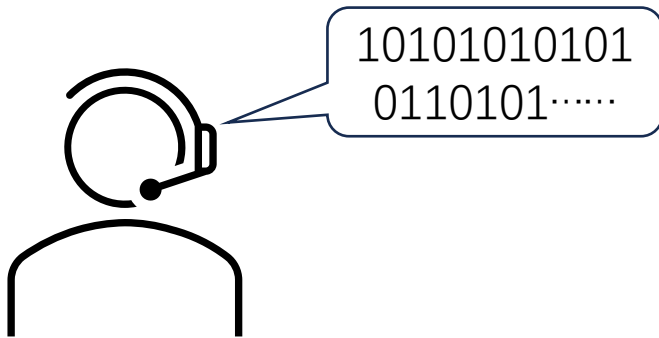


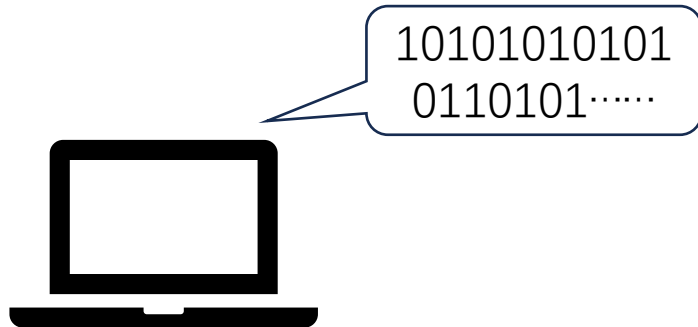
Does AI Play Dice?

Qiang Liu
Tencent Inc.

Can Human Generate Random Numbers?



Persaud [2005]: Human can consciously generate random numbers
If humans can generate sequences of random numbers then [neural networks](#) or forms of artificial intelligence, which are purported to function in ways essentially the same as the human brain, should also be able to generate sequences of random numbers.



Figurska et. al. [2008]: Human cannot consciously generate random numbers
computers are capable of generating the so-called [pseudorandom numbers](#). Such series of numbers are only seemingly random (bias in the randomness quality can be observed)

[2005] Navindra Persaud. Humans can consciously generate random number sequences: A possible test for artificial intelligence. *Medical hypotheses*, 65(2):211–214, 2005.

[2008] Malgorzata Figurska, Maciej Stanczyk, and Kamil Kulesza. Humans cannot consciously generate random numbers sequences: Polemic study. *Medical hypotheses*, 70(1):182–185, 2008.

Can GPT-4 Generate Random Numbers?



10101010101
0110101.....

Should AI has the ability to generate RNs?

- If AI is similar to human, no.
- Yes, because a human computer scientist can apply algorithms producing pseudo-RNs with his/her knowledge.

Should GPT (or llama, 千问 etc.) has the ability to generate RNs?

- No. GPT is an probabilistic model $\Pr(\text{next token} | \text{prompt})$ and then it is similar to human reactions when produce RNs.

