# Why Johnny Can't QM, Session One

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OLLI

3 December 2020


Figure 1 : A Murmuration Of Starlings


Figure 2 : A Murmuration Of *Sturnus vulgaris* (Non-Invasive)

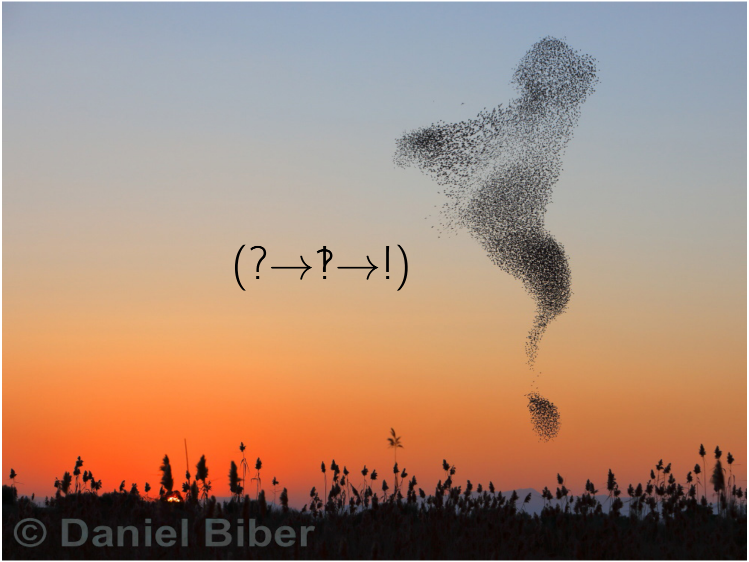


Figure 3 : A Murmuration Of *Sturnus vulgaris* (Non-Invasive)

## The Desire Path (Best Teaching Techniques[1])

# Autodidact

# &

# Think Different

[1] Jean Piaget

# A Pedantic Detour

The world (**Reality**) is not as it seems.

I would prefer to conduct these sessions as a series of extemporaneous discussions wherein each individual explores there own unique path toward grokking[2] ("understanding") QM.

However, I must, before we can proceed, inoculate against a tenacious malady introduced by various non-scientists. ∼Socrates∼Plato∼Aristotle∼

> *You are not entitled to your opinion. You are entitled to your informed opinion. No one is entitled to be ignorant.*
>
> *∼ Harlan Ellison ∼*

[2] Stranger in a strange land.

# First Hand of the Evening in a shack in the Blue Mountains

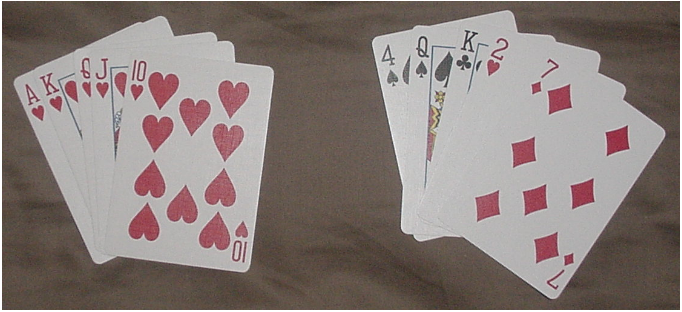

Figure 4 : Richard vs. Red Leonard

# A Deck of Cards Shuffled Many Times

The probability of Order $\alpha \Leftarrow$ Compare $\Rightarrow$ The probability of Order $\beta$

# A Deck of Cards Shuffled Many Times

<u>Deck Order $\alpha$</u>

A♡, 2♡, 3♡, 4♡, 5♡, 6♡, 7♡, 8♡, 9♡, 10♡, J♡, Q♡, K♡,
A♣, 2♣, 3♣, 4♣, 5♣, 6♣, 7♣, 8♣, 9♣, 10♣, J♣, Q♣, K♣,
K♢, Q♢, J♢, 10♢, 9♢, 8♢, 7♢, 6♢, 5♢, 4♢, 3♢, 2♢, A♢,
K♠, Q♠, J♠, 10♠, 9♠, 8♠, 7♠, 6♠, 5♠, 4♠, 3♠, 2♠, A♠

