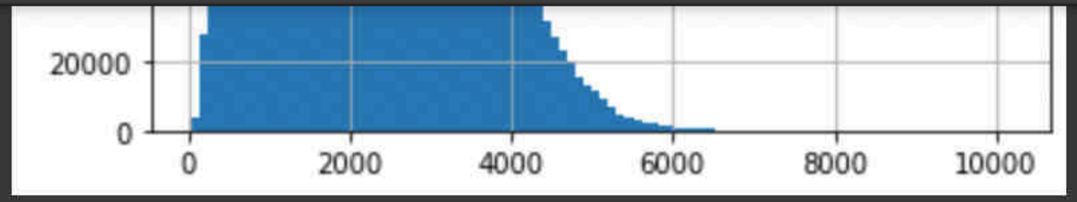

```
df.value_counts(['sourceid', 'dstid']).sort_values()
```

```
(4542026, 5)
```

```
# histogram of travel_times
df["travel_time"].hist(bins = 100)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fde4ea25dd0>
```






```
[ ] df.value_counts(['sourceid', 'dstid']).sort_values()
```

```
sourceid  dstid
69        4       50
167       107     50
          101     50
264       14      50
167       100     50
                  ..
83        88      79
244       32      79
202       201     79
          135     79
45        170     79
Length: 70429, dtype: int64
```

```
[ ] data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    data.shape
```

4.5 M → total

li

lj

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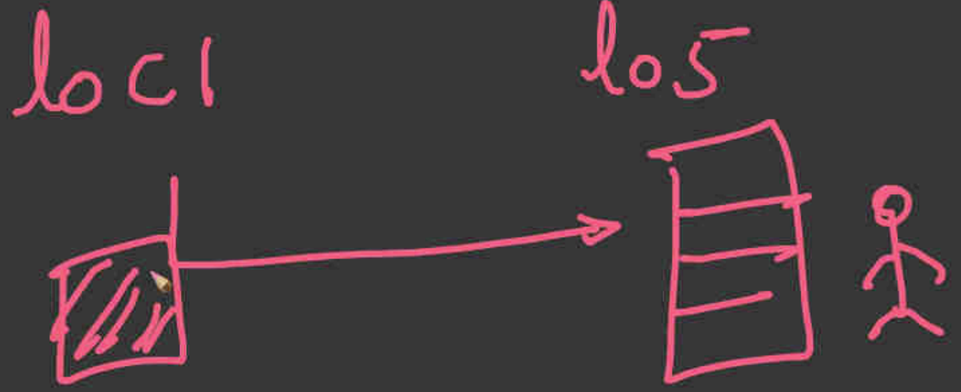
```
    sourceid  dstid
[ ] 69        4       50
    167       107     50
              101     50
    264       14      50
    167       100     50
                      ..
    83        88      79
    244       32      79
    202       201     79
              135     79
    45        170     79
    Length: 70429, dtype: int64
```




```
[ ] data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    data.shape
```

```
(75,)
```

```
data.hist(bins=30)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fde4e9b9f50>
```

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Update

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```
    sourceid  dstid
[ ] 69        4       50
    167       107     50
              101     50
    264       14      50
    167       100     50
                      ..
    83        88      79
    244       32      79
    202       201     79
              135     79
    45        170     79
    Length: 70429, dtype: int64
```

Tasks:

① asy. C.I of the mean .del.time

② asy. C.I of tPg9 of del.time

```
[ ] data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    data.shape
```

```
(75,)
```

```
data.hist(bins=30)
```

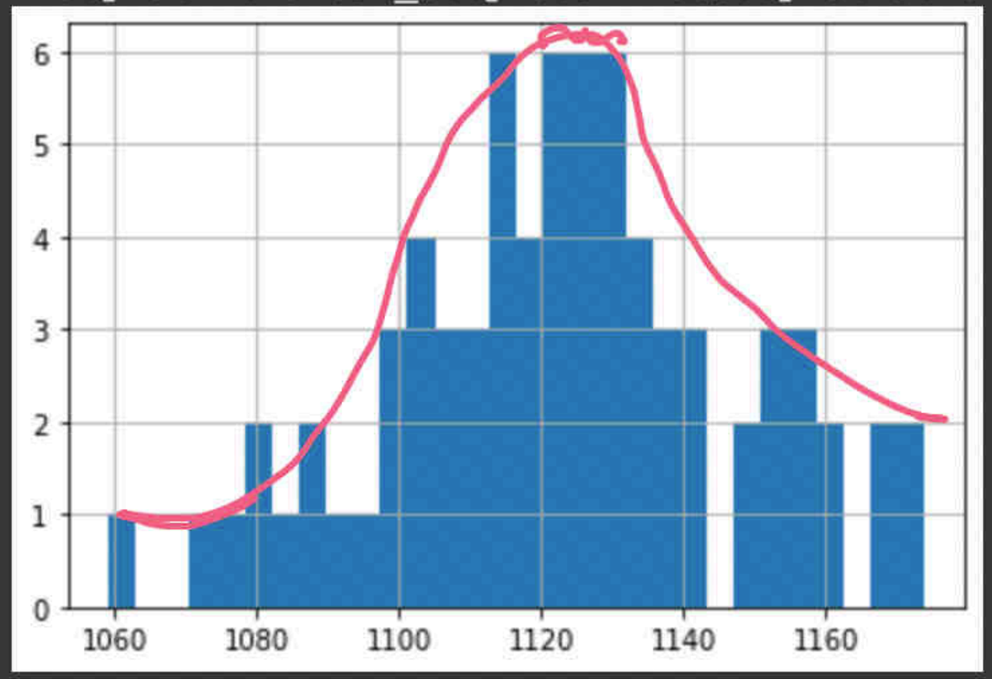
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fde4e9b9f50>
```

```
data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
data.shape
```

```
(75,)
```

```
data.hist(bins=30)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fde4e9b9f50>
```