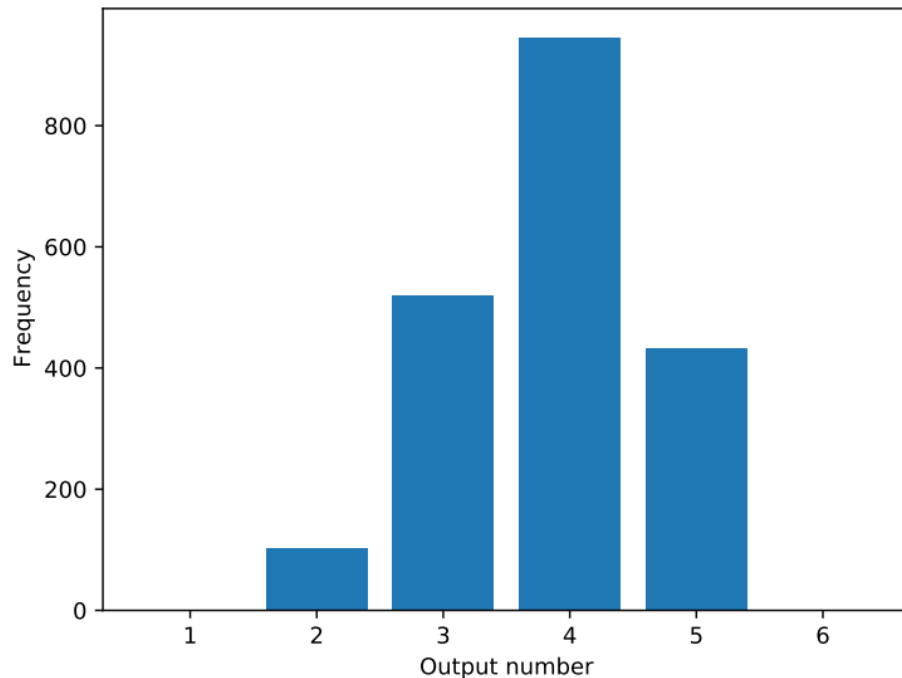


- Yes (maybe). GPT is not only an probabilistic model in generating tokens but acquires an **emergent** ability of **thinking** in applying algorithms like an expert.



EXP1: Generate one RN each time

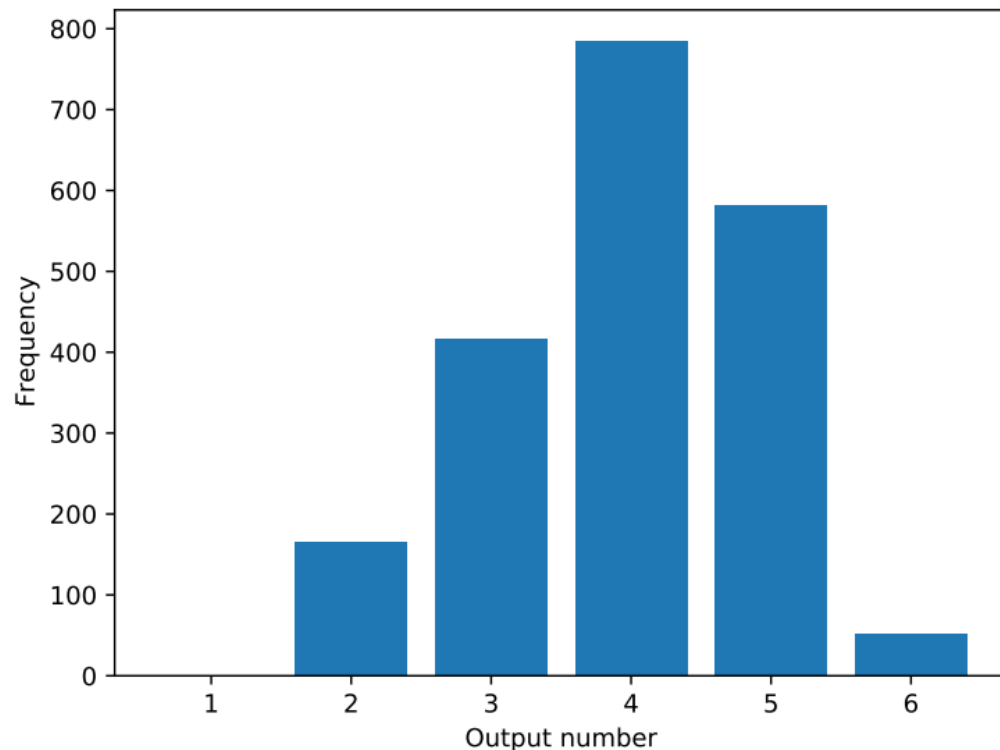
- **Prompt 1:** *You are playing a game of dice. Please generate a random number between 1 and 6, which represents the outcome of rolling a standard six-sided die.*



Not random and highly frequent in the middle.
No 1 and 6.