The probability of Order $\alpha$ $\Leftarrow$ Compare $\Rightarrow$ The probability of Order $\beta$

<u>Deck Order $\beta$</u>

5♣, 9♡, 3♣, 2♠, 10♠, 5♡, J♢, A♢, 10♣, 4♠, Q♠, K♣, 2♡,
7♢, 10♡, 10♢, 7♣, 8♡, 8♣, Q♡, 4♡, 5♢, 4♣, Q♢, 6♠, A♠,
6♡, 3♠, 8♢, 7♡, 7♠, Q♣, 2♢, 2♣, 6♢, A♡, K♠, 3♡, 5♠,
J♣, 9♣, 3♢, 9♠, 6♣, J♠, K♢, 9♢, A♣, J♡, 8♠, 4♢, K♡

# By Any Objective Measure : A gargantuan building with a multitude of tables

Deck Order $\alpha$

A♡, 2♡, 3♡, 4♡, 5♡, 6♡, 7♡, 8♡, 9♡, 10♡, J♡, Q♡, K♡,
A♣, 2♣, 3♣, 4♣, 5♣, 6♣, 7♣, 8♣, 9♣, 10♣, J♣, Q♣, K♣,
K♢, Q♢, J♢, 10♢, 9♢, 8♢, 7♢, 6♢, 5♢, 4♢, 3♢, 2♢, A♢,
K♠, Q♠, J♠, 10♠, 9♠, 8♠, 7♠, 6♠, 5♠, 4♠, 3♠, 2♠, A♠

The probability of Order $\alpha$ is the same as The probability of Order $\beta$.

Deck Order $\beta$

5♣, 9♡, 3♣, 2♠, 10♠, 5♡, J♢, A♢, 10♣, 4♠, Q♠, K♣, 2♡,
7♢, 10♡, 10♢, 7♣, 8♡, 8♣, Q♡, 4♡, 5♢, 4♣, Q♢, 6♠, A♠,
6♡, 3♠, 8♢, 7♡, 7♠, Q♣, 2♢, 2♣, 6♢, A♡, K♠, 3♡, 5♠,
J♣, 9♣, 3♢, 9♠, 6♣, J♠, K♢, 9♢, A♣, J♡, 8♠, 4♢, K♡

# By Any Objective Measure : A gargantuan building with a multitude of tables

Deck Order $\alpha$

A♡, 2♡, 3♡, 4♡, 5♡, 6♡, 7♡, 8♡, 9♡, 10♡, J♡, Q♡, K♡,
A♣, 2♣, 3♣, 4♣, 5♣, 6♣, 7♣, 8♣, 9♣, 10♣, J♣, Q♣, K♣,
K♢, Q♢, J♢, 10♢, 9♢, 8♢, 7♢, 6♢, 5♢, 4♢, 3♢, 2♢, A♢,
K♠, Q♠, J♠, 10♠, 9♠, 8♠, 7♠, 6♠, 5♠, 4♠, 3♠, 2♠, A♠

The probability of Order $\alpha$ is the same as The probability of Order $\beta$.

Deck Order $\beta$

5♣, 9♡, 3♣, 2♠, 10♠, 5♡, J♢, A♢, 10♣, 4♠, Q♠, K♣, 2♡,
7♢, 10♡, 10♢, 7♣, 8♡, 8♣, Q♡, 4♡, 5♢, 4♣, Q♢, 6♠, A♠,
6♡, 3♠, 8♢, 7♡, 7♠, Q♣, 2♢, 2♣, 6♢, A♡, K♠, 3♡, 5♠,
J♣, 9♣, 3♢, 9♠, 6♣, J♠, K♢, 9♢, A♣, J♡, 8♠, 4♢, K♡

