



Sony CSL



CENTRO RICERCHE  
**ENRICO FERMI**

# Artificialità creativa

e altre amenità

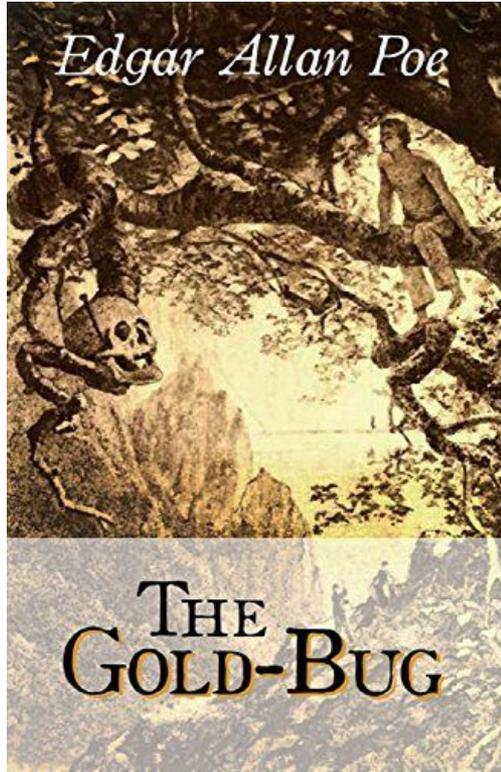
**Alessandro Londei**

Sony Computer Science Laboratory (CSL) - Rome

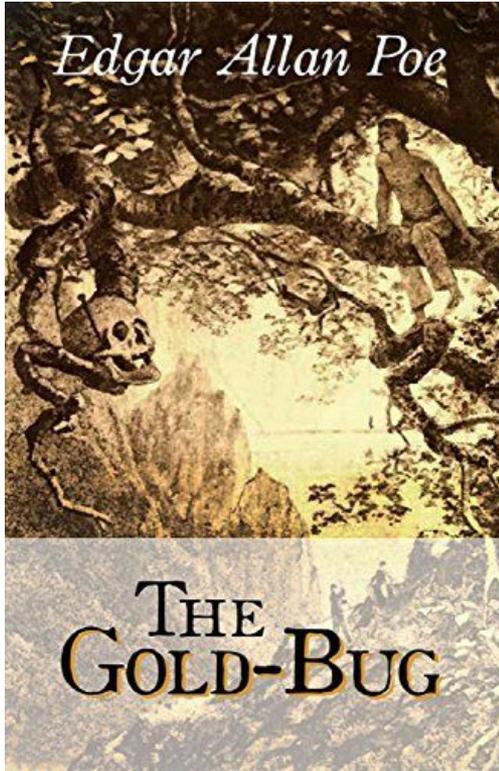
CREF

*[alessandro.londei@sony.com](mailto:alessandro.londei@sony.com)*

# Lo scarabeo d'oro



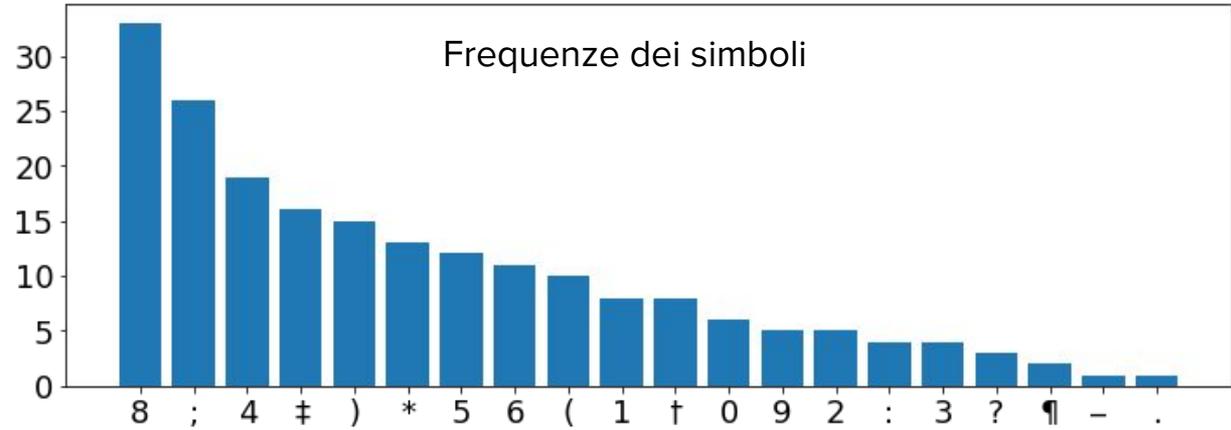
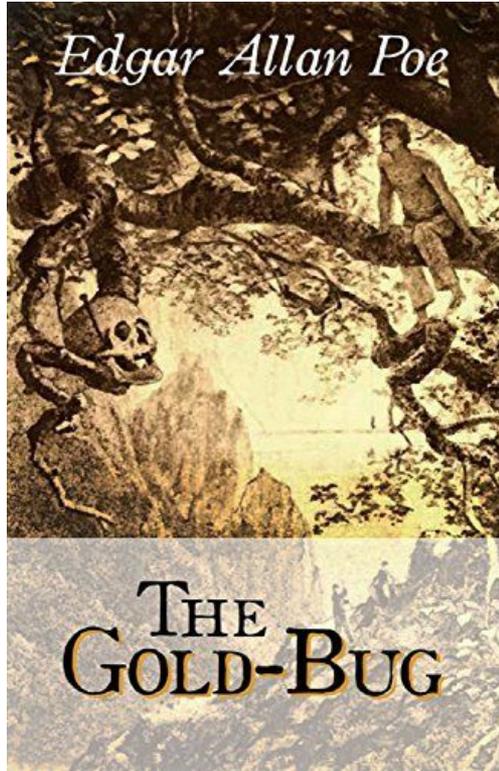
# Lo scarabeo d'oro



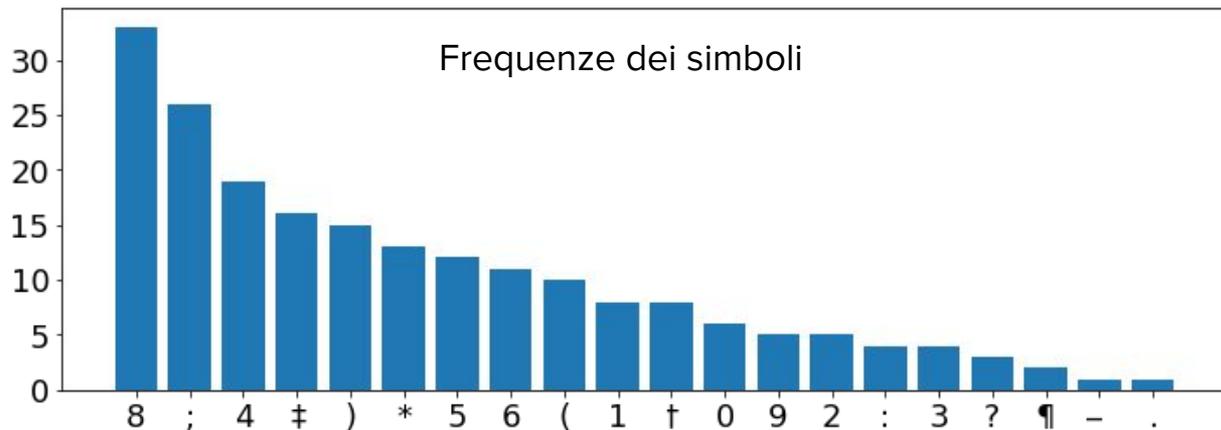
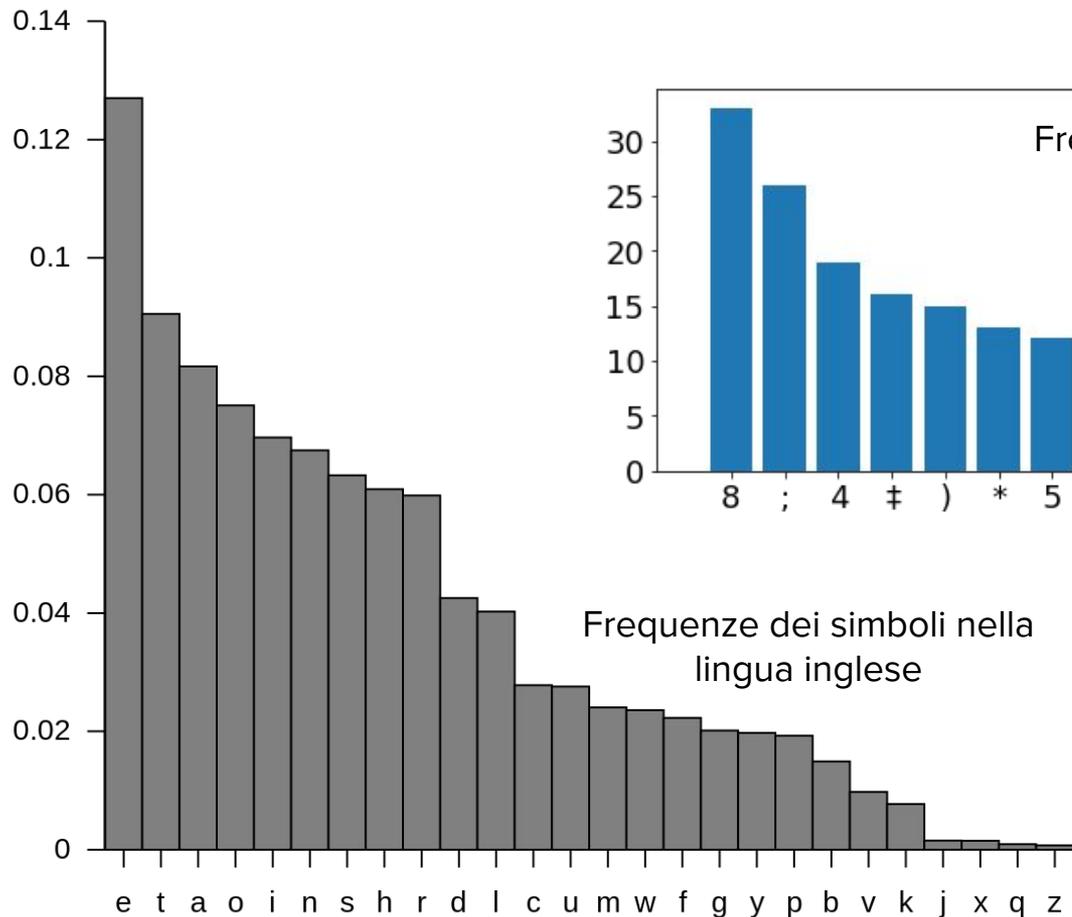
53‡‡†305))6\*;4826)4‡.4‡);806\*;48  
†8¶60))85;1‡(;;‡\*8†83(88)5\*†;46(;  
88\*96\*?;8)\*‡(;485);5\*†2:\*‡(;4956\*  
2(5\*—4)8¶8\*;4069285);)6†8)4‡‡;1  
(‡9;48081;8:8‡1;48†85;4)485†528  
806\*81(‡9;48;(88;4(‡?34;48)4‡;16  
1;:188;‡?;