Implicitly inform GPT the number set

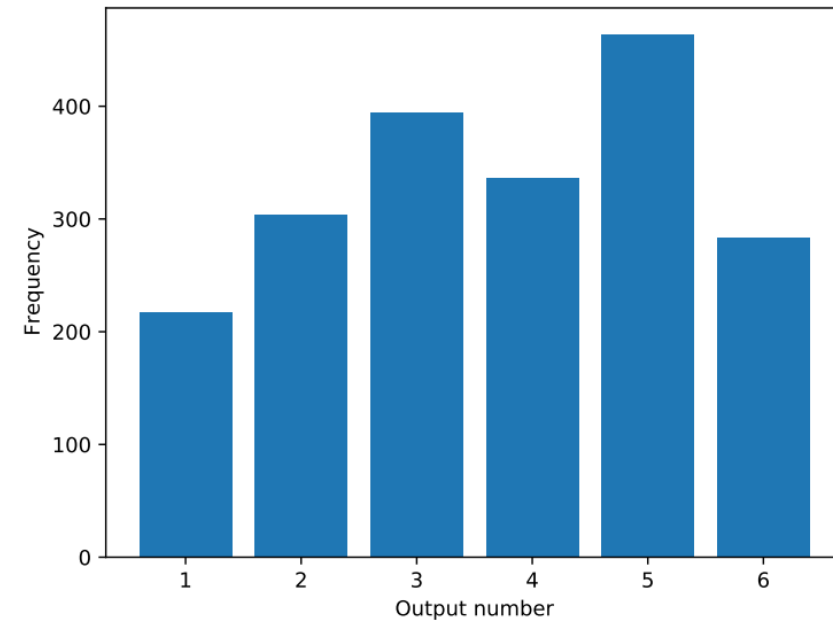
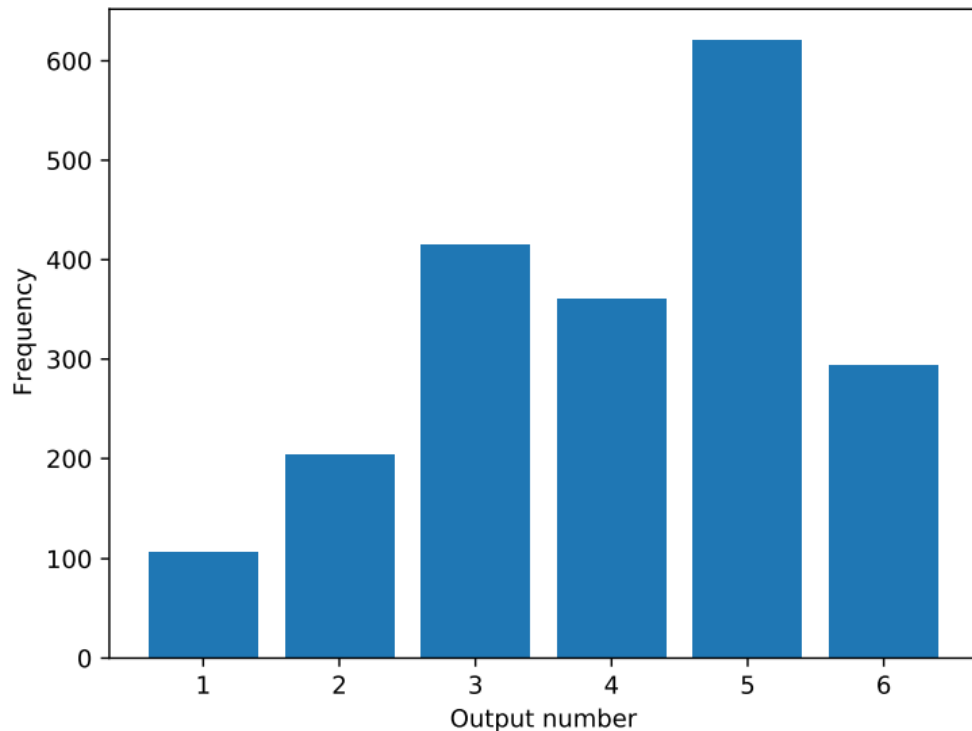
- **Prompt 2:** *You are playing a game of dice. Please generate a random number from [1, 2, 3, 4, 5, 6], which represents the outcome of rolling a standard six-sided die.*



Not random and highly frequent in the middle.
No 1.