# From My (Subjective, Experiential) Point Of View $\cdots$

<u>Deck Order $\alpha$</u>

A♡, 2♡, 3♡, 4♡, 5♡, 6♡, 7♡, 8♡, 9♡, 10♡, J♡, Q♡, K♡,
A♣, 2♣, 3♣, 4♣, 5♣, 6♣, 7♣, 8♣, 9♣, 10♣, J♣, Q♣, K♣,
K♢, Q♢, J♢, 10♢, 9♢, 8♢, 7♢, 6♢, 5♢, 4♢, 3♢, 2♢, A♢,
K♠, Q♠, J♠, 10♠, 9♠, 8♠, 7♠, 6♠, 5♠, 4♠, 3♠, 2♠, A♠

The probability of Order $\alpha \gg$ The probability of Order $\beta \cdots$ ‽

<u>Deck Order $\beta$</u>

5♣, 9♡, 3♣, 2♠, 10♠, 5♡, J♢, A♢, 10♣, 4♠, Q♠, K♣, 2♡,
7♢, 10♡, 10♢, 7♣, 8♡, 8♣, Q♡, 4♡, 5♢, 4♣, Q♢, 6♠, A♠,
6♡, 3♠, 8♢, 7♡, 7♠, Q♣, 2♢, 2♣, 6♢, A♡, K♠, 3♡, 5♠,
J♣, 9♣, 3♢, 9♠, 6♣, J♠, K♢, 9♢, A♣, J♡, 8♠, 4♢, K♡

# More Precisely ···

<u>Deck Order $\alpha$</u>

A♡, 2♡, 3♡, 4♡, 5♡, 6♡, 7♡, 8♡, 9♡, 10♡, J♡, Q♡, K♡,
A♣, 2♣, 3♣, 4♣, 5♣, 6♣, 7♣, 8♣, 9♣, 10♣, J♣, Q♣, K♣,
K♢, Q♢, J♢, 10♢, 9♢, 8♢, 7♢, 6♢, 5♢, 4♢, 3♢, 2♢, A♢,
K♠, Q♠, J♠, 10♠, 9♠, 8♠, 7♠, 6♠, 5♠, 4♠, 3♠, 2♠, A♠

I expect to never see Deck Order $\beta$ again ··· Full Stop

<u>Deck Order $\beta$</u>

5♣, 9♡, 3♣, 2♠, 10♠, 5♡, J♢, A♢, 10♣, 4♠, Q♠, K♣, 2♡,
7♢, 10♡, 10♢, 7♣, 8♡, 8♣, Q♡, 4♡, 5♢, 4♣, Q♢, 6♠, A♠,
6♡, 3♠, 8♢, 7♡, 7♠, Q♣, 2♢, 2♣, 6♢, A♡, K♠, 3♡, 5♠,
J♣, 9♣, 3♢, 9♠, 6♣, J♠, K♢, 9♢, A♣, J♡, 8♠, 4♢, K♡

# Deck Order $\alpha$

$$52! = 8.0658175170943... \times 10^{67} \tag{1}$$

Following a Proper Shuffling Regimen:

$$\mathrm{P}_{\alpha} = 1.239799930857... \times 10^{-68} \tag{2}$$

# Deck Order $\beta$

$$52! = 8.0658175170943\ldots \times 10^{67} \tag{3}$$

Following a Proper Shuffling Regimen:

$$\mathrm{P}_\beta = 1.239799930857\ldots \times 10^{-68} \tag{4}$$

80,658,175,170,943,878,571,660,636,856,403,766,975,289,505,440,883,277,824,000,000,000,001

equals the number of standard decks needed to insure at least two match.

For scale: The diameter of the universe is $8.8 \times 10^{36}$Å

For $n < 52!$

$$p(n) \approx 1 - \left\{ \frac{\left(8.1 \times 10^{67}\right) - 1}{8.1 \times 10^{67}} \right\}^{\frac{n(n-1)}{2}} \quad (5)$$

$$p(n) \approx 1 - \left\{1 - \left(1.239799930857 \times 10^{-68}\right)\right\}^{\frac{n(n-1)}{2}} \quad (6)$$

$$p(n) \approx 1 - \{0.999 \cdots 8760200069142\}^{\frac{n(n-1)}{2}}, \text{ 67 nines} \quad (7)$$