Numero totale di simboli: 20

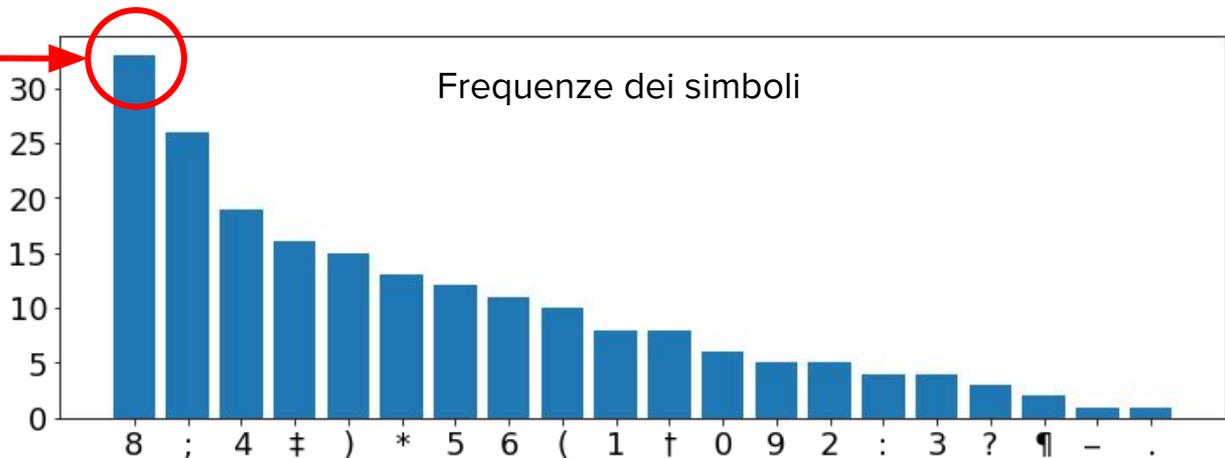
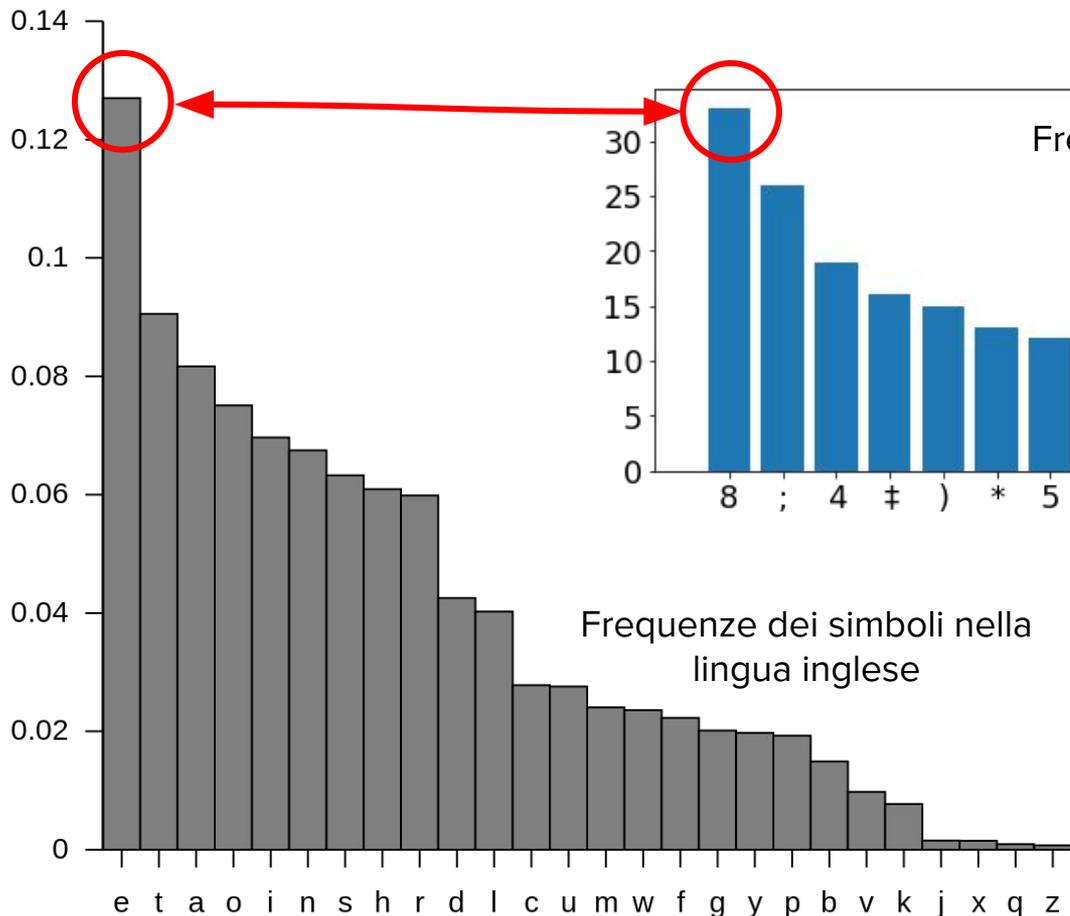
# Lo scarabeo d'oro



# Lo scarabeo d'oro

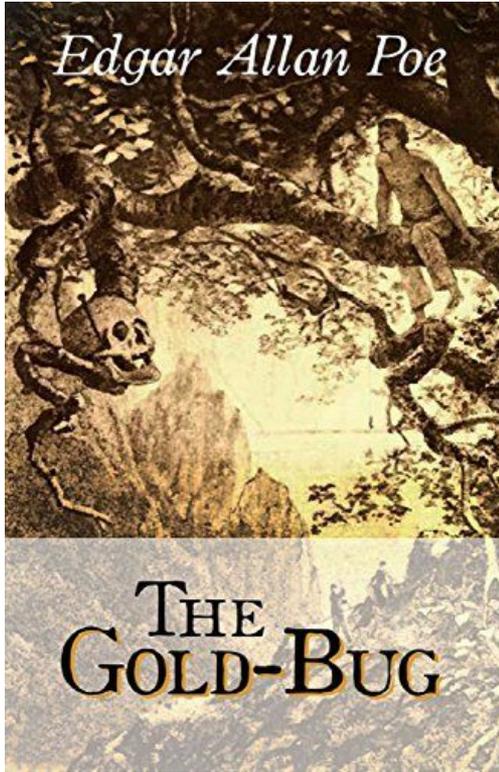


# Lo scarabeo d'oro



8 = e

# Lo scarabeo d'oro



8 = e

53†††305))6\*;4e26)4†.4†);e06\*;4e  
†e¶60))e5;1†(;;†\*e†e3(ee)5\*†;46(;  
ee\*96\*?;e)\*†(;4e5);5\*†2:\*†(;4956\*  
2(5\*—4)e¶e\*;40692e5);)6†e)4††;1  
(†9;4e0e1;e:e†1;4e†e5;4)4e5†52e  
e06\*e1(†9;4e;(ee;4(†?34;4e)4†;16  
1;;1ee;†?;

# Lo scarabeo d'oro

Word	Parts of speech	OEC rank
the	Article	1
be	Verb	2
to	Preposition	3
of	Preposition	4
and	Conjunction	5
a	Article	6
in	Preposition	7
that	Conjunction et al.	8
have	Verb	9
I	Pronoun	10
it	Pronoun	11
for	Preposition	12
not	Adverb et al.	13
on	Preposition	14

8 = e

53†††305))6\*;4e26)4†.4†);e06\*;4e  
†e¶60))e5;1†(;;†\*e†e3(ee)5\*†;46(;  
ee\*96\*?;e)\*†(;4e5);5\*†2:\*†(;4956\*  
2(5\*—4)e¶e\*;40692e5);)6†e)4††;1  
(†9;4e0e1;e:e†1;4e†e5;4)4e5†52e  
e06\*e1(†9;4e;(ee;4(†?34;4e)4†;16  
1;;1ee;†?;

# Lo scarabeo d'oro

Word	Parts of speech	OEC rank
the	Article	1
be	Verb	2
to	Preposition	3
of	Preposition	4
and	Conjunction	5
a	Article	6
in	Preposition	7
that	Conjunction et al.	8
have	Verb	9
I	Pronoun	10
it	Pronoun	11
for	Preposition	12
not	Adverb et al.	13
on	Preposition	14

8 = e

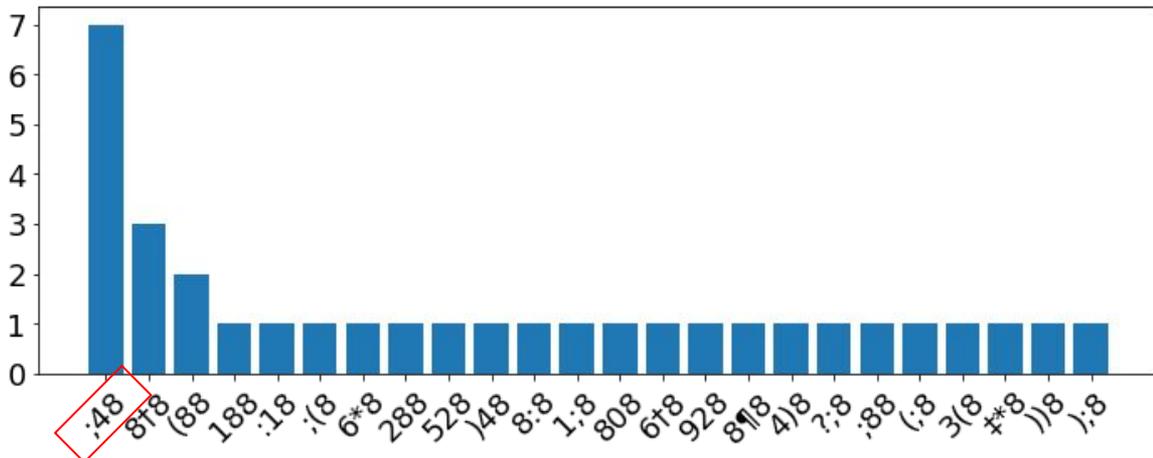
53†††305))6\*;4e26)4†.4†);e06\*;4e  
†e¶60))e5;1†(;;†\*e†e3(ee)5\*†;46(;  
ee\*96\*?;e)\*†(;4e5);5\*†2:\*†(;4956\*  
2(5\*—4)e¶e\*;40692e5);)6†e)4††;1  
(†9;4e0e1;e:e†1;4e†e5;4)4e5†52e  
e06\*e1(†9;4e;(ee;4(†?34;4e)4†;16  
1;;1ee;†?;

**THE** è la parola più frequente in inglese

# Lo scarabeo d'oro

Word	Parts of speech	OEC rank
the	Article	1
be	Verb	2
to	Preposition	3
of	Preposition	4
and	Conjunction	5
a	Article	6
in	Preposition	7
that	Conjunction et al.	8
have	Verb	9
I	Pronoun	10
it	Pronoun	11
for	Preposition	12
not	Adverb et al.	13
on	Preposition	14

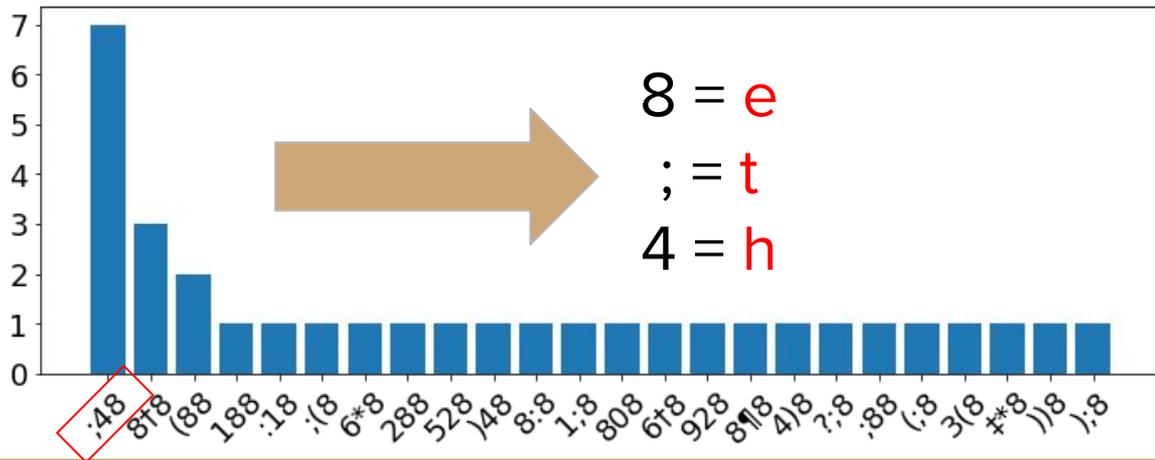
53†††305))6\*;4e26)4†.4†);e06\*;4e  
 †e¶60))e5;1†(;:†\*e†e3(ee)5\*†;46(;  
 ee\*96\*?;e)\*†(;4e5);5\*†2:\*†(;4956\*  
 2(5\*—4)e¶e\*;40692e5);)6†e)4††;1  
 (†9;4e0e1;e:e†1;4e†e5;4)4e5†52e  
 e06\*e1(†9;4e;(ee;4(†?34;4e)4†;16  
 1;:1ee;†?;



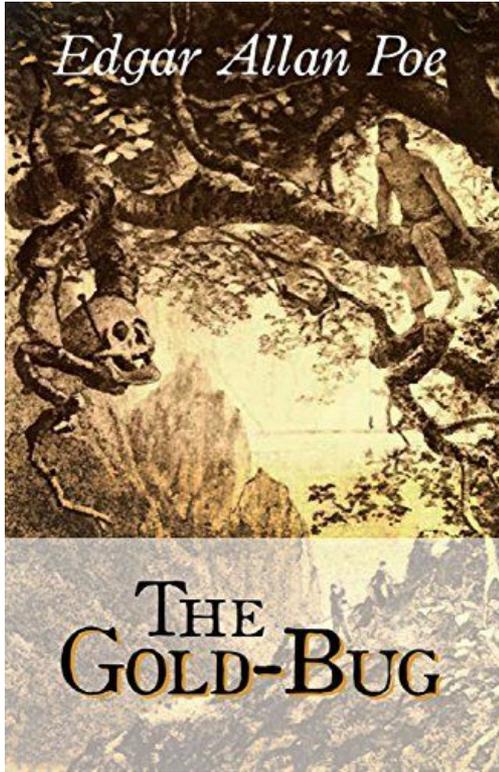
# Lo scarabeo d'oro

Word	Parts of speech	OEC rank
the	Article	1
be	Verb	2
to	Preposition	3
of	Preposition	4
and	Conjunction	5
a	Article	6
in	Preposition	7
that	Conjunction et al.	8
have	Verb	9
I	Pronoun	10
it	Pronoun	11
for	Preposition	12
not	Adverb et al.	13
on	Preposition	14