Elimination of the influence of order

- **Prompt 3:** *You are playing a game of dice. Please generate a random number from [4, 2, 6, 1, 5, 3], which represents the outcome of rolling a standard six-sided die.*



Appending: *The probability of selecting each number should be equal.*

EXP1 conclusion

- GPT-4 cannot generate RNs.

EXP2: generating random sequence

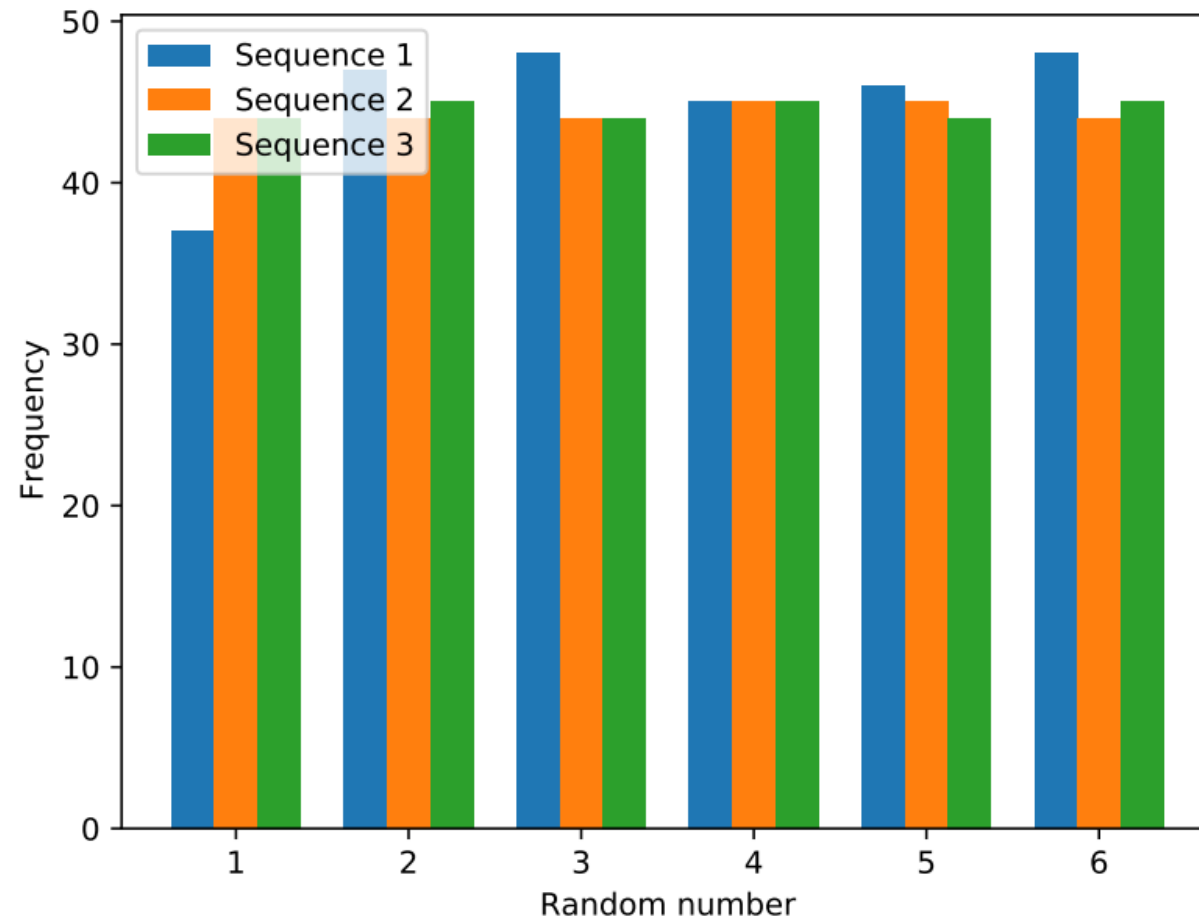
Prompt 4: *You are playing a game of dice. Please generate a random number sequence with 280 numbers. Each number is selected independently from [4, 2, 6, 1, 5, 3], which represents the outcome of rolling a standard six-sided die. The probability of selecting each number should be equal.*