Comp-technique

Bootstrapping

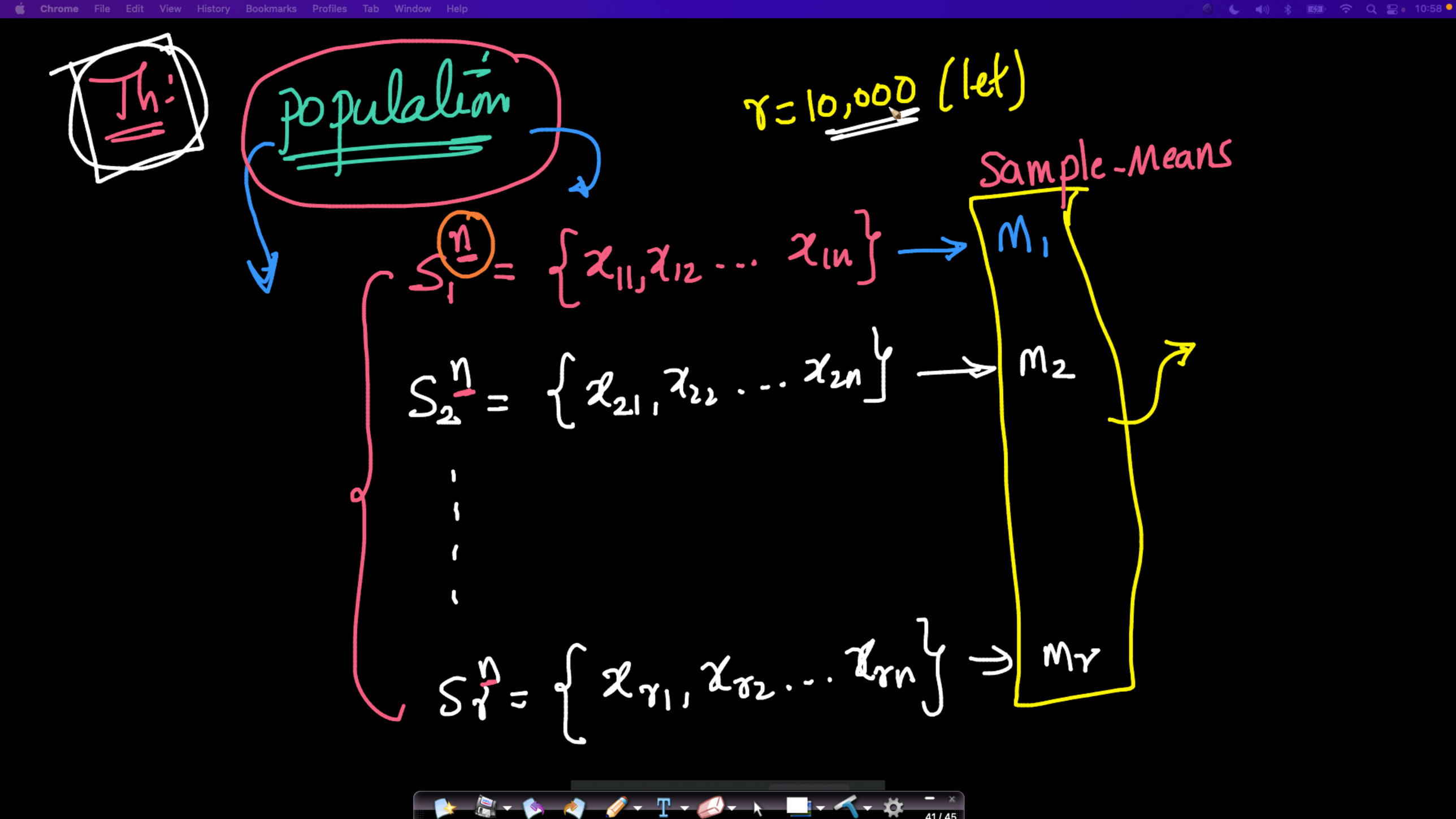
Input: x_1 x_2 ..... x_{75} ... x_n

① randomly sampled

Task: 95% C.I of the pop Mean std. time

② disb of the sample ≈ disb of the pop

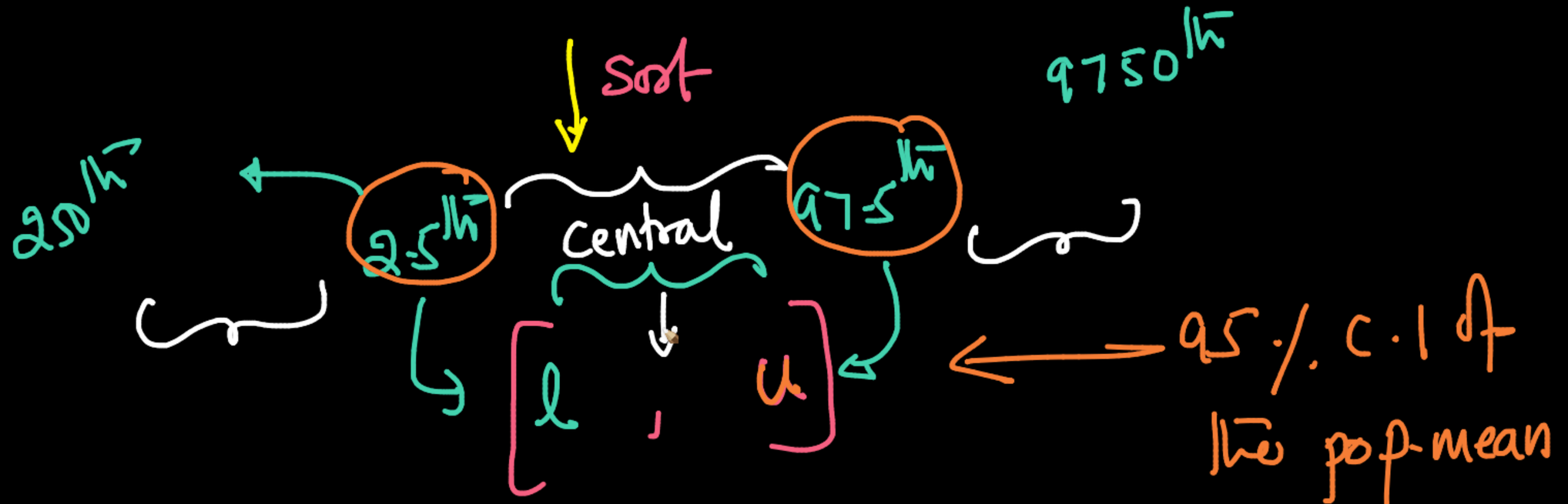
if n is not too small


Th:
Population
r = 10,000 (let)
Sample-Means
$S_1^n = \{x_{11}, x_{12} \dots x_{1n}\} \rightarrow m_1$
$S_2^n = \{x_{21}, x_{22} \dots x_{2n}\} \rightarrow m_2$
$S_r^n = \{x_{r1}, x_{r2} \dots x_{rn}\} \Rightarrow m_r$

Sample Means

$M_1, M_2 \ldots M_r$

10,000



4 lk per

99 lk per

X

95% C.I → 2.5 ka 97.5 ka

90% C.I → 5 ka 95 ka

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Pseudo-code:

means = [ ]

r = 10,000 ;

for i = 1 to r

- randomly sample n points from D

→ $x^i_1, x^i_2, \dots x^i_n$ with "replacement"

→ means[i] = Mean $\{x^i_1, x^i_2, \dots x^i_n\}$

- pick 2.5th per & 97.5th per in means to return

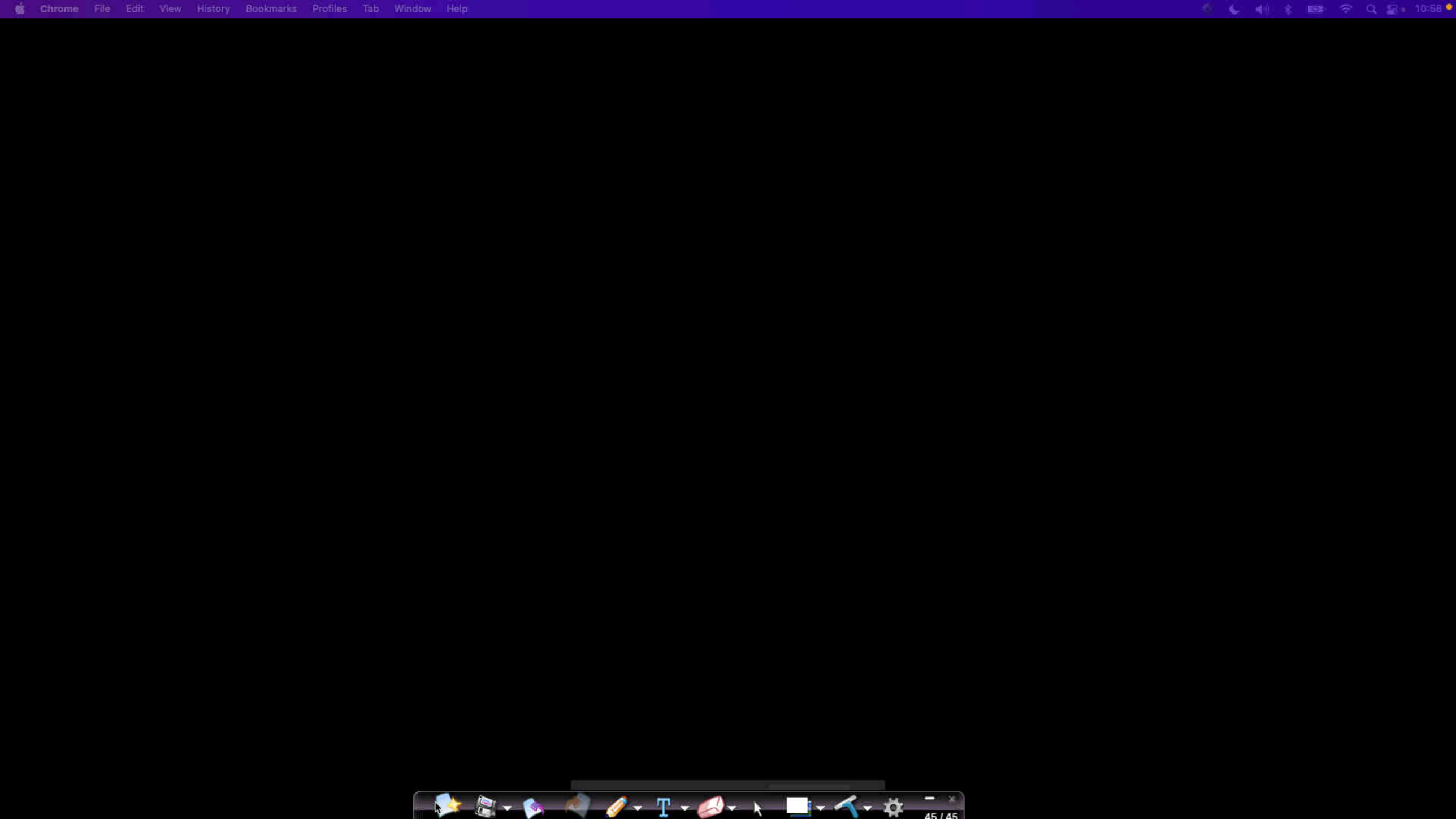
n ≥ 30

n = 50

n ≤ N

D $[x_1, x_2 \dots x_{75}]$ N

44 / 55


Chrome File Edit View History Bookmarks Profiles Tab Window Help
10:58
45 / 45

Width of the C.I → Sample size (n)