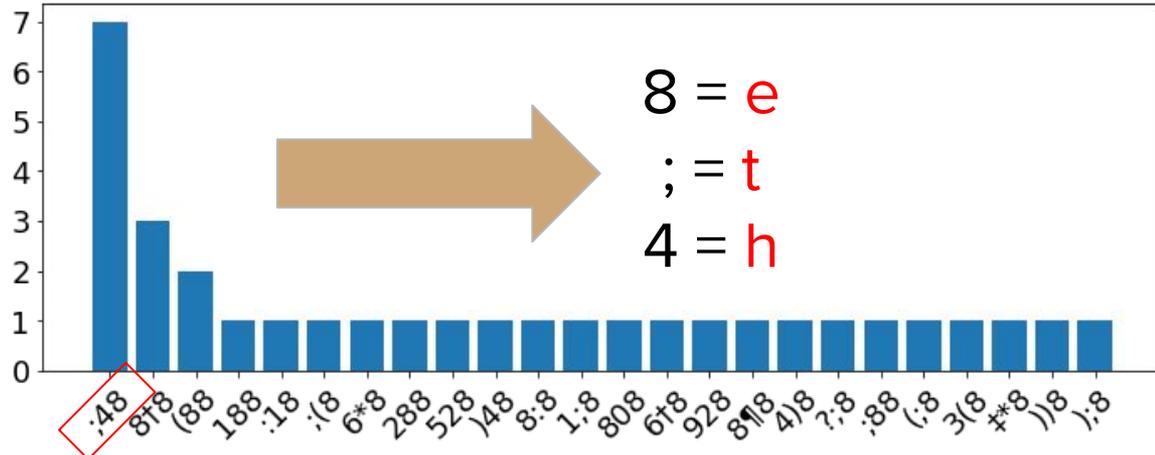
53†††305))6\*;4e26)4†.4†);e06\*;4e  
 †e¶60))e5;1†(;:†\*e†e3(ee)5\*†;46(;  
 ee\*96\*?;e)\*†(;4e5);5\*†2:\*†(;4956\*  
 2(5\*—4)e¶e\*;40692e5);)6†e)4††;1  
 (†9;4e0e1;e:e†1;4e†e5;4)4e5†52e  
 e06\*e1(†9;4e;(ee;4(†?34;4e)4†;16  
 1;:1ee;†?;



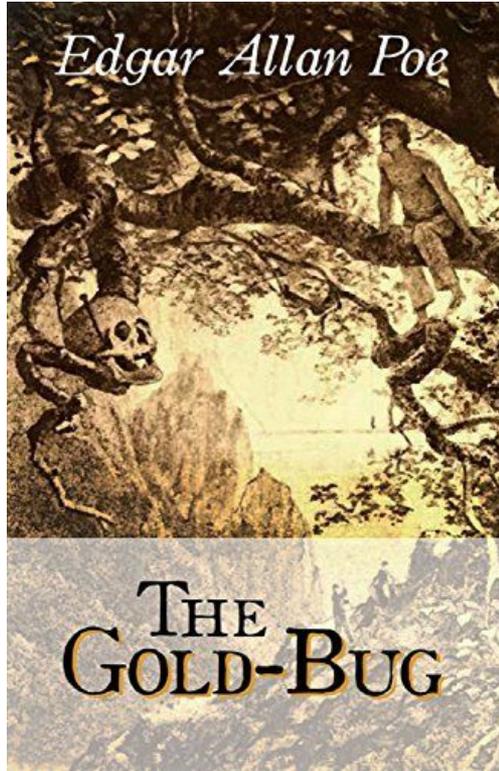
# Lo scarabeo d'oro



53‡‡‡305))6\***the**26)**h‡.h‡)te**06\***th**  
**e†e¶**(60))**e5t1‡(t:‡\*e†e3(ee)5\*†th6**  
**(tee\*96\*?te)\*‡(the5)t5\*†2:\*‡(th95**  
**6\*2(5\*—h)e¶e\*th0692e5)t)6†e)h‡**  
**‡t1(‡9the0e1te:e‡1the†e5th)he5**  
**†52ee06\*e1(‡9thet(eeth(‡?3hthe)**  
**h‡t161t:1eet‡?t**



# Lo scarabeo d'oro



*A good glass in the bishop's hostel in the devil's seat twenty-one degrees and thirteen minutes northeast and by north main branch seventh limb east side shoot from the left eye of the death's-head a bee line from the tree through the shot fifty feet out*

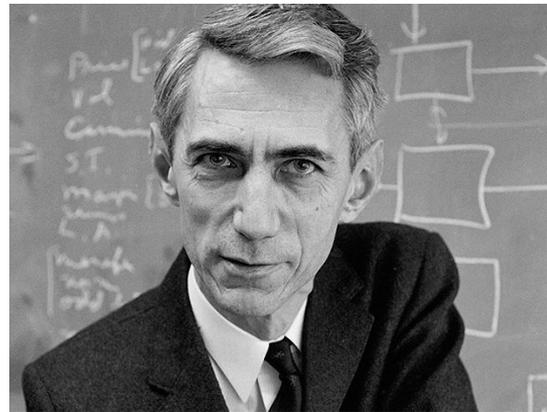
# Prediction and Entropy of Printed English

By C. E. SHANNON

*(Manuscript Received Sept. 15, 1950)*

A new method of estimating the entropy and redundancy of a language is described. This method exploits the knowledge of the language statistics possessed by those who speak the language, and depends on experimental results in prediction of the next letter when the preceding text is known. Results of experiments in prediction are given, and some properties of an ideal predictor are developed.

Claude E. Shannon



(1) THE ROOM WAS NOT VERY LIGHT A SMALL OBLONG

(2) ----ROO-----NOT-V-----I-----SM----OBL-----

(1) READING LAMP ON THE DESK SHED GLOW ON

(2) REA-----O-----D----SHED-GLO--O--

(1) POLISHED WOOD BUT LESS ON THE SHABBY RED CARPET

(2) P-L-S-----O---BU--L-S--O-----SH-----RE--C-----





# Entropia

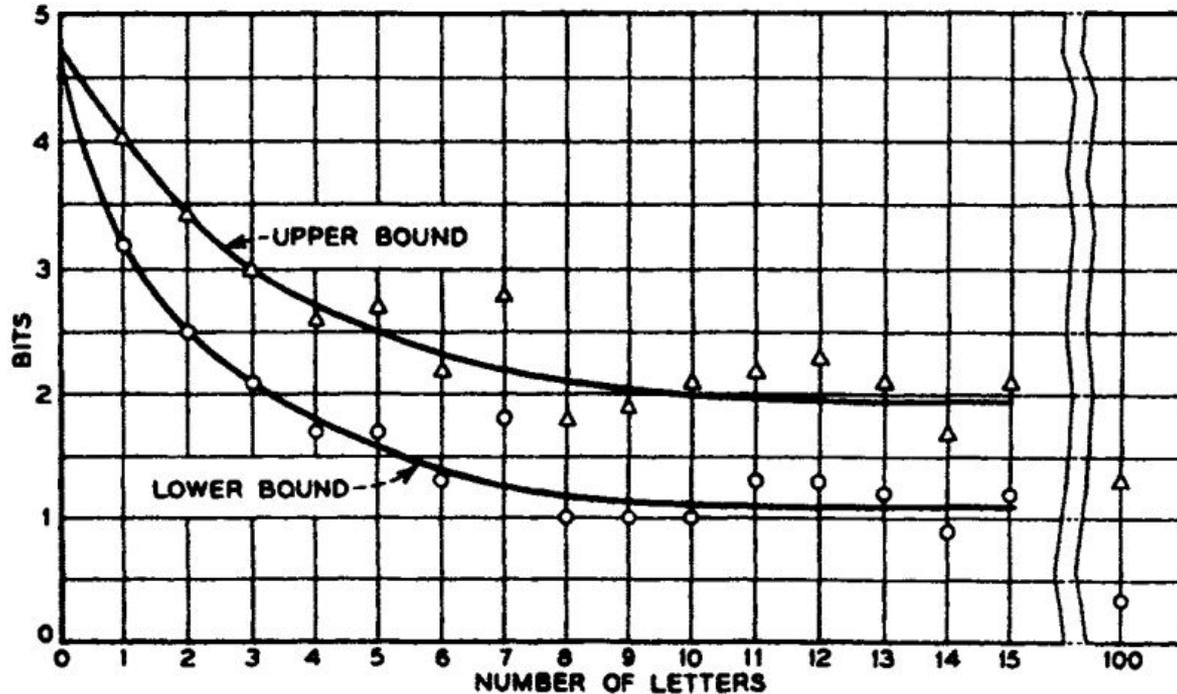
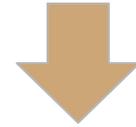


Fig. 4—Upper and lower experimental bounds for the entropy of 27-letter English.

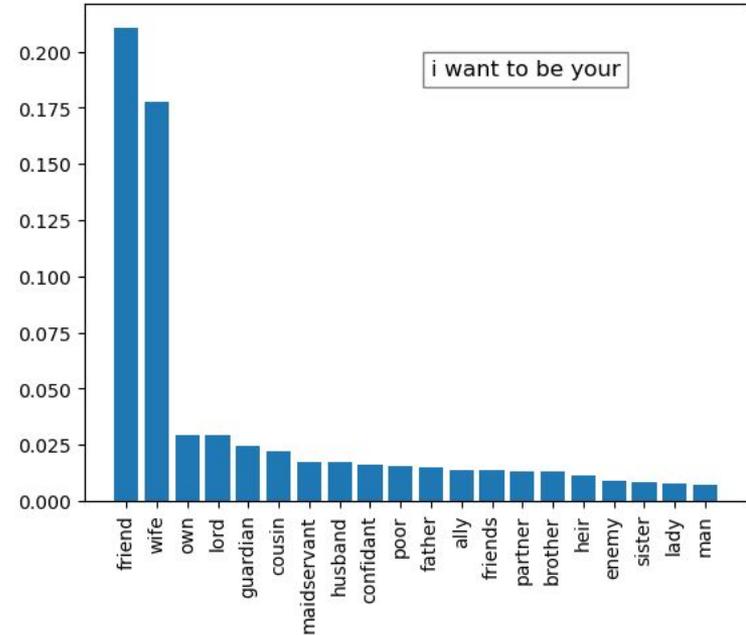
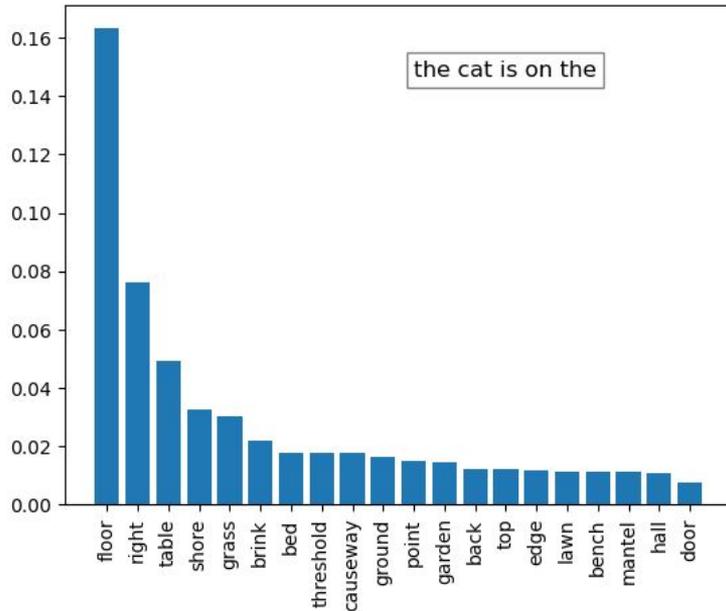
$$H = - \sum p_k \log_2 p_k$$



Approccio PROBABILISTICO

# Approccio Probabilistico per il Linguaggio

Dato un testo formato da una sequenza di parole, quali sono le parole più probabili che possono seguire?



# Approccio Probabilistico per il Linguaggio

Immaginiamo una macchina che attribuisce la **VERA** distribuzione di probabilità delle possibili parole che seguono un testo.

DOMANDA

Potremmo attribuire a questa macchina la qualità dell'**INTELLIGENZA**?