Three output sequences

- **Sequence 1:** 2, 6, 2, 4, 5, 2, 1, 3, 4, 1, 2, 4, 5, 6, 2, 3, 5, 6, 3, 5, 1, 2, 4, 6, 3, 2, 5, 4, 6, 2, 1, 5, 6, 3, 1, 6, 5, 4, 2, 3, 4, 1, 2, 5, 3, 2, 4, 6, 3, 2, 1, 5, 3, 6, 4, 2, 3, 4, 6, 1, 6, 4, 3, 2, 6, 5, 2, 3, 5, 4, 3, 2, 4, 5, 6, 1, 5, 6, 3, 4, 1, 3, 5, 6, 2, 1, 5, 3, 6, 2, 4, 5, 2, 6, 4, 1, 3, 2, 5, 4, 3, 6, 5, 4, 1, 3, 6, 2, 5, 4, 1, 6, 3, 5, 2, 6, 3, 1, 2, 4, 3, 6, 1, 5, 3, 4, 6, 2, 5, 1, 4, 3, 5, 2, 6, 4, 1, 3, 5, 6, 4, 2, 6, 3, 5, 4, 1, 2, 6, 5, 4, 3, 6, 2, 1, 4, 6, 5, 3, 1, 5, 4, 2, 6, 3, 5, 4, 2, 1, 3, 4, 6, 5, 2, 1, 6, 3, 5, 2, 4, 1, 3, 4, 2, 6, 5, 1, 3, 2, 4, 6, 5, 1, 2, 6, 4, 3, 5, 6, 4, 1, 2, 3, 4, 5, 1, 6, 3, 2, 5, 6, 4, 3, 1, 5, 2, 3, 4, 6, 2, 5, 6, 1, 3, 2, 4, 5, 3, 2, 6, 1, 5, 3, 6, 4, 1, 2, 4, 5, 3, 6, 1, 3, 4, 6, 2, 5, 1, 3, 4, 5, 2, 6, 3, 1, 2, 4, 5, 3, 6, 1, 2, 6, 3, 5, 4, 6, 1, 2, 5, 3.
- **Sequence 2:** 157, 2, 5, 4, 6, 1, 1, 3, 2, 5, 6, 4, 4, 5, 2, 3, 1, 6, 6, 3, 5, 2, 1, 4, 2, 1, 4, 3, 6, 5, 5, 2, 4, 3, 6, 1, 3, 5, 6, 4, 2, 1, 3, 6, 5, 1, 4, 2, 6, 1, 4, 3, 2, 5, 3, 1, 5, 4, 6, 2, 2, 6, 1, 4, 5, 3, 6, 1, 5, 2, 3, 4, 1, 5, 3, 6, 2, 4, 5, 6, 4, 1, 3, 2, 4, 3, 6, 1, 2, 5, 6, 3, 4, 5, 2, 1, 3, 6, 1, 4, 2, 5, 4, 6, 5, 1, 2, 3, 2, 5, 6, 4, 1, 3, 6, 4, 1, 3, 2, 5, 3, 5, 1, 6, 4, 2, 1, 5, 3, 6, 2, 4, 4, 6, 5, 1, 3, 2, 4, 3, 5, 6, 1, 2, 6, 1, 3, 5, 4, 2, 4, 3, 5, 2, 1, 6, 5, 6, 4, 2, 1, 3, 1, 4, 5, 2, 3, 6, 4, 5, 1, 6, 2, 3, 3, 2, 1, 4, 6, 5, 1, 4, 3, 2, 5, 6, 1, 2, 5, 4, 3, 6, 5, 2, 1, 4, 3, 6, 1, 6, 4, 3, 5, 2, 2, 1, 5, 3, 4, 6, 6, 5, 3, 1, 4, 2, 4, 1, 6, 5, 2, 3, 4, 6, 3, 2, 1, 5, 5, 6, 1, 3, 4, 2, 6, 2, 4, 5, 3, 1, 1, 2, 6, 4, 3, 5, 2, 3, 1, 5, 6, 4, 5, 1, 2, 3, 4, 6, 3, 6, 5, 1, 4, 2, 5, 4, 3.
- **Sequence 3:** 6, 1, 4, 2, 5, 3, 4, 6, 2, 1, 3, 5, 3, 6, 1, 4, 2, 5, 4, 3, 6, 1, 2, 5, 3, 2, 4, 6, 1, 5, 2, 4, 3, 6, 5, 1, 3, 4, 2, 6, 5, 1, 4, 3, 6, 2, 5, 1, 4, 6, 3, 2, 1, 5, 4, 3, 6, 2, 5, 3, 1, 6, 4, 2, 1, 5, 6, 3, 4, 2, 1, 5, 3, 6, 4, 2, 1, 6, 5, 3, 4, 2, 6, 1, 5, 3, 4, 2, 1, 5, 6, 4, 3, 2, 5, 1, 6, 4, 2, 3, 1, 5, 6, 4, 2, 3, 6, 1, 5, 4, 2, 3, 1, 6, 5, 4, 2, 3, 6, 1, 4, 5, 2, 3, 1, 4, 6, 5, 2, 1, 3, 4, 6, 5, 2, 1, 3, 6, 4, 5, 1, 2, 3, 6, 4, 5, 1, 2, 3, 6, 5, 4, 2, 1, 3, 5, 6, 4, 2, 3, 1, 5, 6, 4, 2, 3, 1, 4, 5, 6, 2, 1, 3, 4, 6, 5, 2, 3, 1, 4, 6, 5, 2, 1, 4, 3, 5, 6, 2, 1, 3, 4, 5, 6, 1, 2, 3, 4, 5, 6, 2, 1, 4, 3, 5, 6, 1, 2, 4, 3, 5, 6, 1, 2, 3, 4, 6, 5, 2, 1, 3, 4, 6, 5, 2, 1, 3, 6, 4, 5, 2, 1, 3, 4, 5, 6, 1, 2, 3, 4, 5, 6, 1, 2, 3, 4, 5, 6, 1, 2, 3, 4, 6, 5, 1, 2, 4, 3, 5, 6, 1, 2, 4, 3, 5, 6, 2.