→ (Std. dev) Variability in the X

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+ Code + Text Connect

95% C.I on 99th percentile value for travel_time via bootsrapping

```
[ ] # What if we want a C.I on the 99th precentile?
    #Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
    # bs_99p is a list of 'r' bootstrap sample's 99th percentiles
    r = 10000
    data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    size = 75
    bs_99p = np.empty(r)

    for i in range(r):
        bs_sample = np.random.choice(data, size=size)
        bs_99p[i] = np.percentile(bs_sample,99)
```

```
[ ] len(bs_99p)
```

```
10000
```

47 / 47

95% C.I on 99th percentile value for travel_time via bootsrapping

```
[ ] # What if we want a C.I on the 99th precentile?
    #Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
    # bs_99p is a list of 'r' bootstrap sample's 99th percentiles
    r = 10000
    data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    size = 75
    bs_99p = np.empty(r)

    for i in range(r):
        bs_sample = np.random.choice(data, size=size)
        bs_99p[i] = np.percentile(bs_sample,99)
```

```
[ ] len(bs_99p)

    10000
```

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+ Code + Text

Connect

Task 1 & 2

95% C.I on 99th percentile value for travel_time via bootsrapping

$n \geq 30$ & $n \leq N$

```
[ ] # What if we want a C.I on the 99th precentile?
    #Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
    # bs_99p is a list of 'r' bootstrap sample's 99th percentiles
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    data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    size = 75
    bs_99p = np.empty(r)

    for i in range(r):
        bs_sample = np.random.choice(data, size=size)
        bs_99p[i] = np.percentile(bs_sample,99)
```

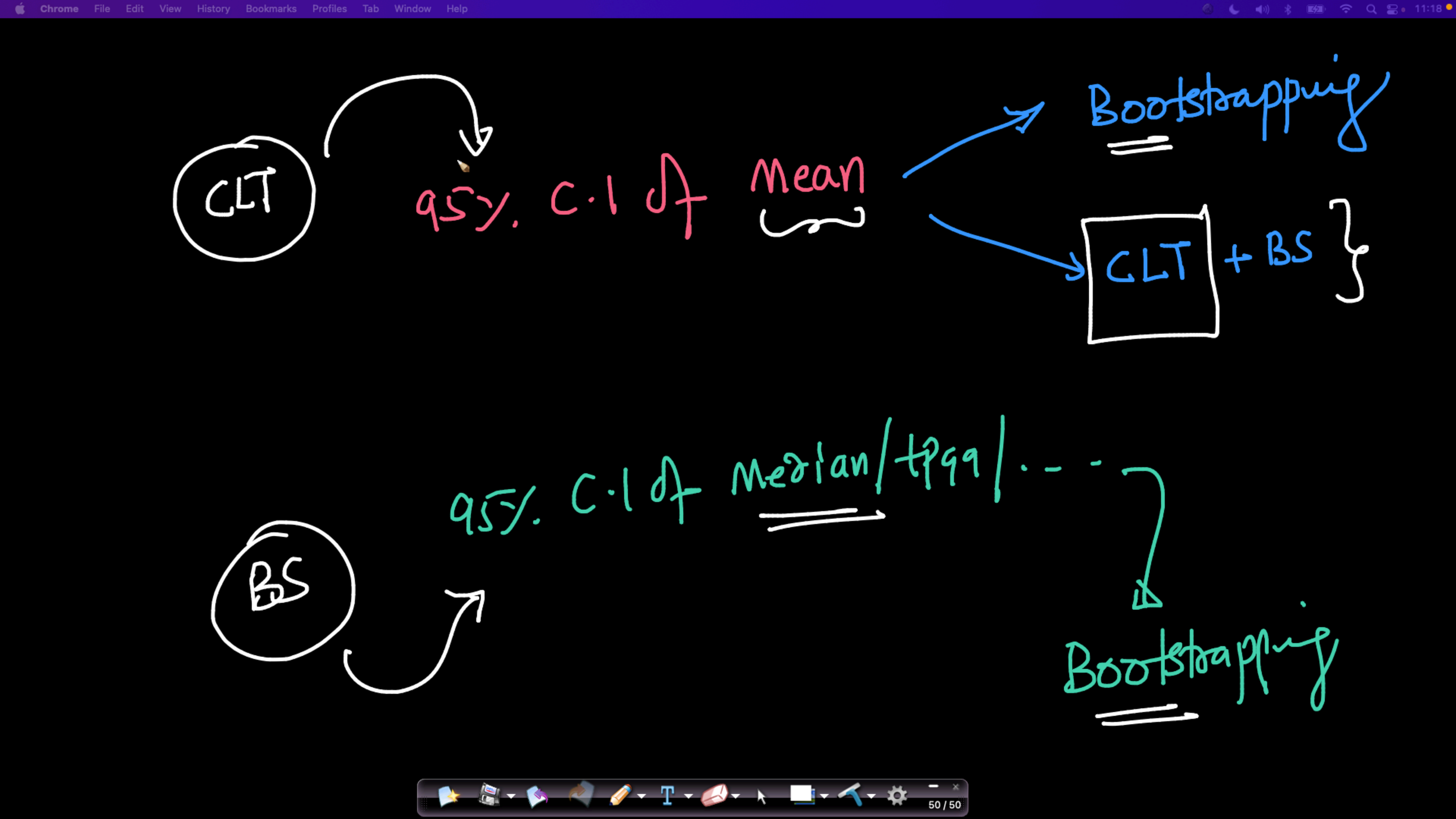
loc1 loc5

N=75

```
[ ] len(bs_99p)
```

```
10000
```

49 / 49


CLT
95% C.I of Mean
Bootstrapping
CLT + BS
95% C.I of Median/tp99/...
BS
Bootstrapping

+ Code + Text Connect

95% C.I on 99th percentile value for travel_time via bootsrapping

N=75

```
[ ] # What if we want a C.I on the 99th precentile?
    #Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size 1000
    # bs_99p is a list of 'r' bootstrap sample's 99th percentiles
    r = 10000
    data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
    size = 75
    bs_99p = np.empty(r)
    for i in range(r):
        bs_sample = np.random.choice(data, size=size)
        bs_99p[i] = np.percentile(bs_sample,99)
```

n=

```
[ ] len(bs_99p)

    10000
```

95% C.I on 99th percentile value for travel_time via bootsrapping

```
[ ] # What if we want a C.I on the 99th precentile?
    #Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
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    for i in range(r):
        bs_sample = np.random.choice(data, size=size)
        bs_99p[i] = np.percentile(bs_sample,99)
```

```
[ ] len(bs_99p)

    10000
```

95% C.I on 99th percentile value for travel_time via bootsrapping

```
# What if we want a C.I on the 99th precentile?
#Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
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data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
size = 75
bs_99p = np.empty(r)

for i in range(r):
    bs_sample = np.random.choice(data, size=size)
    bs_99p[i] = np.percentile(bs_sample,99)
```

n ≤ N = 75

```
[ ] len(bs_99p)
```

```
10000
```

95% C.I on 99th percentile value for travel_time via bootsrapping

```
# What if we want a C.I on the 99th precentile?
#Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
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    bs_sample = np.random.choice(data, size=size)
    bs_99p[i] = np.percentile(bs_sample,99)
```

```
[ ] len(bs_99p)
```

```
10000
```

95% C.I on 99th percentile value for travel_time via bootsrapping

```
# What if we want a C.I on the 99th precentile?
#Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
# bs_99p is a list of 'r' bootstrap sample's 99th percentiles
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size = 75
bs_99p = np.empty(r)

for i in range(r):
  bs_sample = np.random.choice(data, size=size)
  bs_99p[i] = np.percentile(bs_sample,99)
```

```
[ ] len(bs_99p)
```

```
10000
```

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+ Code + Text Connect

95% C.I on 99th percentile value for travel_time via bootsrapping

```
# What if we want a C.I on the 99th precentile?
#Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=1000
# bs_99p is a list of 'r' bootstrap sample's 99th percentiles
r = 10000
data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
size = 75
bs_99p = np.empty(r)

for i in range(r):
    bs_sample = np.random.choice(data, size=size)
    bs_99p[i] = np.percentile(bs_sample,99)
```

tp_{99}^{1} tp_{99}^{2} ⋮ tp_{99}^{r}

```
[ ] len(bs_99p)
```

```
10000
```

56 / 56

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+ Code + Text Connect

```
10000
```

```
[ ] bs_99p
```

```
array([1167., 1167., 1174., ..., 1174., 1174., 1174.])
```

95% C.I on the 99th percentile

[1162.56, 1174.0]

```
[ ] #bs_99p may or maynot be normally distributed.
    print(np.percentile(bs_99p,2.5))
    print(np.percentile(bs_99p,97.5))
```

```
1162.56
1174.0
```

```
[ ] # Point estimate of the 99th percenitle of the 75 observed samples
    print(np.percentile(data,99))
```

```
1174.0
```

57 / 57

Swiggy :-

95% C.I on t99

weather = R

DoW = ...

