Date 11-06-2026

PSYCH 10 Tutorial Session · Fall 2026

Week 7 · The Sampling Machine

Full name (in CAPITAL LETTERS) _____ **SUNet ID** (the part before @stanford.edu) _____ **Section** (e.g., TUES 9:30) _____

Please write legibly so the teaching team can log your attendance: if we can't read your name, we can't give you credit.

The situation

> **Q. Ledger** has built a sampling machine. "Last year I timed every visit to **Café Variantia**, from joining the line to holding a cup: 10,000 waits in all," Ledger says. "The machine draws random samples from those 10,000 waits. It can print a histogram of all the waits, of one sample, or of the means of 1,000 samples. Jo ran it all morning and forgot to put titles on the printouts."
>
> **Four printouts are missing their titles. Match each printout to its title, then use the printouts in Parts 2 and 3.**

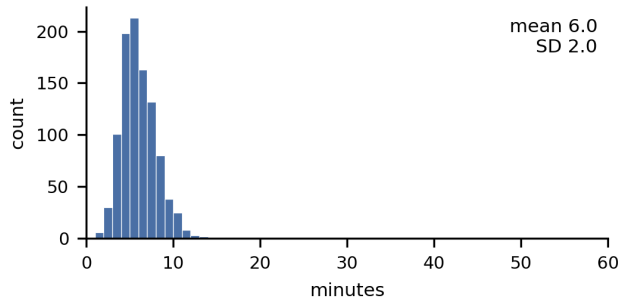
The file

Last year's 10,000 waits had a mean of 6 minutes and an SD of 6 minutes. Most waits were short, but a few were very long, because the espresso machine broke down about once a week.

Part 1 · Match the printouts

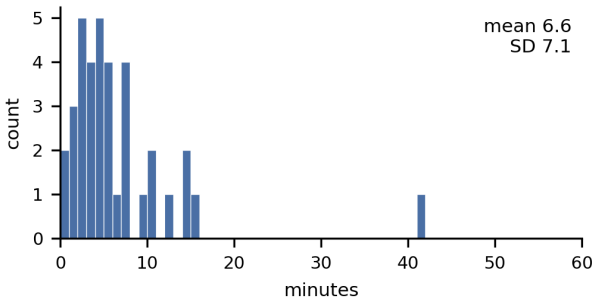
Under each printout, circle its title. Each title belongs to one printout.

Printout A



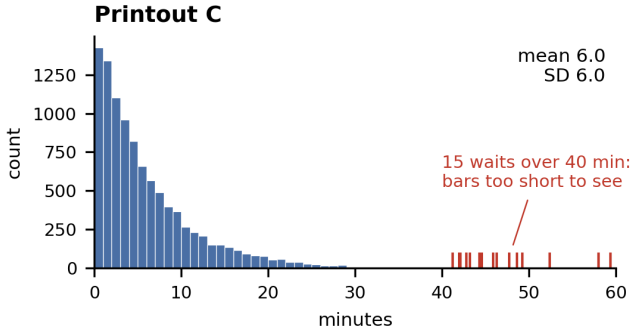
all 10,000 waits · one sample of 36
means of samples of 9 · means of samples of 36

Printout B



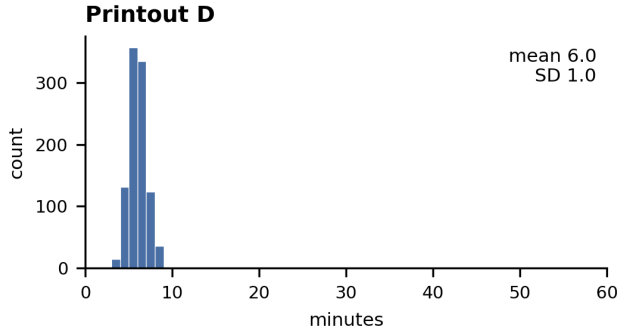
all 10,000 waits · one sample of 36
means of samples of 9 · means of samples of 36

Printout C



all 10,000 waits · one sample of 36
means of samples of 9 · means of samples of 36

Printout D



all 10,000 waits · one sample of 36
means of samples of 9 · means of samples of 36

How can you tell printout A from printout D?