RNs distribution

The RNs are random!

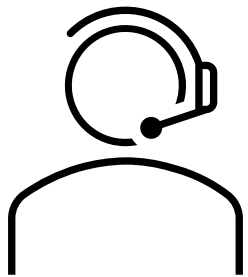
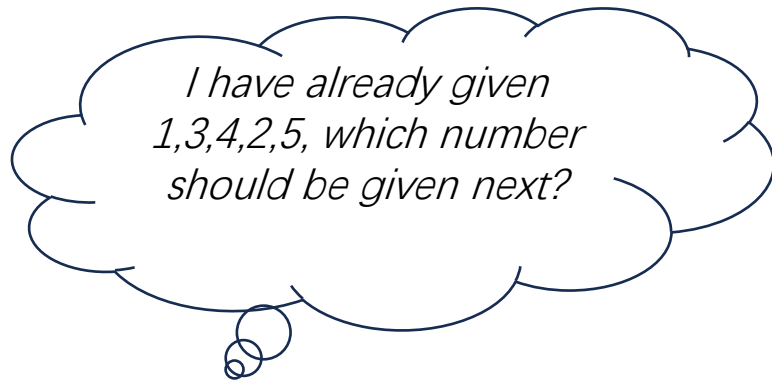


Correlations

The number of identical numbers in continuedly throwing dice should follow:

$$E[|\{x_i = x_j | d = i - j\}|] = \frac{N - d}{6}.$$

Where i and j are the index of two numbers x_i and x_j .