ToD = ...

festival = ...

↓

Bayesian ML

CLT

Bootstrapping → no assumptions about population

Non-Param Techchniques

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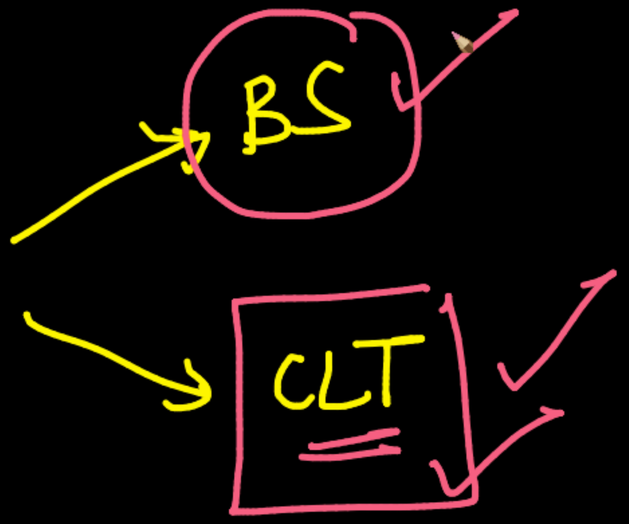
Param. stats → Make some assumptions about the pop

↗ CLT

95% C.I of Mean



60 / 60

CLT:

means

X:

any d'sb
of finite
Mean &
std-dev

necessary cond 2

if pop. mean & std-dev σ are finite

mean sample means

$S_1^n \rightarrow m_1$

$S_2^n \rightarrow m_2$

$S_3^n \rightarrow m_3$

$\vdots$

$S_r^n \rightarrow m_r$

$\frac{\sigma}{\sqrt{n}}$

d'sb of sample means

CLT:

Statement →

X: finite pop mean (μ) & pop Std-dev (σ)

each sample is size n

disb. of sample means

$$N\left(\mu, \frac{\sigma}{\sqrt{n}}\right)$$

as $n \to \infty$

CLT + BS

$\mathcal{D} = x_1, x_2 \ldots x_{75} = N$ → random sample of size n from pop

BS

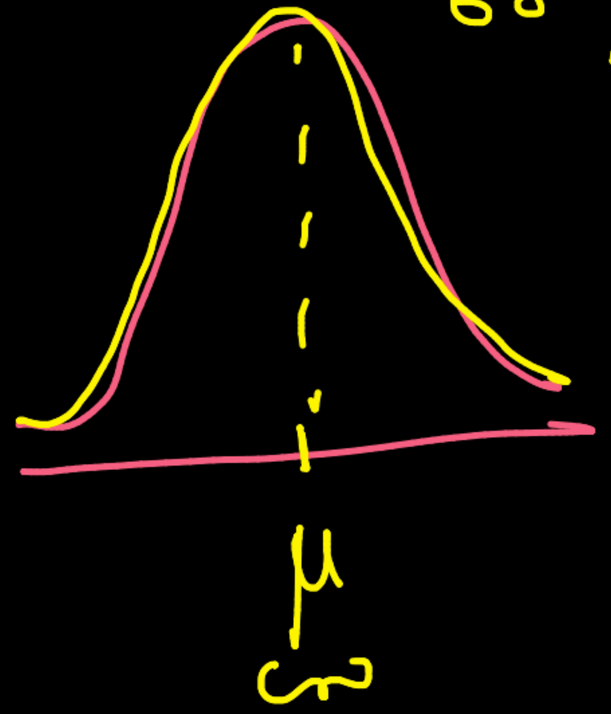
$S_1^{n=50}$ → m_1

$S_2^{n=50}$ → m_2

S_Y^{n} → m_Y

sample means

→



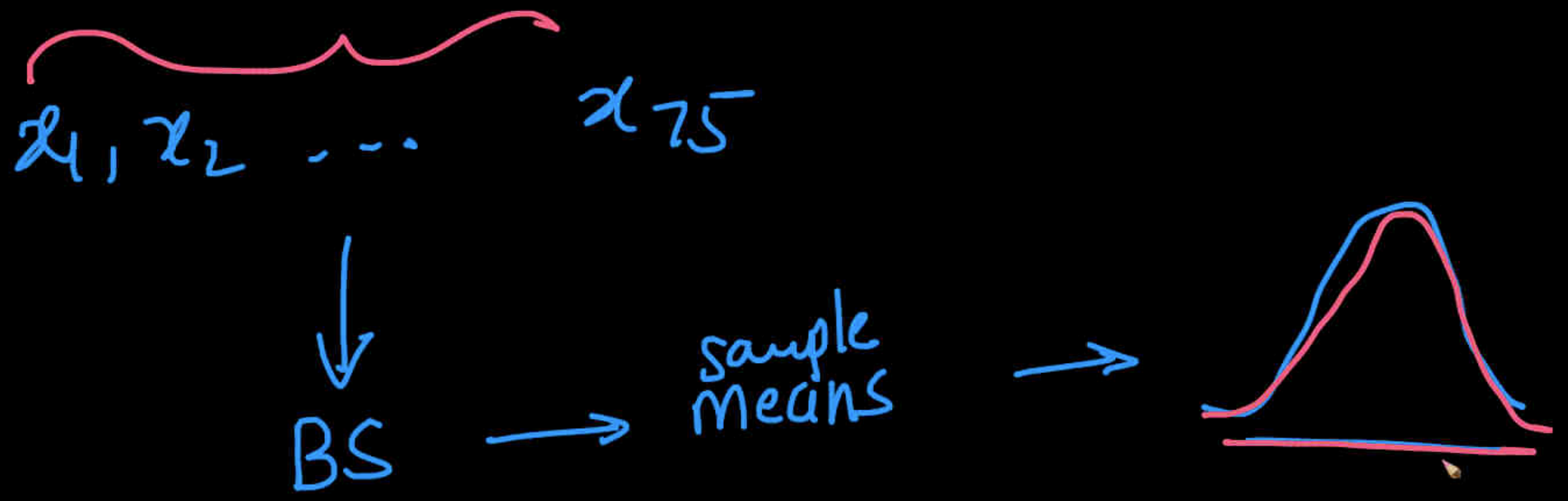
68-95-99.7 rule

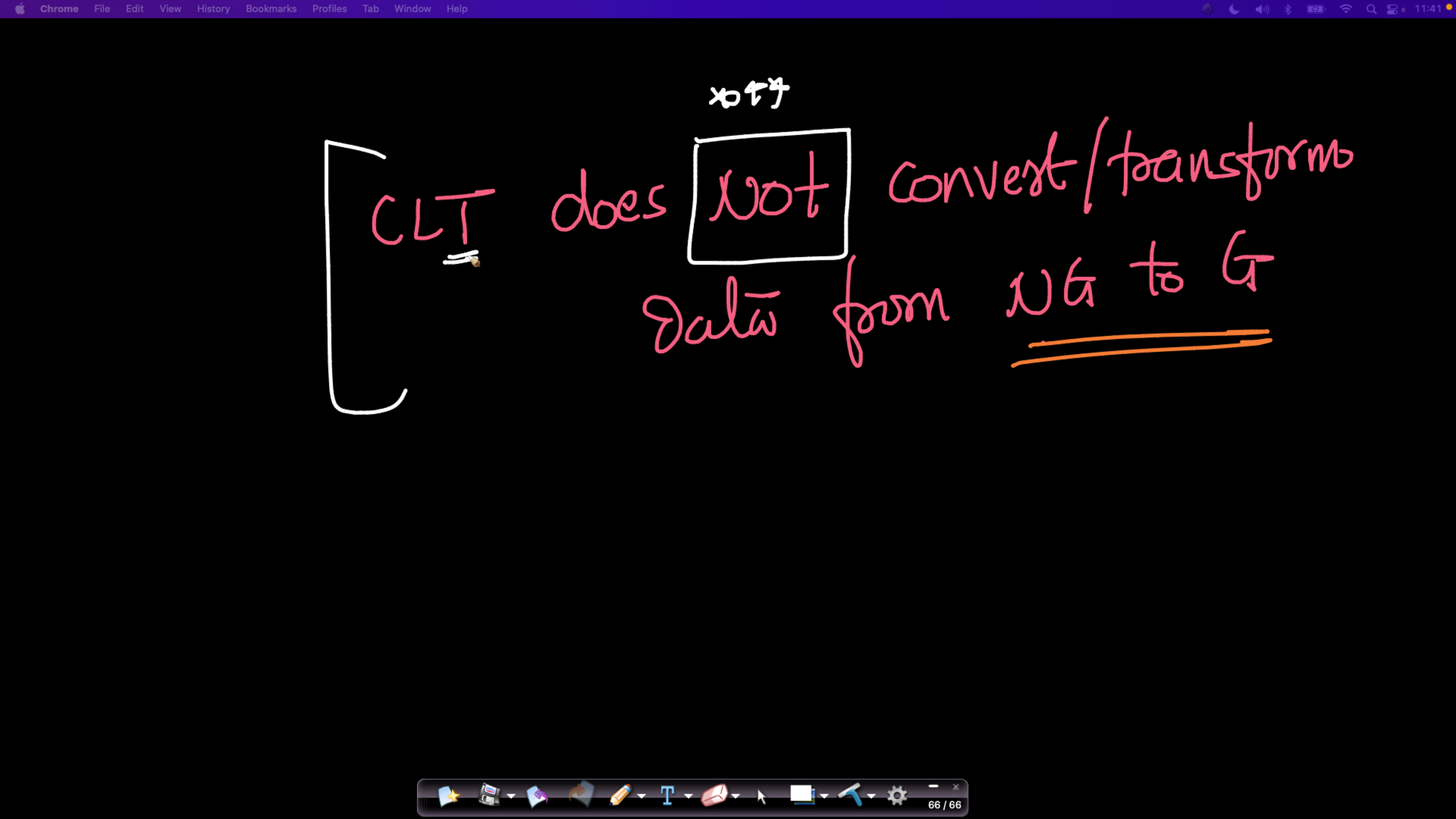
Sample-means $\sim N\left(\mu, \frac{\sigma}{\sqrt{n}}\right)$ ← S