**YES**

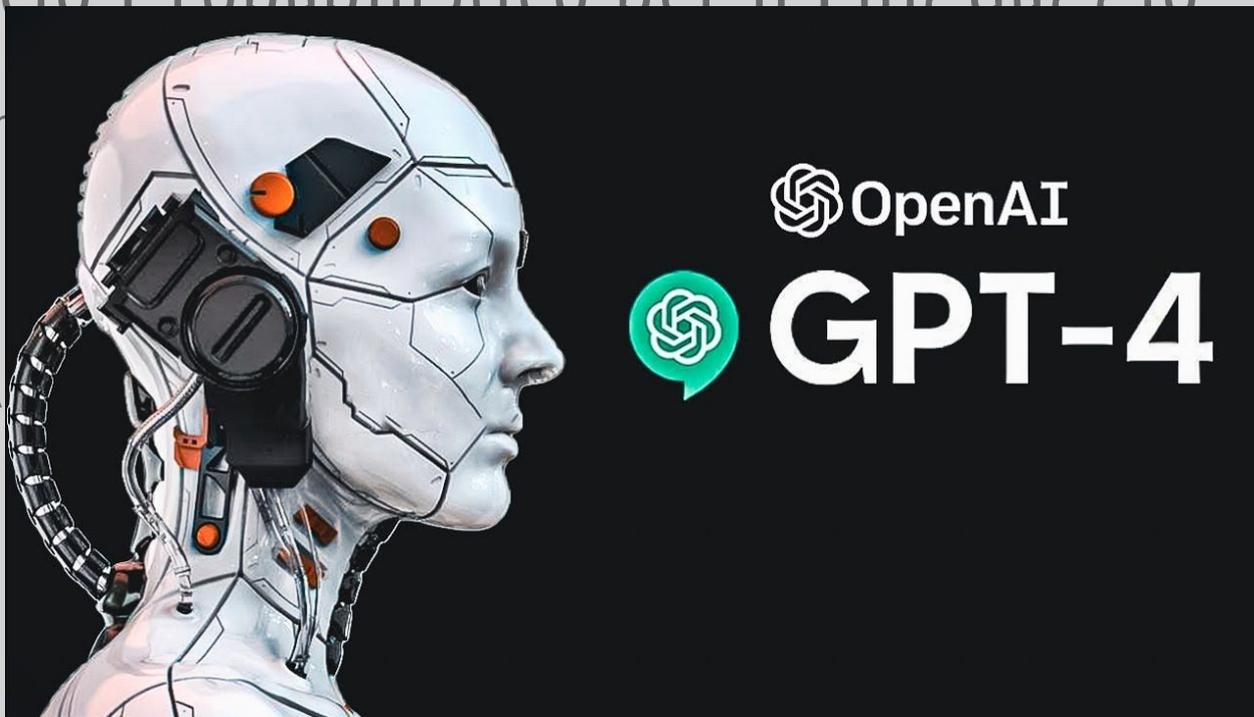
**NO**

# Approccio Probabilistico per il Linguaggio

Immaginar  
probabilità

DOMANDA

Potremmo



ZA?

# GPT4

## Sparks of Artificial General Intelligence: Early experiments with GPT-4

Sébastien Bubeck    Varun Chandrasekaran    Ronen Eldan    Johannes Gehrke  
Eric Horvitz    Ece Kamar    Peter Lee    Yin Tat Lee    Yuanzhi Li    Scott Lundberg  
Harsha Nori    Hamid Palangi    Marco Tulio Ribeiro    Yi Zhang

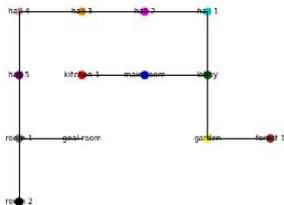
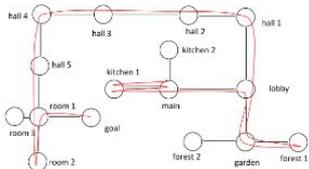
Microsoft Research



Produce Javascript code that creates a random graphical image that looks like a painting of Kandinsky



Can you compose a short tune (say four to eight bars) using ABC notation?



Can you draw a pyplot plot showing the position of the rooms/places and connect them using lines?

<https://arxiv.org/abs/2303.12712>



GPTx è intelligente?



# ChatGPT

HA

I have a bag of apples, there are 5 apples in it, if I take 2 out of it, how many apples are left in the bag?



If you have a bag with 5 apples in it and you take 2 out of it, then there will be 3 apples left in the bag. This is because  $5 - 2 = 3$ .



HA

If I take out 2 more apples, how many apples are still in the bag now?



If you have a bag with 5 apples in it and you take 2 apples out, then there will be 3 apples left in the bag. If you take out 2 more apples, then there will be 1 apple left in the bag. This is because  $3 - 2 = 1$ .



In total, if you take out 4 apples from a bag with 5 apples in it, then there will be 1 apple left in the bag. This is because  $5 - 4 = 1$ .

HA

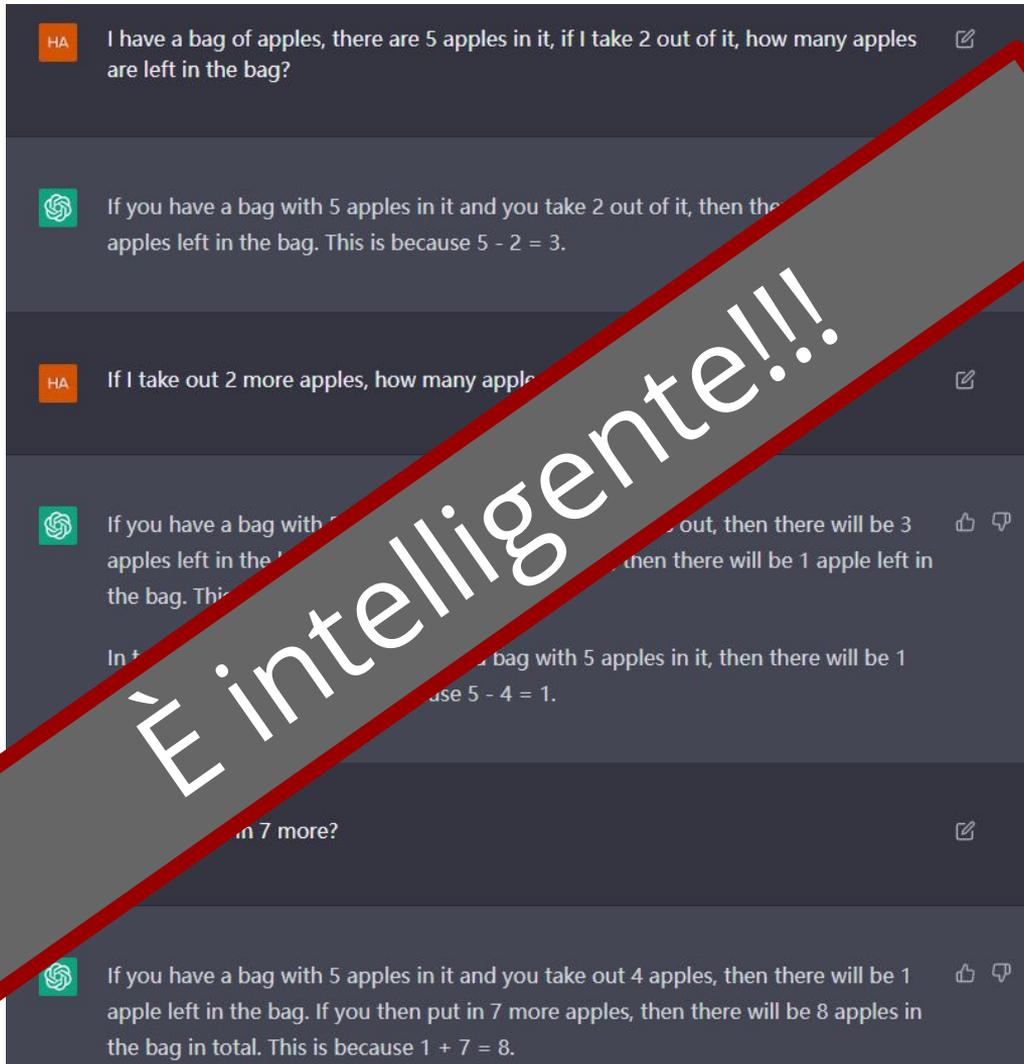
What if I put in 7 more?



If you have a bag with 5 apples in it and you take out 4 apples, then there will be 1 apple left in the bag. If you then put in 7 more apples, then there will be 8 apples in the bag in total. This is because  $1 + 7 = 8$ .



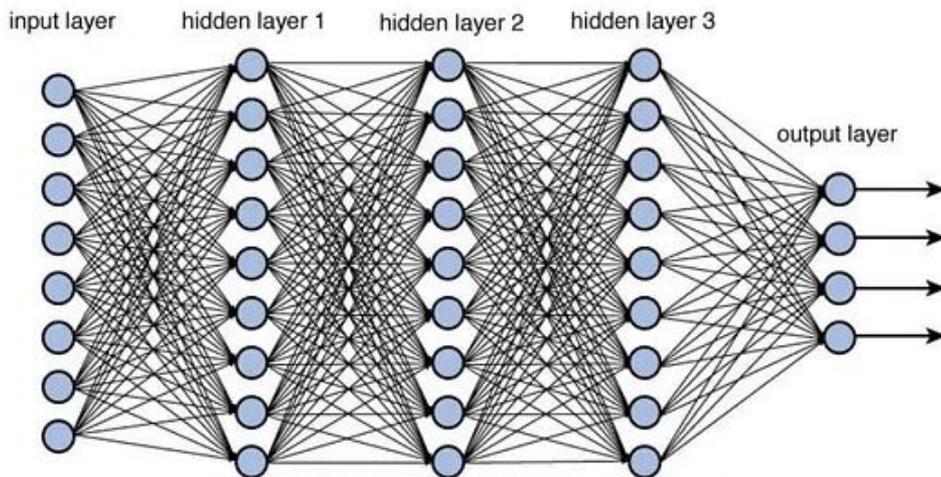
# ChatGPT



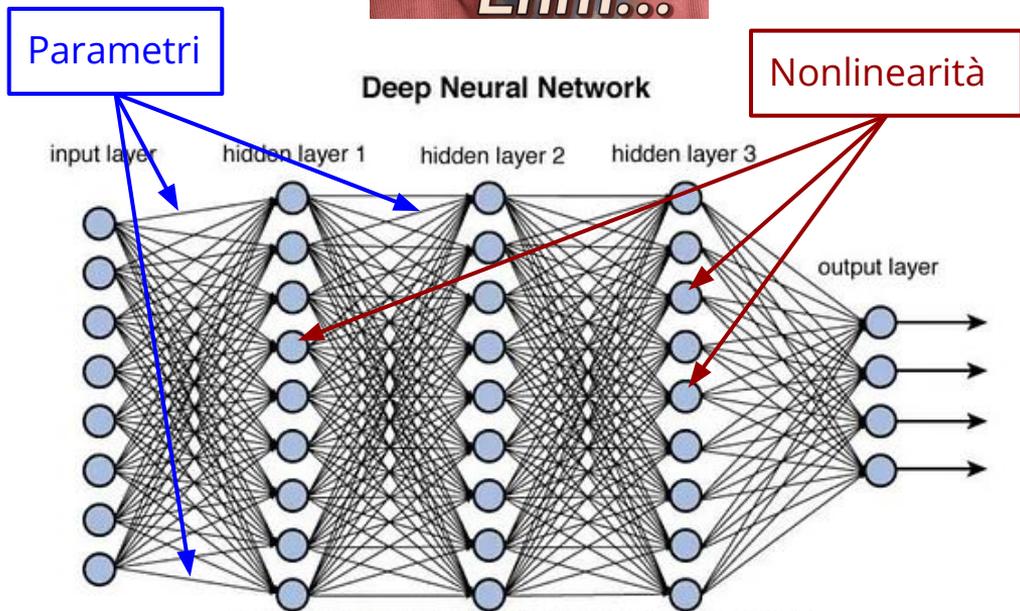
# È intelligente...?



Deep Neural Network



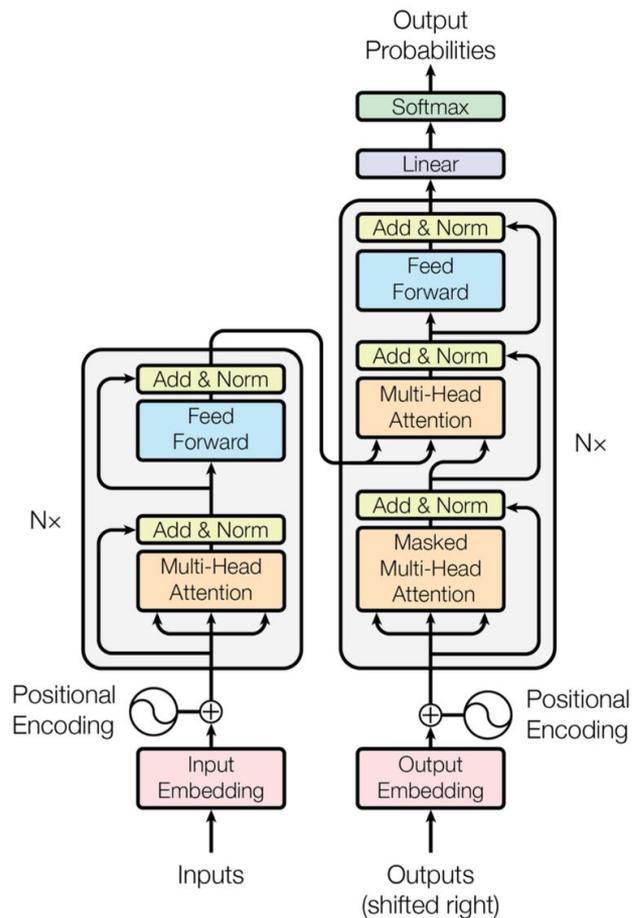
# È intelligente...?