# The Birthday Paradox (albeit writ large)

To find how many shuffled decks are needed to have a 50% chance of seeing two decks with the cards in the same order, set $\cdots$

$$\{0.999\cdots 8760200069142\}^{\frac{n(n-1)}{2}} \approx 0.5 \tag{8}$$

$$\frac{n(n-1)}{2} \times \ln\{0.999\cdots 8760200069142\} \approx \ln 0.5 \tag{9}$$

$$n(n-1) \approx n^2 \text{ , and , } \ln(1+x) = \sum_{n=1}^{\infty}(-1)^{n+1}\frac{x^n}{n} \approx x \tag{10}$$

$$n^2 \approx 2 \times \frac{\ln 0.5}{\ln\{0.999\cdots 8760200069142\}} \tag{11}$$

$$n^2 \approx 2 \times \frac{-0.69314718055}{-1.23979993085 \times 10^{-68}} \tag{12}$$

$$n^2 \approx 10^{68} \implies n \approx 10^{34} \tag{13}$$

# A Simpler Case

The universe formed about $4.36 \times 10^{17}$ seconds ago.

$$10^{34} = \left(10^{17}\right)^2 \implies \text{You cannot do an experiment.}$$

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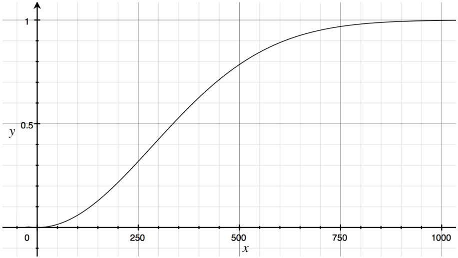


Figure 5 : 81,000 (rather than $8.1 \times 10^{67}$) “states” or “outcomes”

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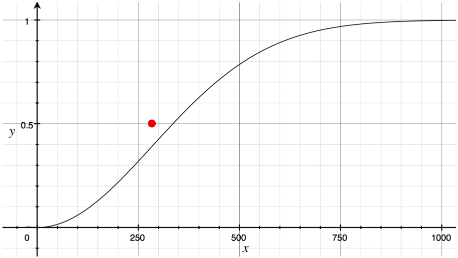


Figure 5 : 81,000 (rather than $8.1 \times 10^{67}$) "states" or "outcomes"

$$n(n-1) \lessapprox n^2 \text{ therefore } 335 \approx n_{50\%} > \sqrt{81,000} = 284.60498941\ldots$$

# A Deck of Cards Shuffled Many Times

The probability of Order $\alpha$ $\Leftarrow$ Compare $\Rightarrow$ The probability of Order $\beta$

# The 113 Prime Factors of 52!

$$52! = F_1 \times F_2 \times F_3$$

$$F_i = \begin{cases} F_1 = 47^{(1)} \times 43^{(1)} \times 41^{(1)} \times 37^{(1)} \times 31^{(1)} \\ F_2 = 29^{(1)} \times 23^{(2)} \times 19^{(2)} \times 17^{(3)} \times 13^{(4)} \\ F_3 = 11^{(4)} \times 7^{(8)} \times 5^{(12)} \times 3^{(23)} \times 2^{(49)} \end{cases} \tag{14}$$

$$52! = \begin{cases} (47)(43)(41)(37)(31)(29)(529)(361)(4,913) \\ \times(28,561)(14,641)(5,764,801)(244,140,625) \\ \times(94,143,178,827)(562,949,953,421,312) \end{cases} \tag{15}$$

# And Now For Something Completely Different!

# $0 = 1 + e^{i\pi}$, five important numbers

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$$\arctan y = \sum_{n=0}^{\infty} (-1)^n \frac{y^{(2n+1)}}{(2n+1)} = y - \frac{y^3}{3} + \frac{y^5}{5} - \frac{y^7}{7} + \ldots \qquad (16)$$

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$$\arctan 1 = \frac{\pi}{4} \implies \frac{\pi}{4} = \sum_{n=0}^{\infty} (-1)^n \frac{1}{(2n+1)} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots \qquad (17)$$

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$$\pi = 4 \times \left\{ 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots \right\} \qquad (18)$$

