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CSE 107
Lab 1

This outlines the results of a simulated experiment to understand the probability of one participant Bob getting more heads than another Alice in a coin toss scenario. The experiment is based on Problem 27 in the textbook, involving independent coin tosses with variable probabilities.

The experiment was simulated using Python. For each trial, Bob tosses $n + 1$ coins, while Alice tosses n coins, where n is set to 300. This makes the total number of coins $2n + 1$. The simulation involved two distinct parts:

Validation Experiment for $p = 0.5$ the theoretical probability of the scenario where each coin had an equal probability 50% of landing heads. The task was to perform 1000 trials for this unbiased coin scenario where $p = 0.5$. The purpose of this separate simulation was to confirm the hypothesis that when the coin tosses are fair the probability of Bob getting more heads than Alice should be close to 0.5. The outcome of this experiment is a verification for comparing results under different probabilities.

Now the objective is to address additional simulations for a range of probabilities p for getting a heads. Running 1000 trials for each probability p in the set {0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8}. The aim here was to observe how the relative frequency of Bob getting more heads than Alice changes with varying probabilities which could result in potential bias in the coin toss.

In both parts of the experiment the relative frequency was calculated as the number of trials where Bob tossed more heads divided by the total number of trials.
relative frequency = (number of trials in which Bob tossed more heads)/(total number of trials)

The following table shows the relative frequency of Bob getting more heads than Alice for each probability p:

p	Relative Frequency
0.2	0.481
0.3	0.496
0.4	0.505
0.5	0.487
0.6	0.519
0.7	0.514
0.8	0.484

Conjecture

The probability that Bob tosses more heads than Alice does depend on the probability p of a coin landing heads. This dependency is not uniformly strong across all values of p. The extent of dependency varies displaying a distinct relationship between p and the outcome of Bob getting more heads than Alice.

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When p is close to 0.5 which represents a fair coin the probability of Bob getting more heads approximates the theoretical expectation of 0.5 with some variation. This suggests a weaker dependency on p in this range. It is important to note that in a fair coin scenario p=0.5 it is expected that the relative frequency to be very close to 0.5. However, the table shows 0.487 for p=0.5.This is slightly lower than the expected 0.5 but can be considered within an acceptable range due to the random nature of the experiment and the finite number of trials.

As p deviates from 0.5 the relative frequency of Bob getting more heads shows a noticeable shift. This indicates a stronger dependence on p . The direction and magnitude of this shift are not entirely consistent with the expected results since atp = 0.6 and p = 0.7 , the relative frequencies were 0.519 and 0.514 respectively which are higher than 0.5 but not as high as one might expect for such probabilities. Then at p = 0.2 and p = 0.8 the relative frequencies were 0.481 and 0.484 which does not reflect the expected strong results towards fewer or more heads.

While the probability of Bob tossing more heads than Alice is influenced by p this influence is complex and does not always align with a straightforward expectation of bias. The dependency on p is weaker near the fair coin scenario and stronger as p moves away from 0.5 but the relationship is not entirely predictable or linear. Thus it can be observed that the probability that Bob tosses more heads than Alice depends on p but this dependency is distinct. Therefore based on the results and analysis of the coin toss experiment it can be concluded that the probability of Bob tossing more heads than Alice depends on the probability p of a coin landing heads but this dependency varies in strength