175 miliardi di parametri (GPT3)

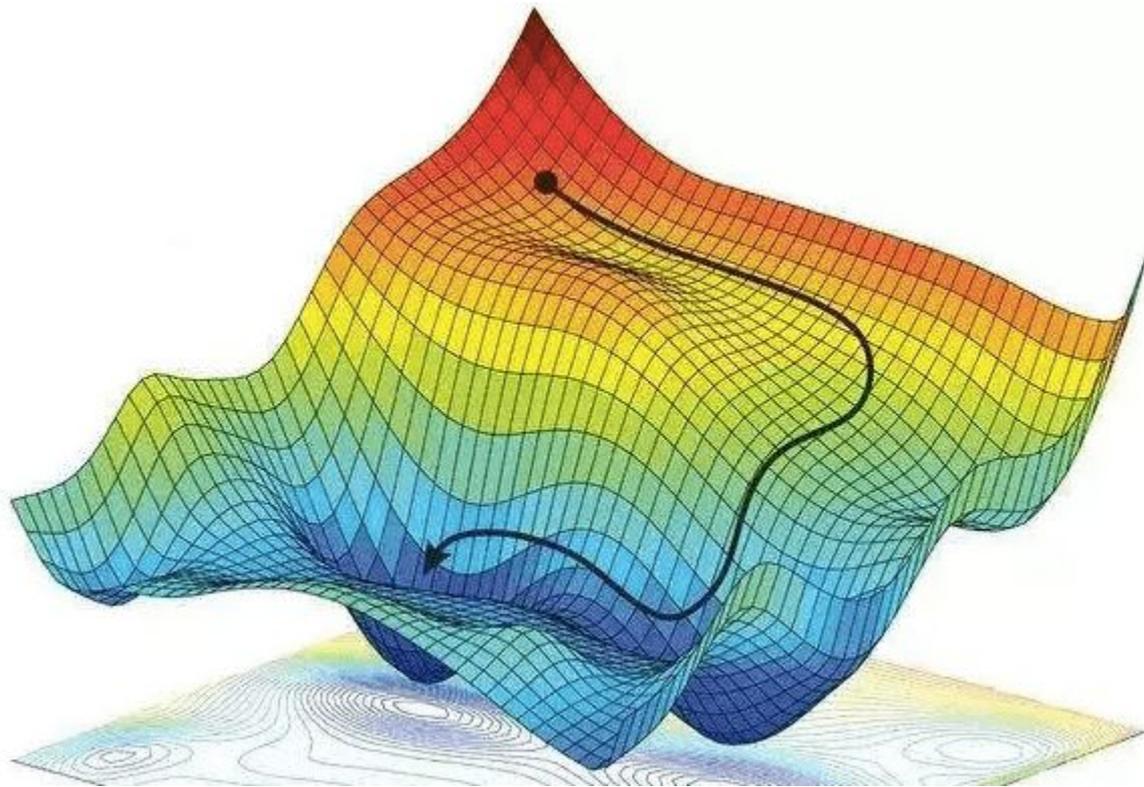
# È intelligente...?

Model Name	$n_{\text{params}}$	$n_{\text{layers}}$	$d_{\text{model}}$	$n_{\text{heads}}$	$d_{\text{head}}$	Batch Size	Learning Rate
GPT-3 Small	125M	12	768	12	64	0.5M	$6.0 \times 10^{-4}$
GPT-3 Medium	350M	24	1024	16	64	0.5M	$3.0 \times 10^{-4}$
GPT-3 Large	760M	24	1536	16	96	0.5M	$2.5 \times 10^{-4}$
GPT-3 XL	1.3B	24	2048	24	128	1M*	$2.0 \times 10^{-4}$
GPT-3 2.7B	2.7B	32	2560	32	80	1M	$1.6 \times 10^{-4}$
GPT-3 6.7B	6.7B	32	4096	32	128	2M	$1.2 \times 10^{-4}$
GPT-3 13B	13.0B	40	5140	40	128	2M	$1.0 \times 10^{-4}$
GPT-3 175B or "GPT-3"	175.0B	96	12288	96	128	3.2M	$0.6 \times 10^{-4}$

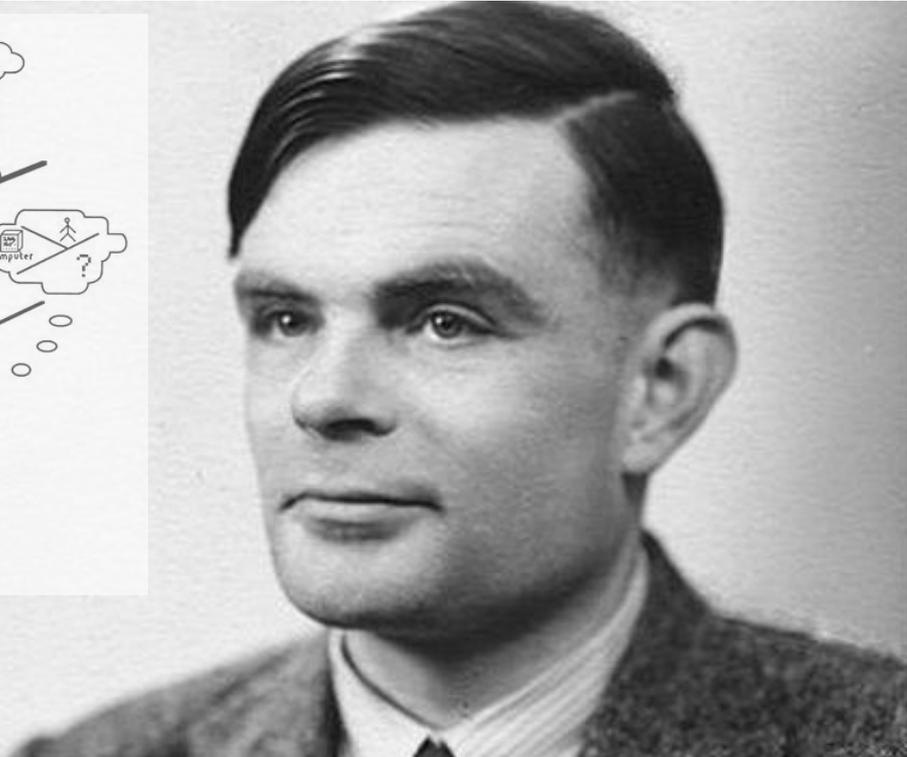


175 miliardi di parametri

È intelligente...?



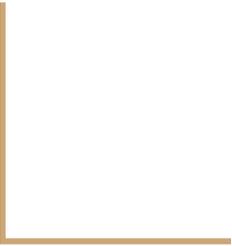
# È intelligente...?



Alan Turing



GPTx è creativa?



È creativa?

**Tutto ciò che GPT ha letto (e imparato)**

È creativa?



È creativa?



**Tutto ciò che GPT ha letto (e imparato)**

# È creativa?

**Sì!**  
(riempire i buchi secondo il contesto)



**Tutto ciò che GPT ha letto (e imparato)**

# È creativa?

(riempire i buchi secondo il contesto)

Sì!

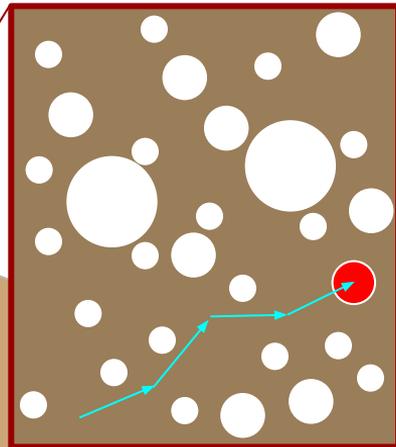
## Frase lette:

1. Il papà fa il pranzo alla bambina
2. La mamma prepara il pranzo di natale

## Frase generata (possibile):

La mamma fa il pranzo alla bambina

Tutto ciò che GPT ha letto (e imparato)



# È creativa?

(riempire i buchi secondo il contesto)

Sì!

## Frase lette:

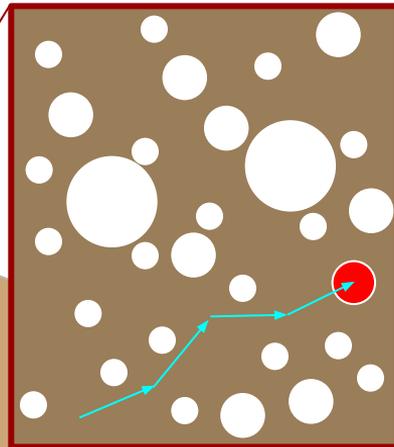
1. Il papà fa il pranzo alla bambina
2. La mamma prepara il pranzo di natale

## Frase generata (possibile):

La mamma fa il pranzo

**RICOMBINAZIONE  
DELL'INFORMAZIONE**

**Tutto ciò che GPT ha letto (e imparato)**



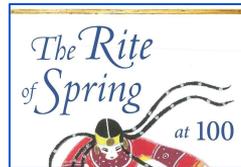
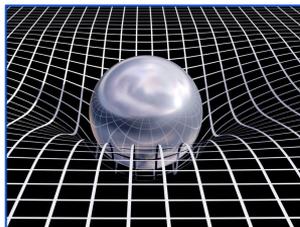
È creativa?

Innovazione

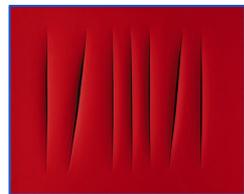
**Tutto ciò che GPT ha letto (e imparato)**



È creativa?

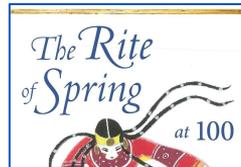
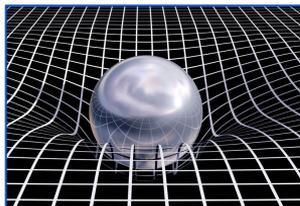


Innovazione

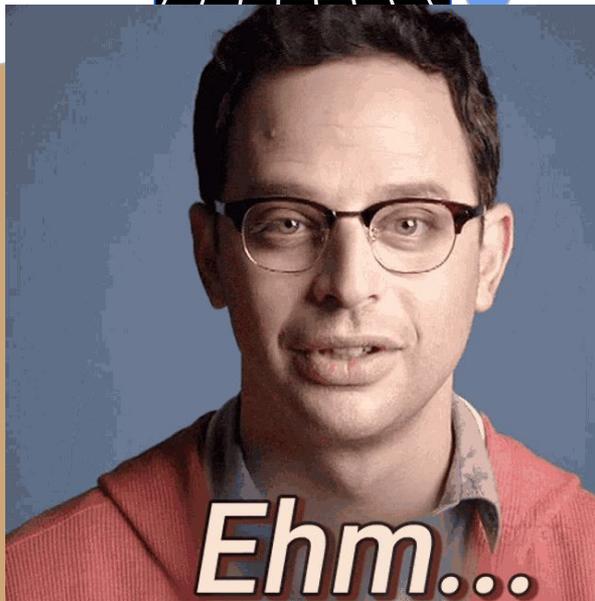
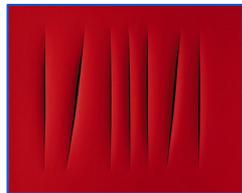


**Tutto ciò che GPT ha letto (e imparato)**

È creativa?



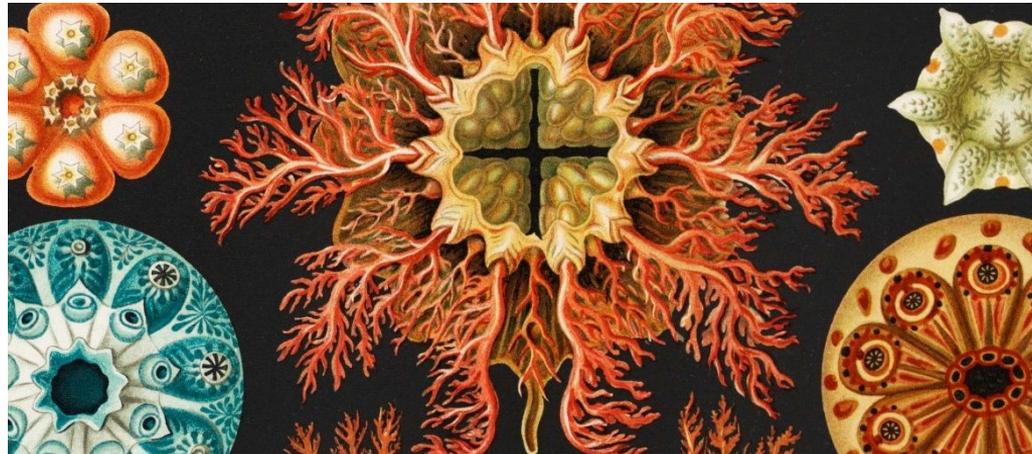
Innovazione



Tutto ciò che GPT ha letto (e imparato)

# È creativa?

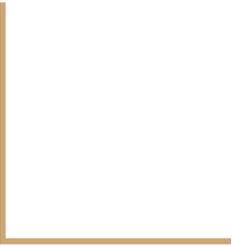
Il “Pensiero Creativo” consiste nella “capacità di ideare diverse soluzioni alternative per risolvere un problema, mediante un **ragionamento flessibile** che favorisce la creazione di risposte **insolite ed originali** al nostro quesito”