_____

Printout B has one wait of about 41 minutes, far from the other waits. Jo thinks the sampling machine made an error and wants to delete this wait. Circle one: delete · keep. Justify your answer.

Part 2 · The standard error

Take many random samples of the same size and compute an estimate, such as the mean, from each sample. The distribution of these estimates is a **sampling distribution**, and its SD is called the **standard error**. For the mean of a sample of n waits, the standard error is **the SD of all 10,000 waits divided by $\sqrt{n}$**.

a. For samples of 9, the standard error of the mean is 6 / $\sqrt{9}$ = _____ minutes. For samples of 36, it is 6 / $\sqrt{36}$ = _____ minutes. The samples of 36 are 4 times as large, and their standard error is _____ as large.

b. The waits are skewed. For samples of 36, circle the shape of the sampling distribution of the mean: **skewed · roughly normal**

c. Jo says: "The standard error for samples of 36 is small, so the 36 waits in my one sample should have an SD much smaller than 6 minutes." Circle one: **right · wrong**. Justify your answer using two printouts.

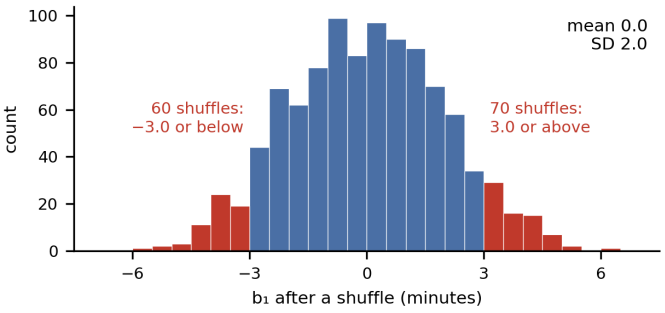
Part 3 · The new espresso machine

The café has a new espresso machine, and the manager, **Percy Lator**, says that it has shortened the wait. To test this claim, Percy timed 36 visits. Half of the visits, chosen at random, were served from the new machine, and the other half from the old machine.

The mean wait was 7.0 minutes with the old machine and 4.0 minutes with the new machine. The difference between the two means is b_1 = 4.0 — 7.0 = —**3.0 minutes**.

Could a difference of this size arise by chance, with no effect of the new machine? Jo set the sampling machine to **shuffle**. In each shuffle, the machine deals the labels "new" and "old" (18 of each) to the 36 waits at random and computes b_1 for the shuffled labels. **Printout E** is a histogram of the b_1s from 1,000 shuffles. It approximates the sampling distribution of b_1 if the new machine made no difference.

Printout E



a. In one shuffle, b_1 was —2.5 minutes. Circle the source of this difference: **the new machine · the random dealing of the labels**

b. The **p-value** is the probability of a b_1 at least as far from 0 as Percy's —3.0, in either direction, if the new machine made no difference (the empty model). Estimate it from the red counts on printout E: p-value = (_____ + _____) / 1,000 = _____

c. Percy says: "The wait was 3 minutes shorter, so the new machine works." By a common convention, researchers reject the empty model when the p-value is below .05. Is Percy's conclusion justified? Circle one: **yes · no**. Justify your answer using the p-value.

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d. For Percy's 36 visits, the standard error of b_1 is about 2.0 minutes (the SD of printout E). Suppose Percy repeats the study with 4 times as many visits (144, half on each machine), and b_1 is again —3.0 minutes. By the pattern in Part 2a, the new standard error would be about _____ minutes, so the shuffled b_1s would vary less around 0. Circle your prediction for the new p-value: **larger than in part b · about the same · smaller than in part b**