$\hat{\mu}$ ← $m_1, m_2 \cdots m_r$ → Mean (m_i's) $= \hat{\mu} \approx \mu$

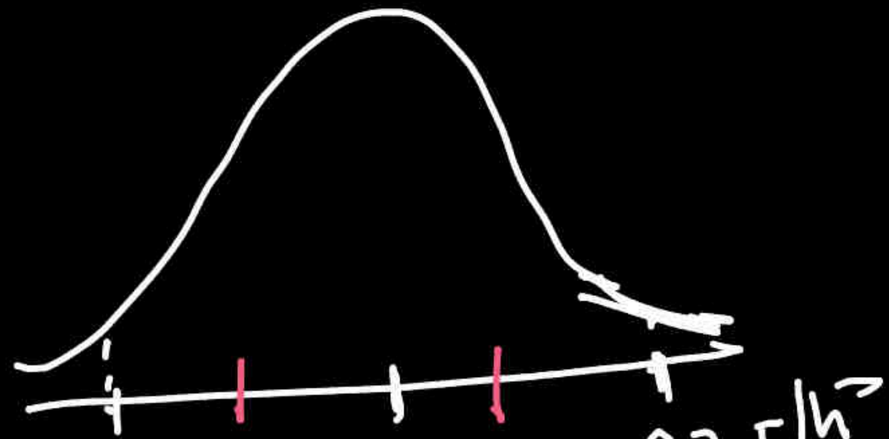
S (let)

95% C.I of mean → $\left[\hat{\mu} - 1.96 S, \hat{\mu} + 1.96 S\right]$


$x_1, x_2 \ldots x_{75}$
BS
sample means


CLT does not convert/transform
data from UG to G
66 / 66

68 - 95 - 99.7



$\mu - 1.96\sigma$

$\mu + 1.96\sigma$

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+ Code + Text Connect

CLT for C.I on mean of travel_time

```
[ ]  # Let's create r=10000 bootstrap samples, and let each bootstrap sample be of size=50
     # bs_means is a list of 'r' bootstrap sample means
     r = 10000
     data = df[(df["sourceid"] == 1) & (df["dstid"] == 5)] ["travel_time"]
     size = 50
     bs_means = np.empty(r)

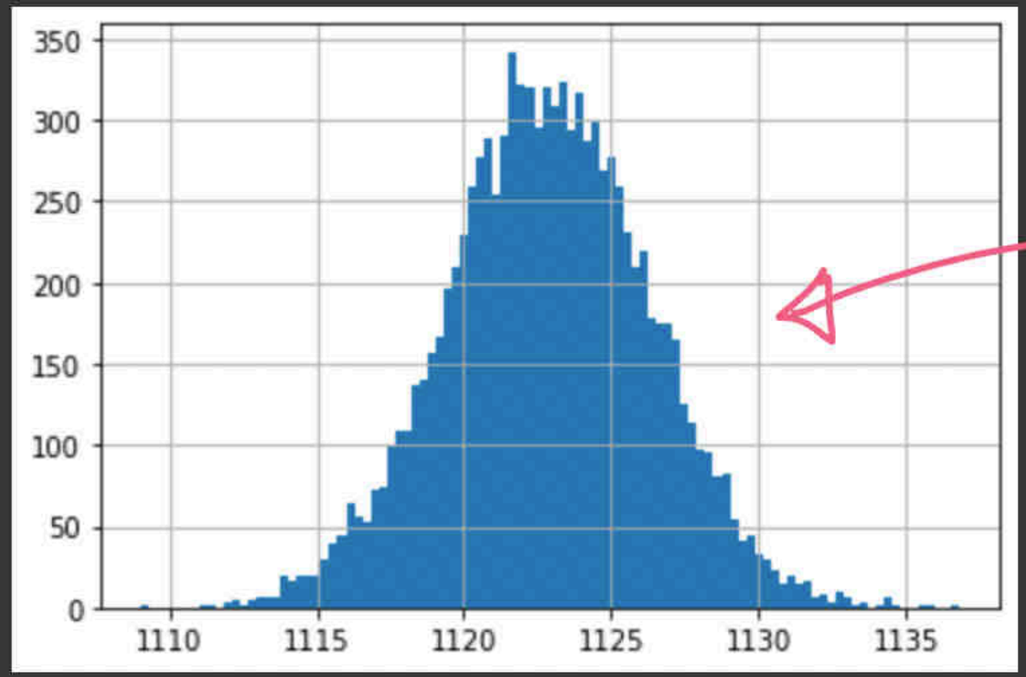
     for i in range(r):
         bs_sample = np.random.choice(data, size=size)
         bs_means[i] = np.mean(bs_sample)
```

```
[ ]  import matplotlib.pyplot as plt
     plt.figure()
     plt.hist(bs_means, bins=100)
     plt.grid()
     plt.show()
```

68 / 68

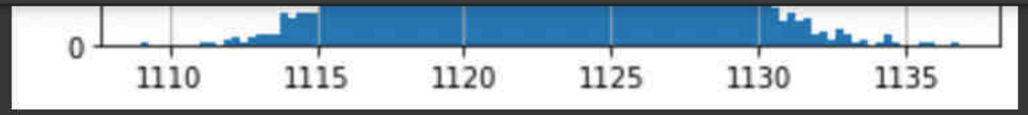
```
plt.figure()
plt.hist(bs_means, bins=100)
plt.grid()
plt.show()
```

n



disb of Sample-means

```
[ ] # QQ-plot with normal distribution
```



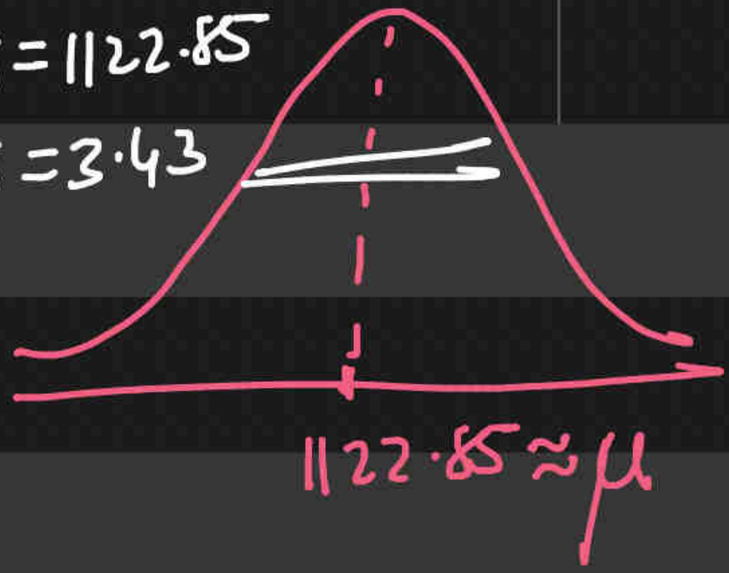

```
# QQ-plot with normal distribution
```

```
# compute C.I on the mean given that bs_means follows Gaussian distribution: CLT
print(np.mean(bs_means))
print(np.std(bs_means))
```

```
1122.85326
3.4374772628193493
```