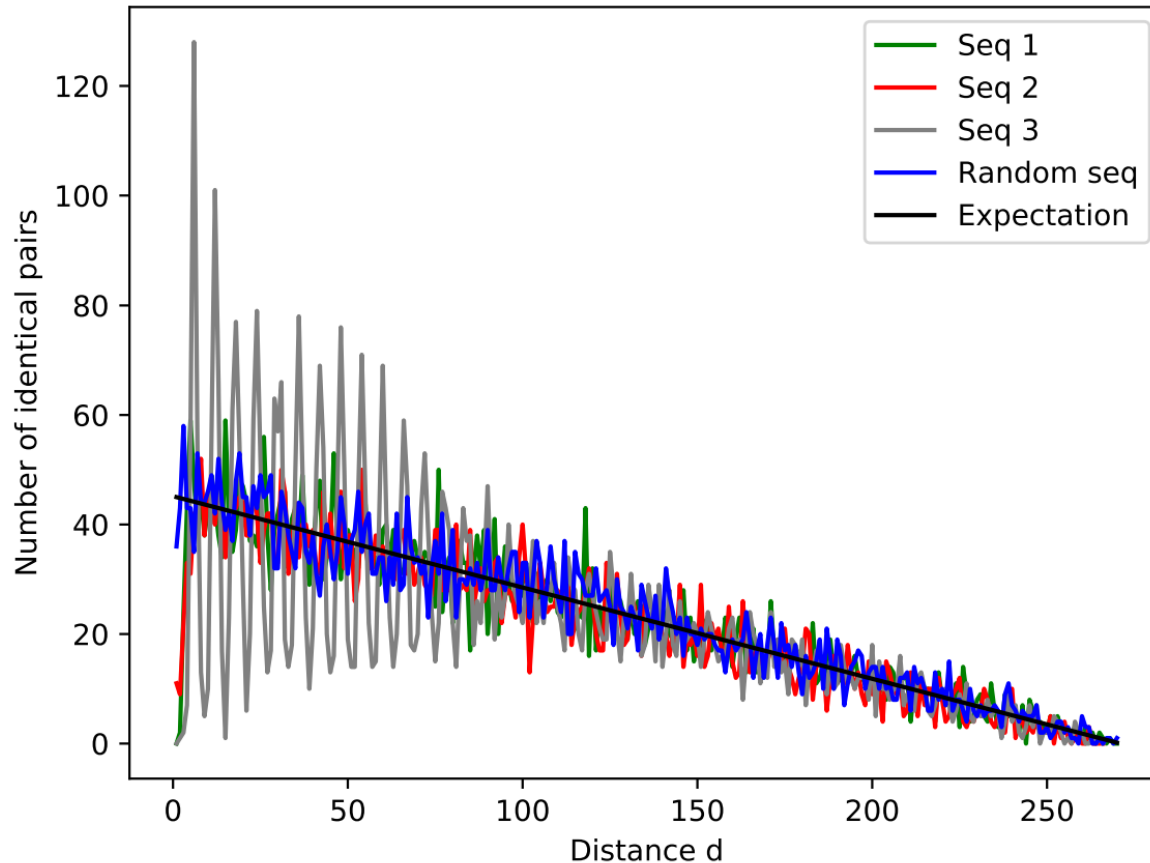
1, 3, 4, 5, 2, 6, 3, 1, 2, 4



$\Pr(X_1 = x_8) = 6/36$ and there are 10-7 pairs.

Correlations

Seq. 1: Overall no correlations except **no identical adjacent numbers**;
Seq. 2: Similar to seq. 1 but low chance of adjacent identical numbers;
Seq. 3: **Periodical correlations** indicating repeating of short random seqs.



Expectation should be an linear decay curve and realistic RNs curves oscillates around the expectation.

In seq.1 and seq.2 GPT-4 avoids to generate the previous numbers to ensure the randomness; In seq.3 GPT-4 fakes the random seq in a lazy way.

Similar to non-expert human behavior

Conclusion

- GPT-4 do not play dice.
- GPT-4 tries to compensate for the uniformity of random numbers by sacrificing independence when acting as a dice.
- No emergent behaviors such as GPT-4 applies an underlying algorithm within the model when generating RNs (that's why most LLM systems applies the Retrieval/algorithm argumentation)
- **Should AI look like human? Is Turing test a right exam?**
- **AI is not able to generate RNs. Can AI provide unbiased and fair decisions?**