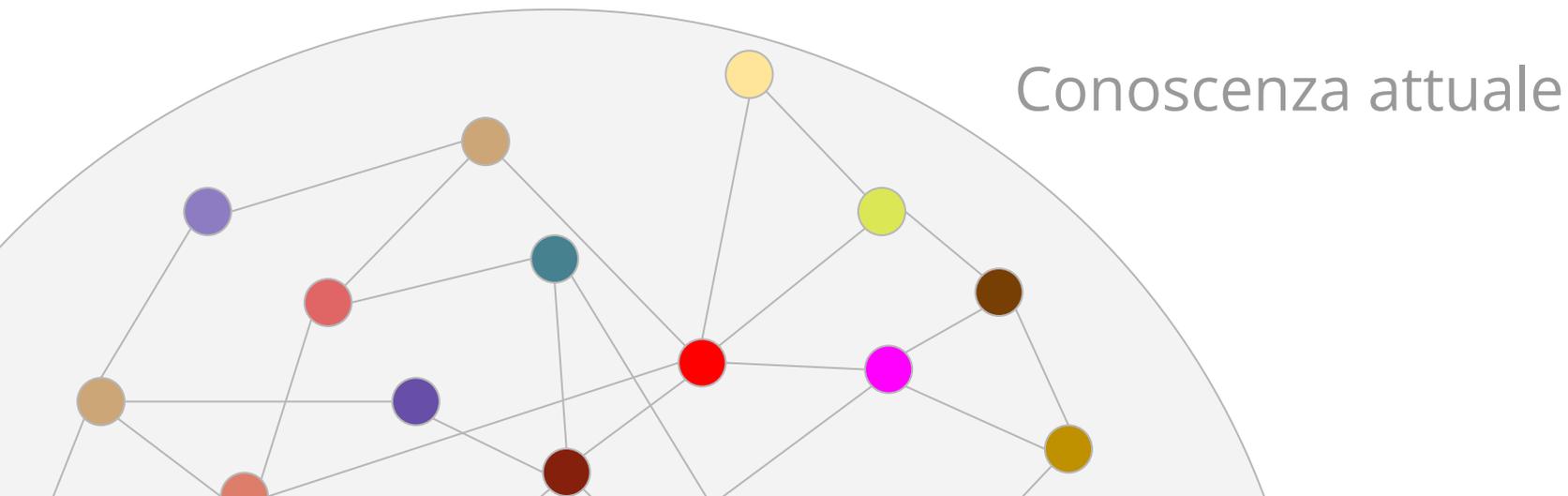
Ernst Haeckel 1904



Adiacente Possibile

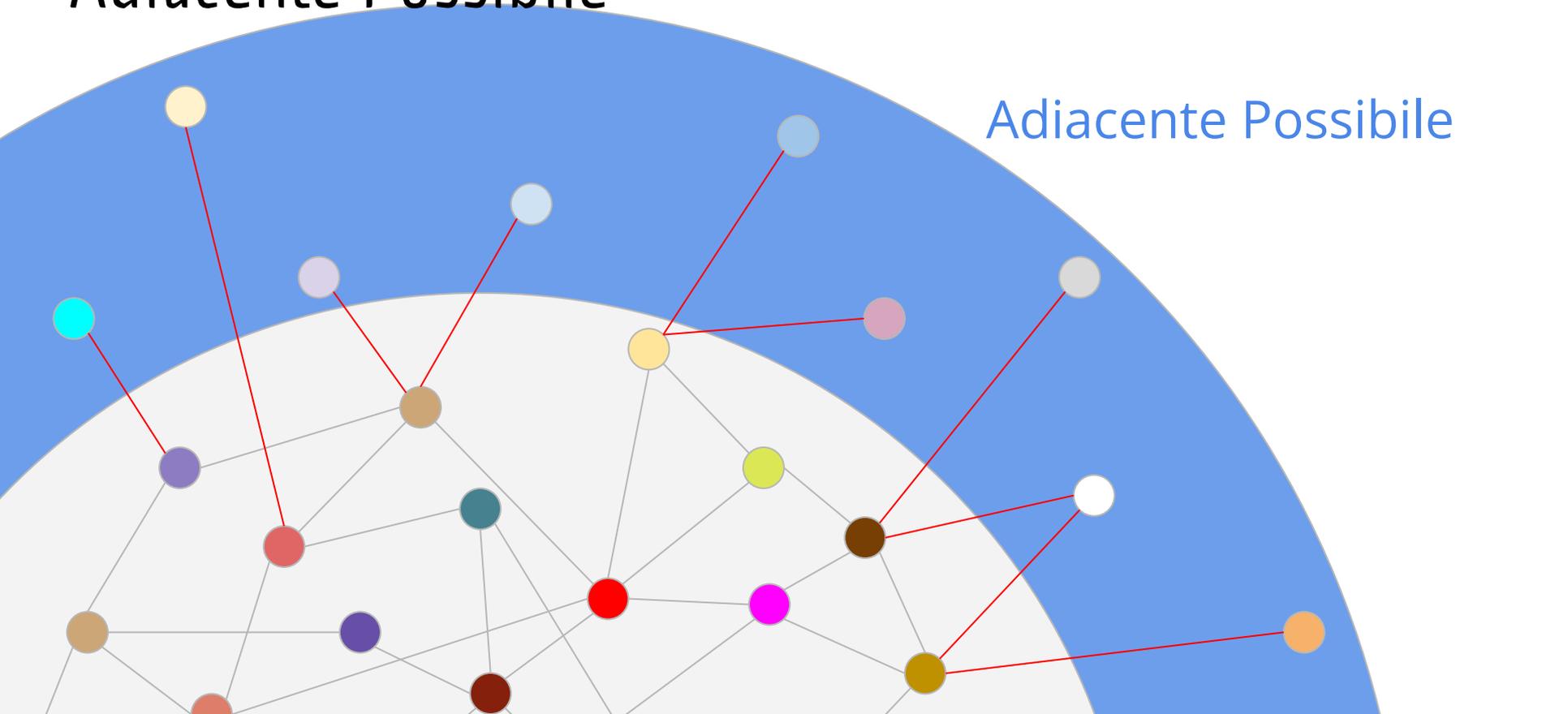


# Adiacente Possibile

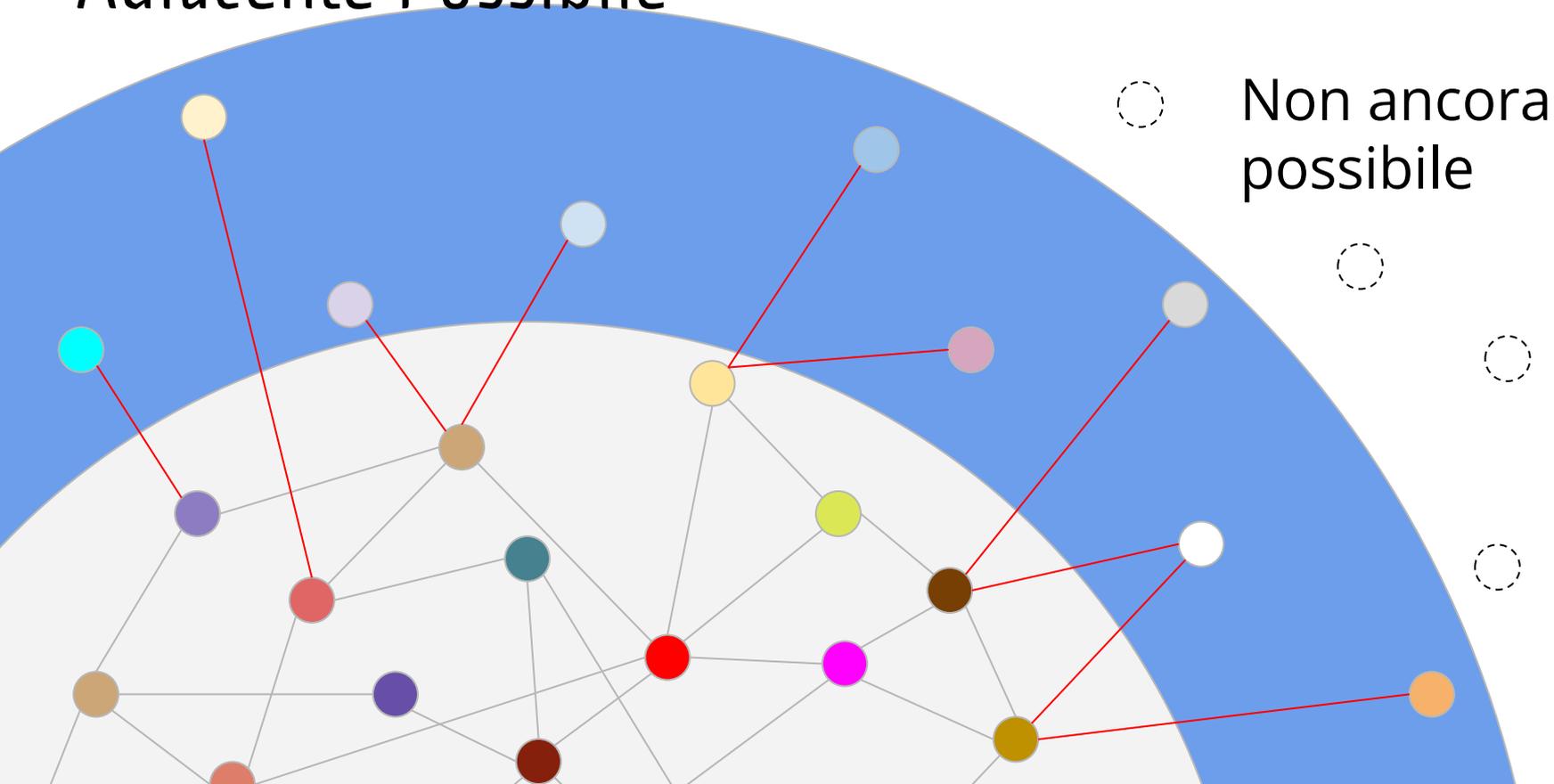


# Adiacente Possibile

Adiacente Possibile

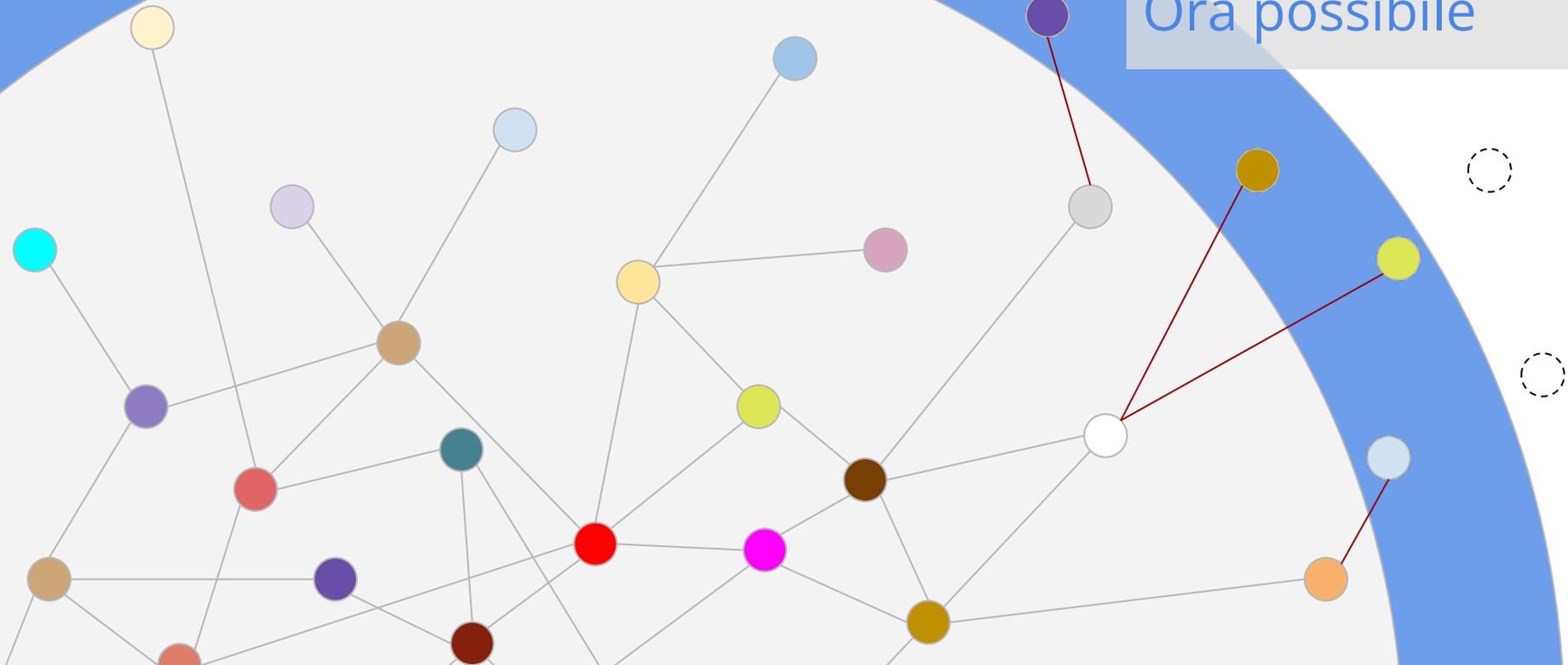


# Adiacente Possibile

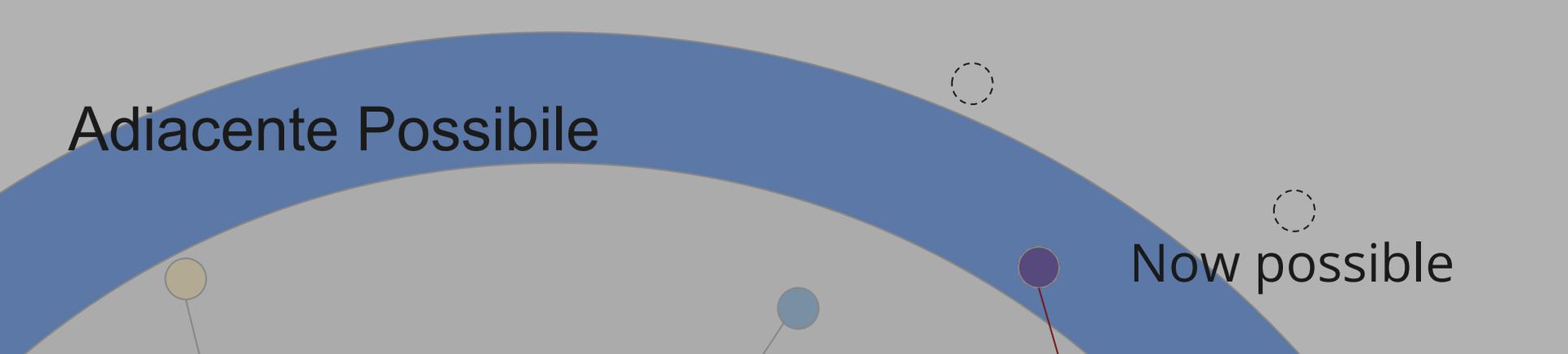


# Adiacente Possibile

Ora possibile

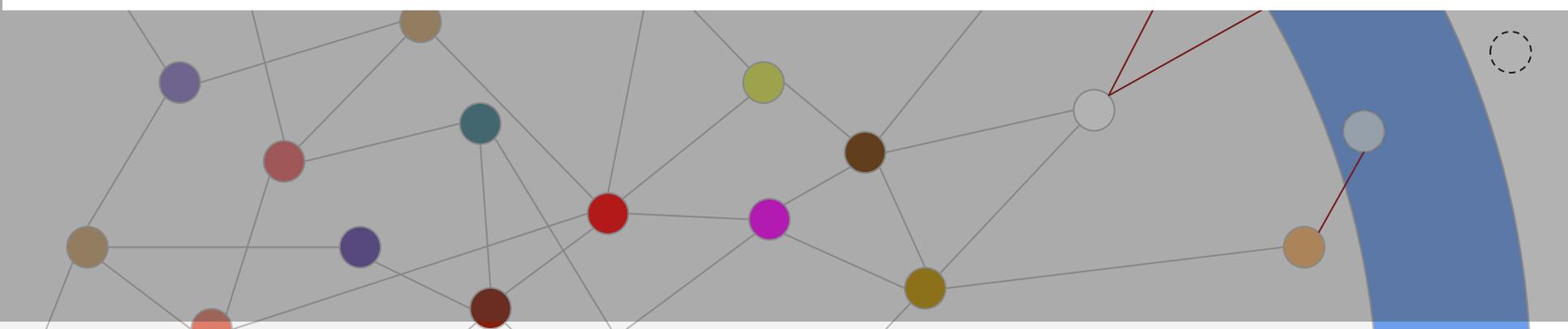


# Adiacente Possibile



Now possible

"... l'adiacente possibile consiste in tutte quelle cose (a seconda del contesto, possono essere idee, molecole, genomi, prodotti tecnologici, ecc.) che sono a un passo da ciò che esiste realmente, e quindi possono nascere da modifiche incrementali e ricombinazioni di materiale esistente. Ogni volta che si crea qualcosa di nuovo in questo modo, una parte del possibile precedentemente adiacente si attualizza ed è quindi delimitata a sua volta da un nuovo possibile adiacente".



# Adiacente Possibile Relativo (e comune...)



# Creatività

- Exploiting

