# The Monty Hall problem

August 5, 2022

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?

We use a simulation to find the answer. First, we define a function to simulate a game:

```julia
using Random; Random.seed!(1)
function whichDoor(👈; nds=3)
  🚪 = fill("🐐", nds)
  🚗 = rand(1:nds)
  🚪[🚗] = "🚗"
  if 🚪[👈] == "🚗"
    host = rand(setdiff(1:nds, 👈))
  else
    host = rand(setdiff(1:nds, [👈, 🚗]))
  end
  👌 = rand(setdiff(1:nds, [👈, host]))
  return (👈=👈, 🚗=🚗, 👌=👌, host=host)
end

# look at ten games
for i in 1:10
  println(whichDoor(rand(1:3)))
end
```

```r
set.seed(1)
whichDoor = function(choice, nds=3) {
  doors = rep("goat", nds)
  car = sample(1:nds, 1)
  doors[car] = "car"
  if (doors[choice] == "car") {
```

```
        host = sample((1:nds)[-choice], 1)
    } else if (nds == 3){
        host = (1:nds)[-c(choice, car)]
    } else {
        host = sample((1:nds)[-c(choice, car)], 1)
    }
    if (nds ==3) {
        switch = (1:nds)[-c(choice, host)]
    } else {
    switch = sample((1:nds)[-c(choice, host)], 1)
    }
    return(c(choice=choice, car=car, switch=switch, host=host))
}

# look at ten games
for (i in 1:10)
    print(whichDoor(sample(1:3, 1)))
```

Here are the results for the ten games:

```
(☜ = 1, 🚗 = 2, ✋ = 2, host = 3)
(☜ = 3, 🚗 = 1, ✋ = 1, host = 2)
(☜ = 3, 🚗 = 1, ✋ = 1, host = 2)
(☜ = 1, 🚗 = 1, ✋ = 2, host = 3)
(☜ = 1, 🚗 = 1, ✋ = 3, host = 2)
(☜ = 2, 🚗 = 2, ✋ = 3, host = 1)
(☜ = 2, 🚗 = 3, ✋ = 3, host = 1)
(☜ = 3, 🚗 = 3, ✋ = 2, host = 1)
(☜ = 3, 🚗 = 2, ✋ = 2, host = 1)
(☜ = 1, 🚗 = 2, ✋ = 2, host = 3)
```

```
choice    car switch   host
     3      1      1      2
choice    car switch   host
     2      1      1      3
choice    car switch   host
     3      1      1      2
choice    car switch   host
     2      3      3      1
choice    car switch   host
     3      2      2      1
choice    car switch   host
     1      3      3      2
choice    car switch   host
     1      1      2      3
choice    car switch   host
```

```
    2    2    1    3
choice   car switch   host
    1    3    3    2
choice   car switch   host
    1    3    3    2
```

Now let's define a function to count the frequency from a larger number of the simulated games.

```
function countMTH(n; nds=3)
    n_keep, n_switch = 0, 0
    for i in 1:n
        game = whichDoor(rand(1:3), nds=nds)
        if game.☜ == game.🚗
            n_keep += 1
        elseif game.👌 == game.🚗
            n_switch += 1
        end
    end
    return (n_keep, n_switch) ./ n
end

# simulate 100 games to approximate the probabilities
probabilities = countMTH(100)
```

```
countMTH = function(n, nds=3){
   games = replicate(n, whichDoor(sample(1:3, 1), nds=nds))
   mean(games[1,] == games[2,])
   mean(games[3,] == games[2,])
   return (c(mean(games[1,] == games[2,]), mean(games[3,] == games[2,])))
   }

# simulate 100 games to approximate the probabilities
probabilities = paste(countMTH(100), collapse=", ")
```

The approximate probabilities of keeping the original choice and switching are (0.32, 0.68).