$\hat{\mu} = 1122.85$

$S = 3.43$



$\hat{\mu} - 2S$

```
print(np.mean(bs_means)-2*np.std(bs_means))
print(np.mean(bs_means)+2*np.std(bs_means))
```

```
1115.9783054743614
1129.7282145256388
```

```
# could we just use the 2.5th percentile and 97.5th percentile value
```

```
[ ]
```

```
1122.85326
3.4374772628193493
```

```
[ ] print(np.mean(bs_means)-2*np.std(bs_means))
    print(np.mean(bs_means)+2*np.std(bs_means))
```

```
1115.9783054743614
1129.7282145256388
```

```
[ ] # could we just use the 2.5th percentile and 97.5th percentile value
    print(np.percentile(bs_means,2.5))
    print(np.percentile(bs_means,97.5))

    # what if r is say 100 and not 10,000?
```

```
1116.02
1129.52
```

95% C.I on 99th percentile value for travel_time via bootsrapping

CLT:

Sample-means $\sim N\left(\mu, \frac{\sigma}{\sqrt{n}}\right)$ as $n \to \infty$

$m_1, m_2 \ldots m_r$

↳ std. dev of sample means = std. error

Terminology

CLT:

[1122.1 1155.1]

width = 30.0

{ Margin of Error = 1/2 width

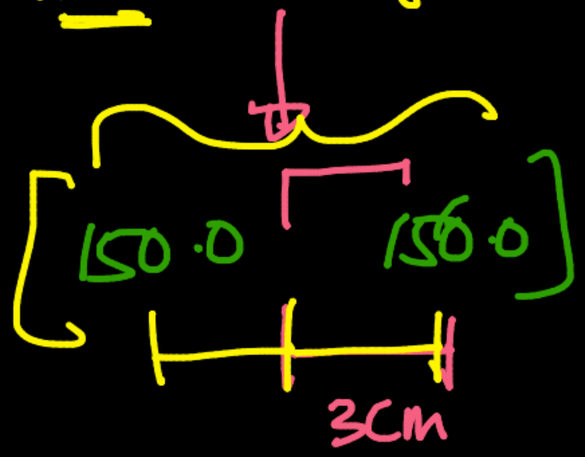
Q

heights

{ Sample-size = 100

MoE = 3cm

95% C.I for Mean height



CLT

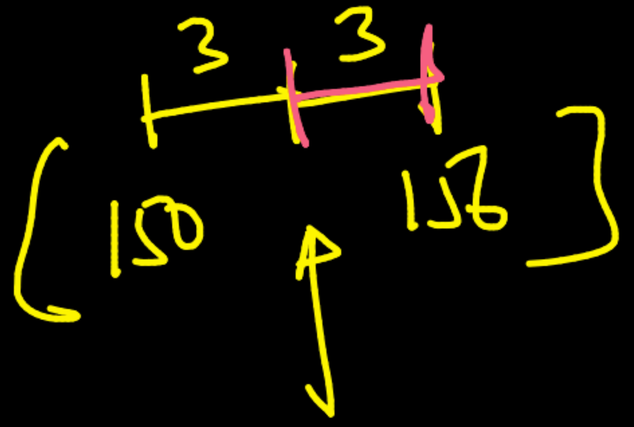
Sample mean $\sim N\left(\mu, \frac{\sigma}{\sqrt{n}}\right)$

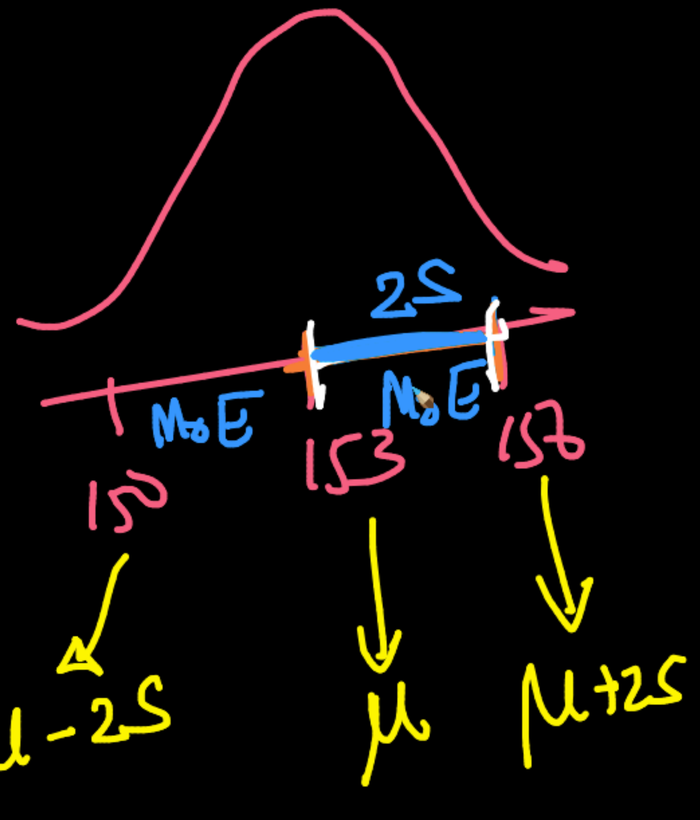
Q How many more samples do I have to get to make my MoE = 1.5 cm

360

asy. C.I of Mean
CLT

C-1 →

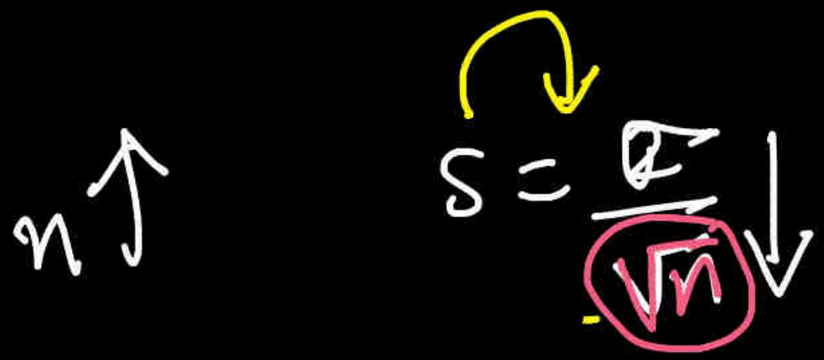


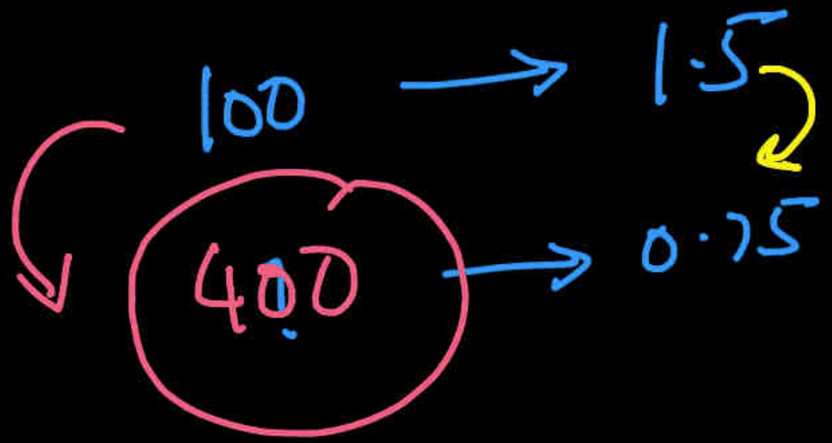


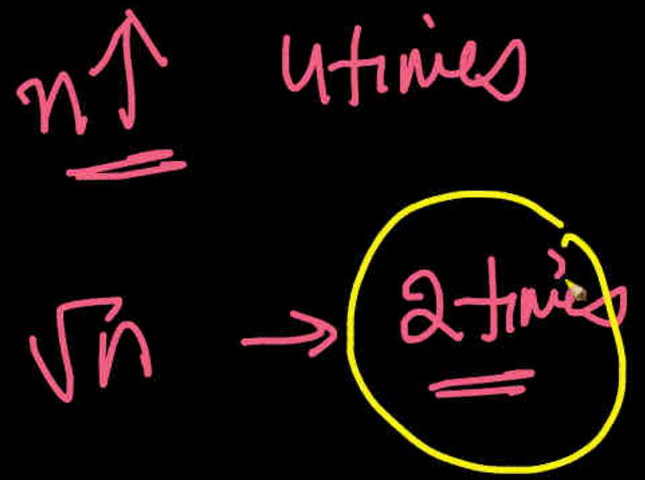
$$\text{Sample means} \sim N\left(\mu, \frac{\sigma}{\sqrt{n}}\right)$$