Utilizzare una mappa di conoscenza al fine di migliorare le prestazioni di un sistema

# Creatività

- Exploiting

Utilizzare la propria mappa di conoscenza al fine di migliorare le prestazioni

- Exploring

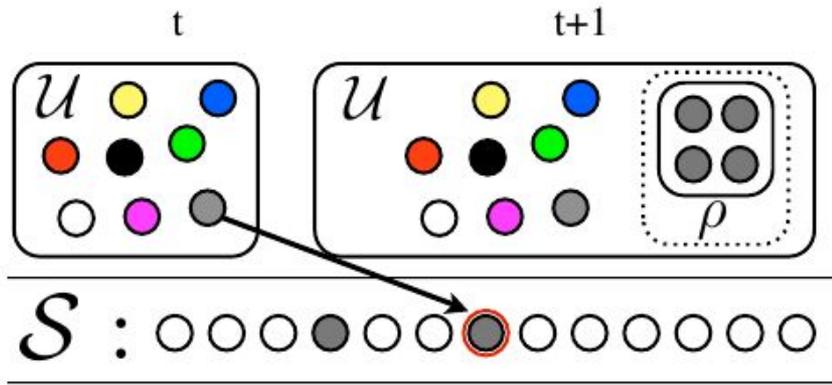
Far uso dalla propria conoscenza al fine di esplorare elementi nuovi (e interessanti) da integrare

Innovazione



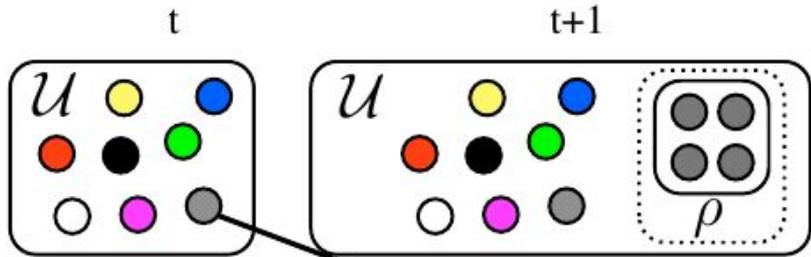
# Urne di Polya

a Reinforcement

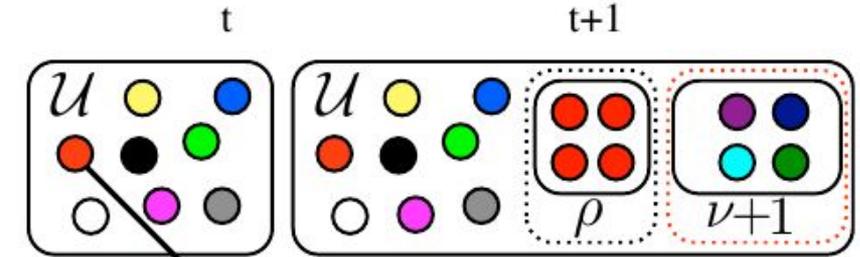


# Urne di Polya

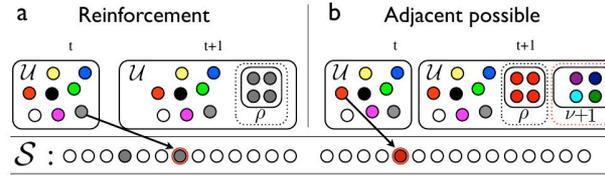
a Reinforcement



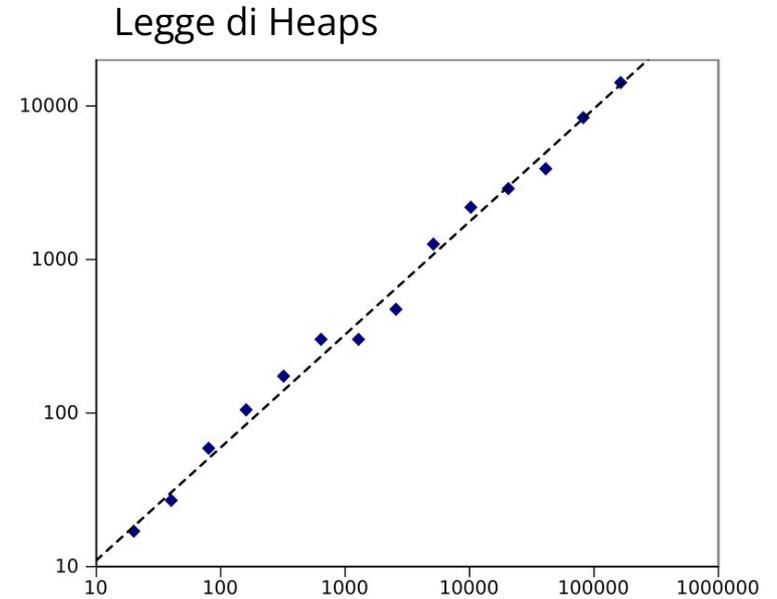
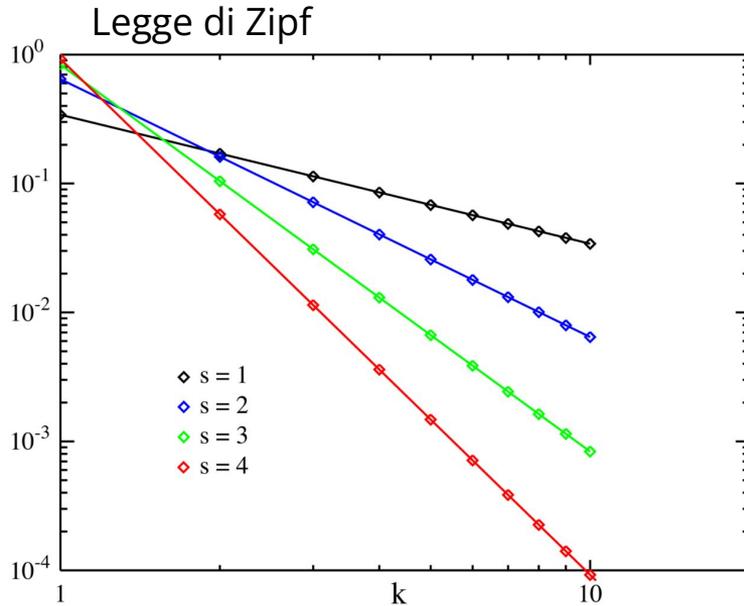
b Adjacent possible



# Urne di Polya



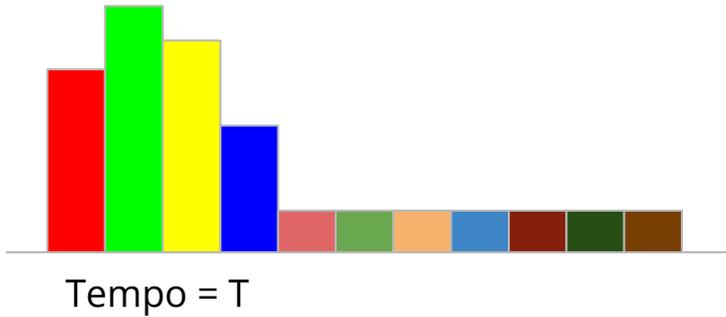
Rate of innovation:  $\frac{\nu}{\rho}$



# Urne di Polya

Distribuzioni

Possibile  
(Urna)

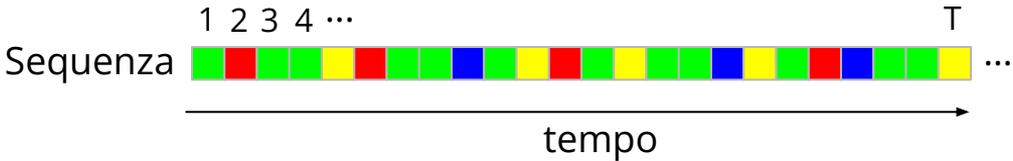
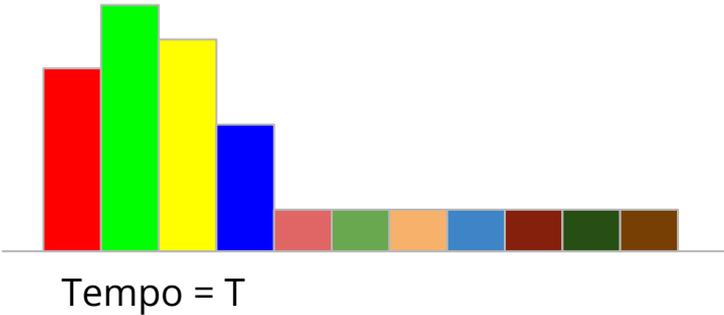


# Urne di Polya

## Distribuzioni

Possibile  
(Urna)