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$$\arctan 1 = \frac{\pi}{4} \implies \frac{\pi}{4} = \sum_{n=0}^{\infty} (-1)^n \frac{1}{(2n+1)} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots \tag{17}$$

$$\pi = 4 \times \left\{ 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots \right\} \tag{18}$$

$$\pi = 3.1415926535897932384626433832795028841971693 \ldots \tag{19}$$

# $0 = 1 + e^{i\pi}$, five important numbers

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + ... \tag{20}$$

# $0 = 1 + e^{i\pi}$, five important numbers

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + ... \tag{20}$$

$$e = \sum_{n=0}^{\infty} \frac{1}{n!} = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + ... \tag{21}$$

# $0 = 1 + e^{i\pi}$, five important numbers

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots \qquad (20)$$

$$e = \sum_{n=0}^{\infty} \frac{1}{n!} = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \ldots \qquad (21)$$

$$e = \left\{ 1 + \frac{1}{1} + \frac{1}{2} + \frac{1}{6} + \frac{1}{24} + \ldots \right\} \qquad (22)$$

# $0 = 1 + e^{i\pi}$, five important numbers

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots \tag{20}$$

$$e = \sum_{n=0}^{\infty} \frac{1}{n!} = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \ldots \tag{21}$$

$$e = \left\{ 1 + \frac{1}{1} + \frac{1}{2} + \frac{1}{6} + \frac{1}{24} + \ldots \right\} \tag{22}$$

$$e = 2.71828182845904523536028747135266249775724 70\ \ldots \tag{23}$$

# Deterministic(‽) Randomness?

$\pi = 3.14159265358979323846264338327950288419716 93\ \ldots$

$e = 2.71828182845904523536028747135266249775724 70\ \ldots$

# Deterministic(‽) Randomness?

$$\pi = 3.14159265358979323846264338327950288419716939 \ldots$$

$$e = 2.71828182845904523536028747135266249775724709 \ldots$$

What is the next digit of $\pi$?

What is the next digit of $e$?

# Deterministic(‽) Randomness?

$$\pi = 3.14159265358979323846264338327950288419716939\ldots$$
$$e = 2.71828182845904523536028747135266249775724709\ldots$$

What is the next digit of $\pi$?

What is the next digit of $e$?

Until calculated you wouldn't know that the next digit is "9".

# Deterministic(‽) Randomness?

$$\pi = 3.14159265358979323846264338327950288419716939\ldots$$

$$e = 2.71828182845904523536028747135266249775724709\ldots$$

What is the next digit of $\pi$? What is the next digit of $e$?

Until calculated you wouldn't know that the next digit is "9".

∼ ∼ Assertions Of Questionable Value ∼ ∼

The digits of $\pi$ and of $e$ are not random for any meaningful understanding of the word "random" (okay maybe I should use the word "stochastic").

$\pi$ and $e$ contain all finite length numbers an infinite number of times. There can be no upper bound to the length of "red" matched number strings.

# ∼ Early Computers ∼

```
      integer i
      do 10 i = 1, 4
         i = i + 1
         write i
10    continue
```

```
2
3
4.01
4.99
```

# ∼ Early Computers ∼

```
      integer i
      do 10 i = 1, 4
         i = i + 1
         write i
10    continue
```

```
2
3
4.01
4.99
```

| | A | B |
|---|---|---|
| 1 | e^(pi) – pi = | 20.00 |
| 2 | | |
| 3 | | |

Figure 6 : $e^{\pi} - \pi = 20.00$, Coincidence? I think not!

# A Zeroth Order Fallacy

Johnny is unable to appreciate the Extraordinary

(A) = (pattern of Intricate Behavior)

(B) = (Superior Poker Hand)

(C) = (occurrence of an Improbable Event)

(D) = (Mind Blowing Observation)

**because** Johnny demands the Extraordinary

(A) must have been preceded by an equally extraordinary cause.

(B) must have been preceded by an equally extraordinary cause.

(C) must have been preceded by an equally extraordinary cause.

(D) must have been preceded by an equally extraordinary cause.


Figure 7 : A Murmuration Of Starlings