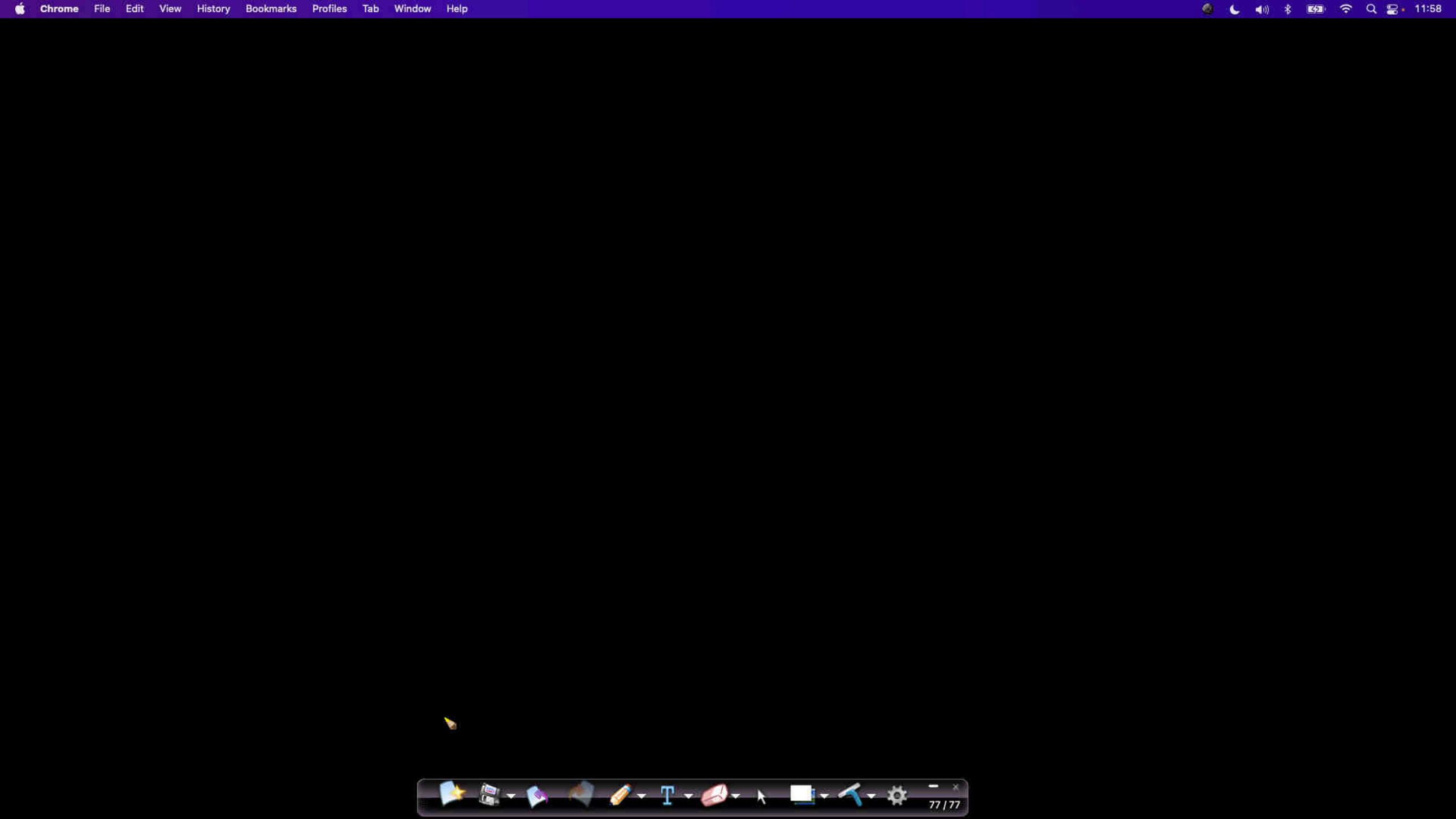
σ: SD, n: sample size

$$\frac{2\sigma}{\sqrt{n}} \downarrow$$





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11:58
77 / 77

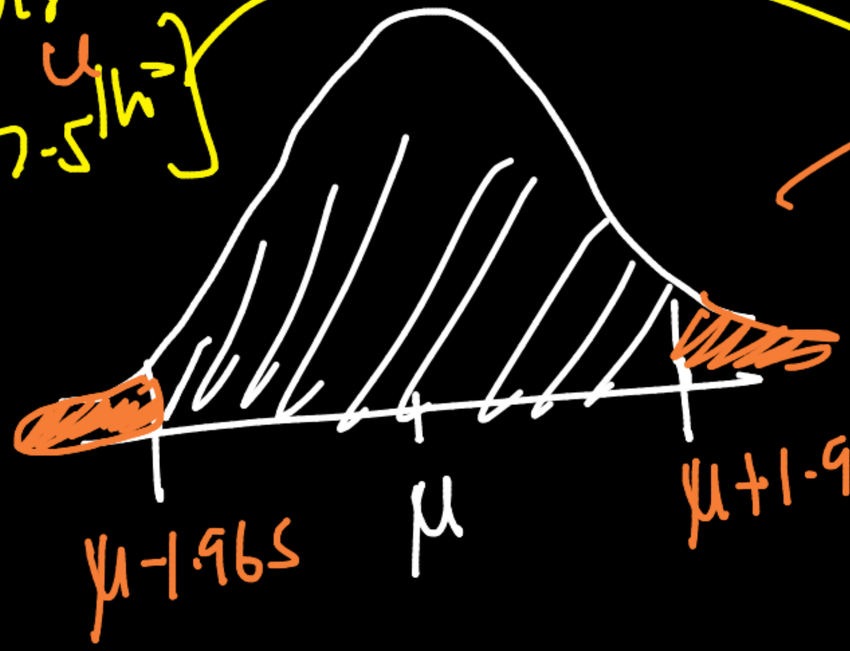
1. 95% C.I of any metric ⟶ BS

95 C.I of Mean ⟶ CLT + BS

2. CLT is NOT a transformation

$M_1, M_2 \cdots M_r$

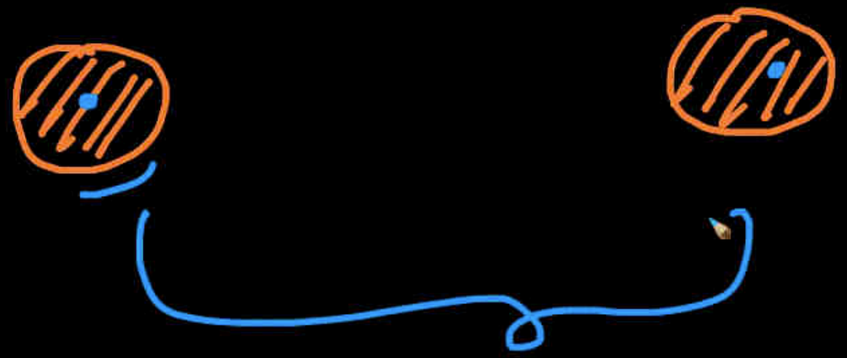
[l 2.5 lh, u 97.5 lh]

