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| Image result for monty hall problem  Image from: <https://www.youtube.com/watch?v=DlphpbxNTLw> | | | |
| The Monty Hall Problem is a well-known brain teaser, and I assume that most of you might not only have heard about it but also know the best answer. Let start with the recall of the question:  Suppose you're on a game show, and you're given the choice of three doors: Behind one door is a car; behind the others, goats. You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat. He then says to you, "Do you want to pick door No. 2?" Is it to your advantage to switch your choice? | | | |
| Lets think about how we approach to the problem rather than what the best answer is. I suggest four different ways to give an answer on this question – you might have more and better ideas though :   * Intuitive thinking * Experimental setup * Computer simulation * Mathematical approach | | | |
| -Good intuition comes from years of knowledge and experience that allows us to understand how people and the world works. Though we have no idea about this problem - what is your first choice using your intuition on this puzzle? | | | |
| -To answer this question based on experimental events, we can setup the stage for the show, gathering all of the IS members and play the game one by one; we might gain insights on the best choice from the records of the game results. It would be fun, but there might be some drawbacks such as time inefficiency and invalid results. About 30 people does not seem to be enough to validate the outcomes. | | | |
| -As for the next approach, a simulation is an approximate [imitation](https://en.wikipedia.org/wiki/Imitation) of the operation of a process or system [Wikipedia]. For the simulation, a model is developed based on the game show. First, there are three random numbers for this simulation:   * The car is assigned one of three doors (1, 2 or 3) at random * The player chooses one of these three doors at random (no intuitive skill) * The player’s decision on switching the initial choice is random (Yes or No) | | | |
| Let start with 30 participants to play the Monty Hall Game in simulation. The best thing about using a simulation would be the time efficiency – using a computer simulation it only takes 0.2 seconds to play. Three plots below represent the location of the car, the initial choice and switching status, respectively – but they do not look random, as some groups are greedier in proportion to others. Do you think this is caused by the small sample size? | | | |
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| This time we play the game 5,000,000 times. That is a bigger sample size than the NZ population. It takes 2.8 minutes – a long wait compared to the first simulation, but worthwhile to do it. Look at the pies!! They are all beautifully balanced meaning the random numers are correctly assigned. | | | |
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| Before seeing the result of the simulations, just remember that the main concern of this problem is about the chance of winning the car depending on wether to switch from the initial choice.  Here we can see the first 10 outcomes from the 5million samples:    The two plots below are from the 30 samples (left) and 5M samples (right): the horizontal line (x-axis) represents the switching status (left columns: no-switch, right-columns: switch) and color represents the winning status (Yellow: win, Grey: lost): | | | |
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| What can you find out?  I can see two significant results: One is that the switched participants have a bigger winning chance than the non switchers in both of the 30 and 5M simulations. The other one is that the simulation with a bigger number of samples (5M) gives us a clear idea on how much greater the chance of winning the switchers have compared to the non switchers – twice of chance! | | | |
| -The last option I am thinking of is the boring mathematical approach, but it is quite simple:  The probability of winning the car from a random choice is 1/3 as shown in the left image below. After the initial choice, the two not choosen doors can be regarded as a group, and the probability of winning the car for that group is 2/3 as shown in the right image. After the show host opened one of the doors from the not choosen doors (boxed group), the probability for the remaining not choosen door still remains as 2/3. This is a perfect match with the simulation outcome – no, actually the simulation result is matching with the theoretical mathematics, haha ☺ | | | |
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