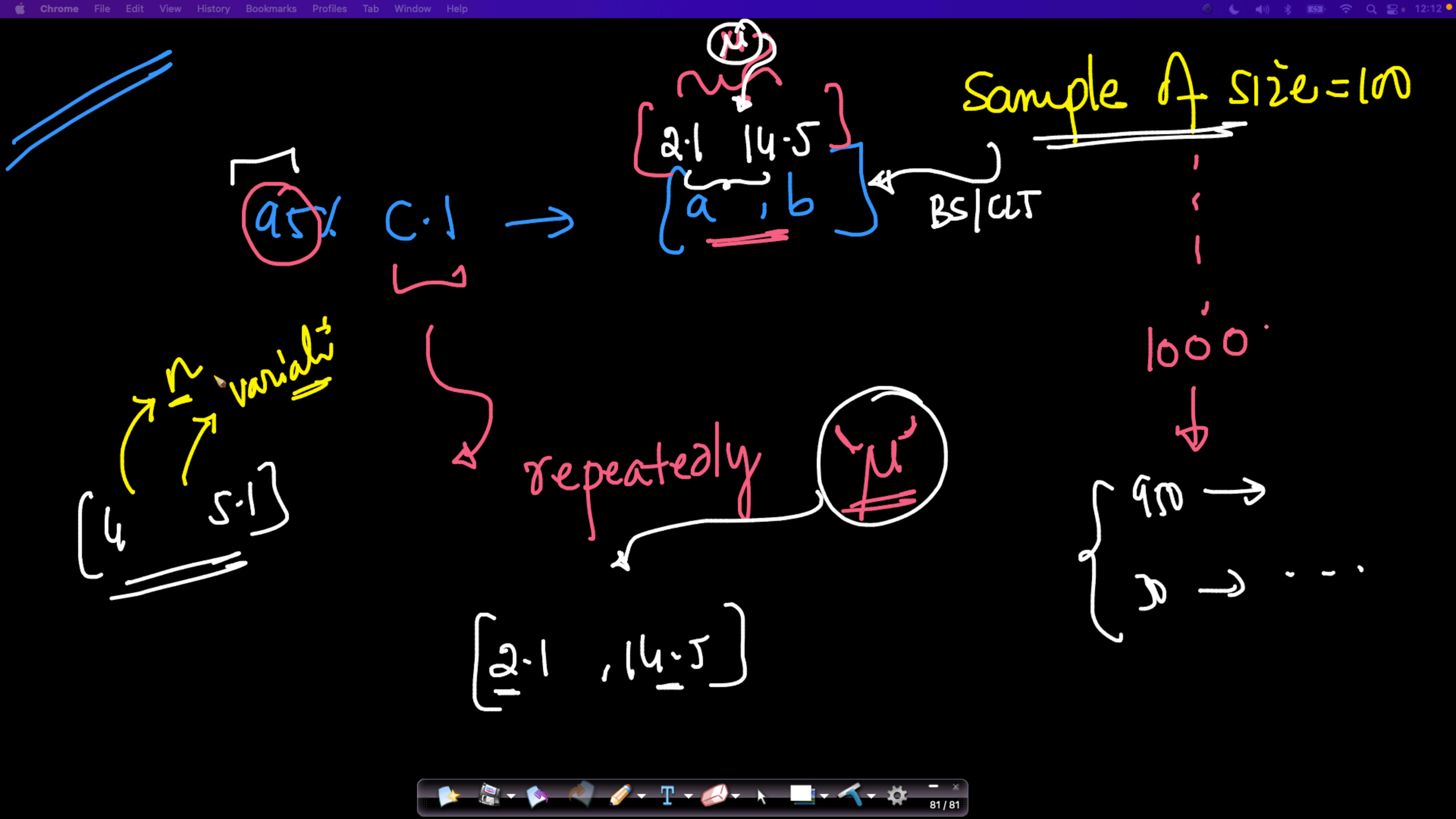


68 - 95 - 99.) rule

$\mu - 1.96S$

$\mu + 1.96S$




Chrome File Edit View History Bookmarks Profiles Tab Window Help
95%
C.I
[2.1 14.5]
[a ; b]
BS|CLT
Sample of size=100
1000
[4 5.1]
variable
repeatedly
[2.1 , 14.5]
81 / 81

who were hospitalized with Covid-19 and had evidence of lower respiratory tract infection. Patients were randomly assigned to receive either remdesivir (200 mg loading dose on day 1, followed by 100 mg daily for up to 9 additional days) or placebo for up to 10 days. The primary outcome was the time to recovery, defined by either discharge from the hospital or hospitalization for infection-control purposes only.

RESULTS

A total of 1062 patients underwent randomization (with 541 assigned to remdesivir and 521 to placebo). Those who received remdesivir had a median recovery time of 10 days (95% confidence interval [CI], 9 to 11) as compared with 15 days (95% CI, 13 to 18) among those who received placebo (rate ratio for recovery, 1.29; 95% CI, 1.12 to 1.49; P<0.001, by a log-rank test). In an analysis that used a proportional-odds model with an eight-category ordinal scale, the patients who received remdesivir were found to be more likely than those who received placebo to have clinical improvement at day 15 (odds ratio, 1.5; 95% CI, 1.2 to 1.9, after adjustment for actual disease severity). The Kaplan–Meier estimates of mortality were 6.7% with remdesivir and 11.9% with placebo by day 15 and 11.4% with remdesivir and 15.2% with placebo by day 29 (hazard ratio, 0.73; 95% CI, 0.52 to 1.03). Serious adverse events were reported in 131 of the 532 patients who received remdesivir (24.6%) and in 163 of the 516 patients who received placebo (31.6%).

CONCLUSIONS

Our data show that remdesivir was superior to placebo in shortening the time to recovery in adults who were hospitalized with Covid-19 and had evidence of lower respiratory tract infection. (Funded by the National Institute of Allergy and Infectious Diseases and others; ACTT-1 ClinicalTrials.gov number, NCT04280705.)

Remdesivir for 5 or 10 Days in Patients with Severe Covid-19
J.D. Goldman and Others

CORRESPONDENCE SEP 3, 2020
Remdesivir for the Treatment of Covid-19 — Preliminary Report

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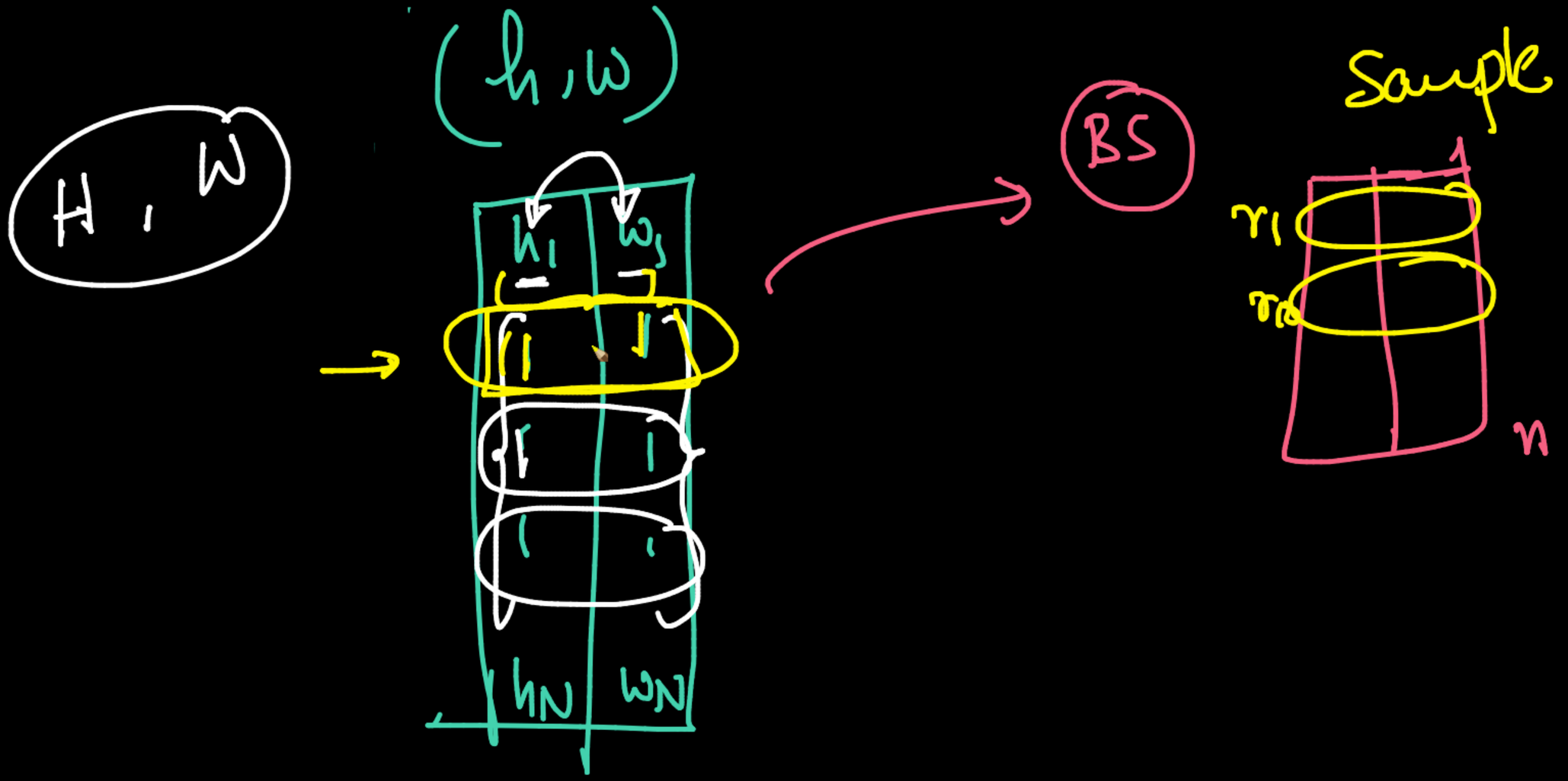
H , W
(h , w)
BS
Sample
n

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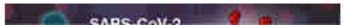

QUICK TAKE

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