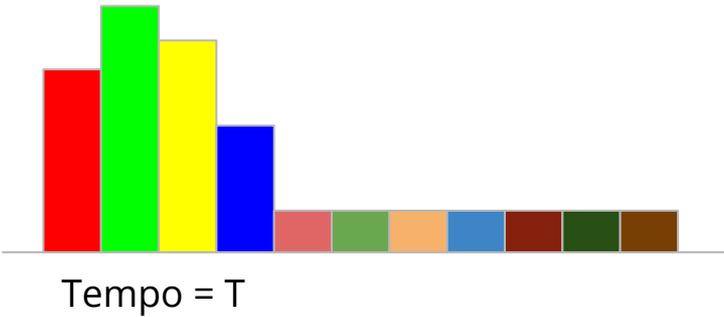
Osservata  
(Sequenza)



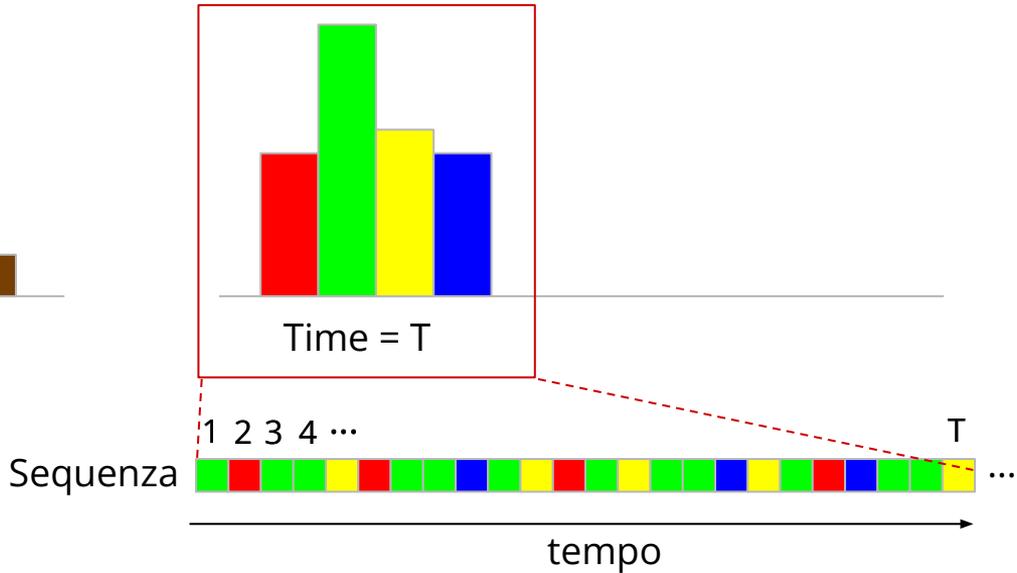
# Urne di Polya

## Distribuzioni

Possibile  
(Urna)



Osservata  
(Sequenza)

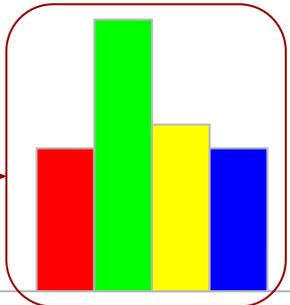
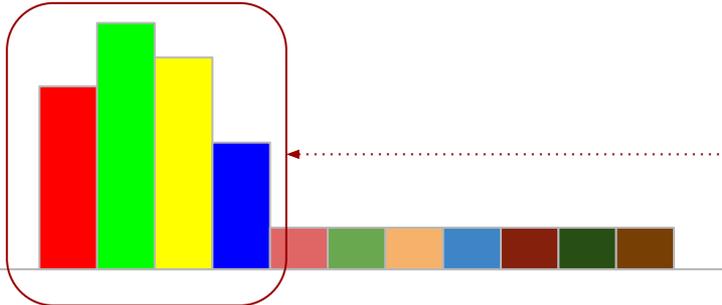


# Urne di Polya

## Distribuzioni

Possibile  
(Urna)

Osservata  
(Sequenza)

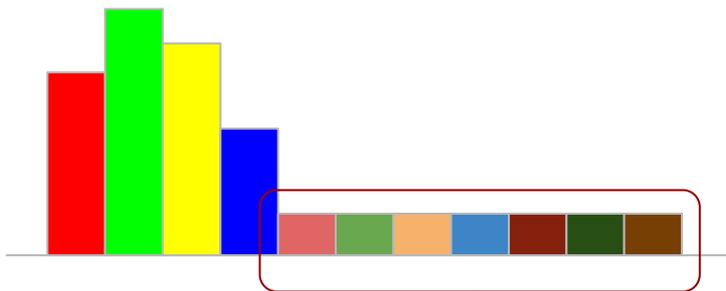


Apprendimento del passato

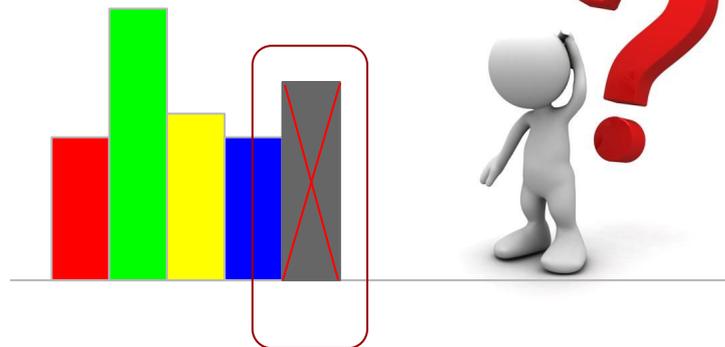
# Urne di Polya

## Distribuzioni

Possibile  
(Urna)

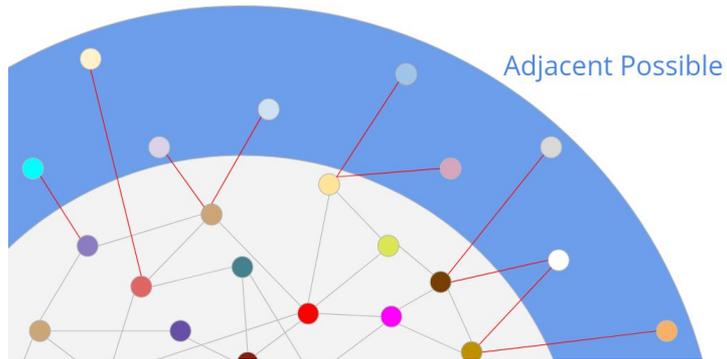


Osservata  
(Sequenza)

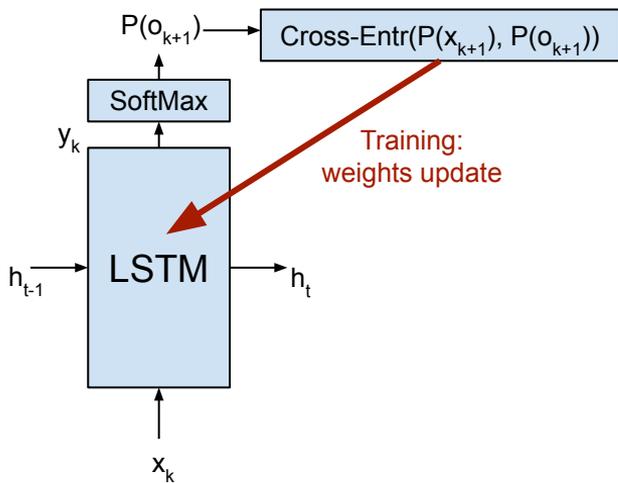


Anticipare le novità

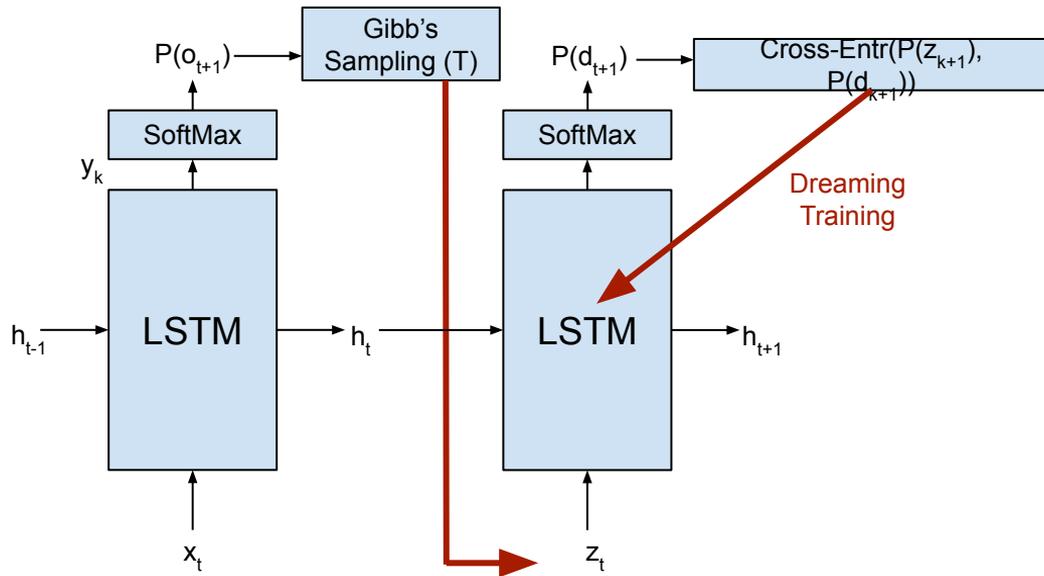
# Dreaming AI



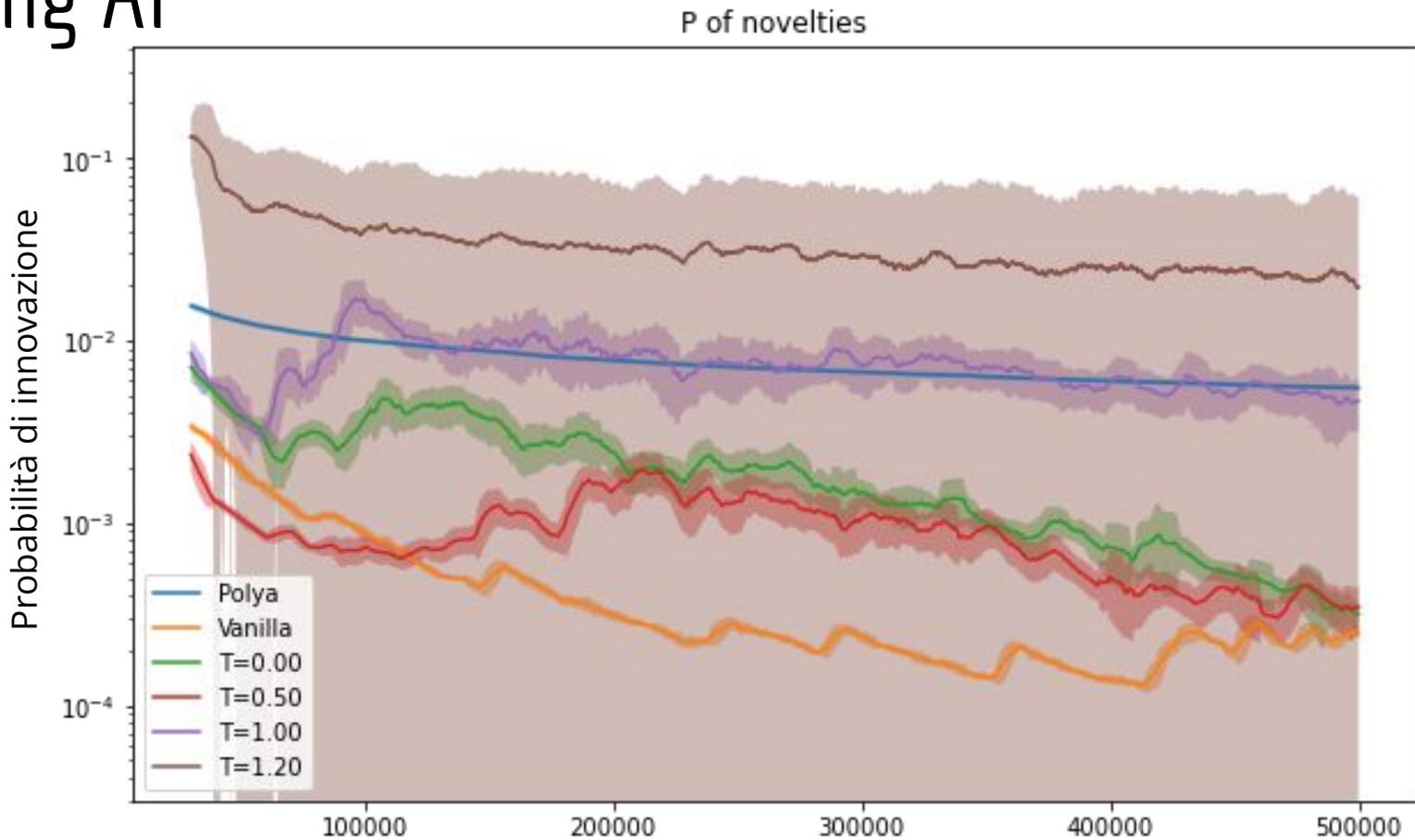
Classic training step



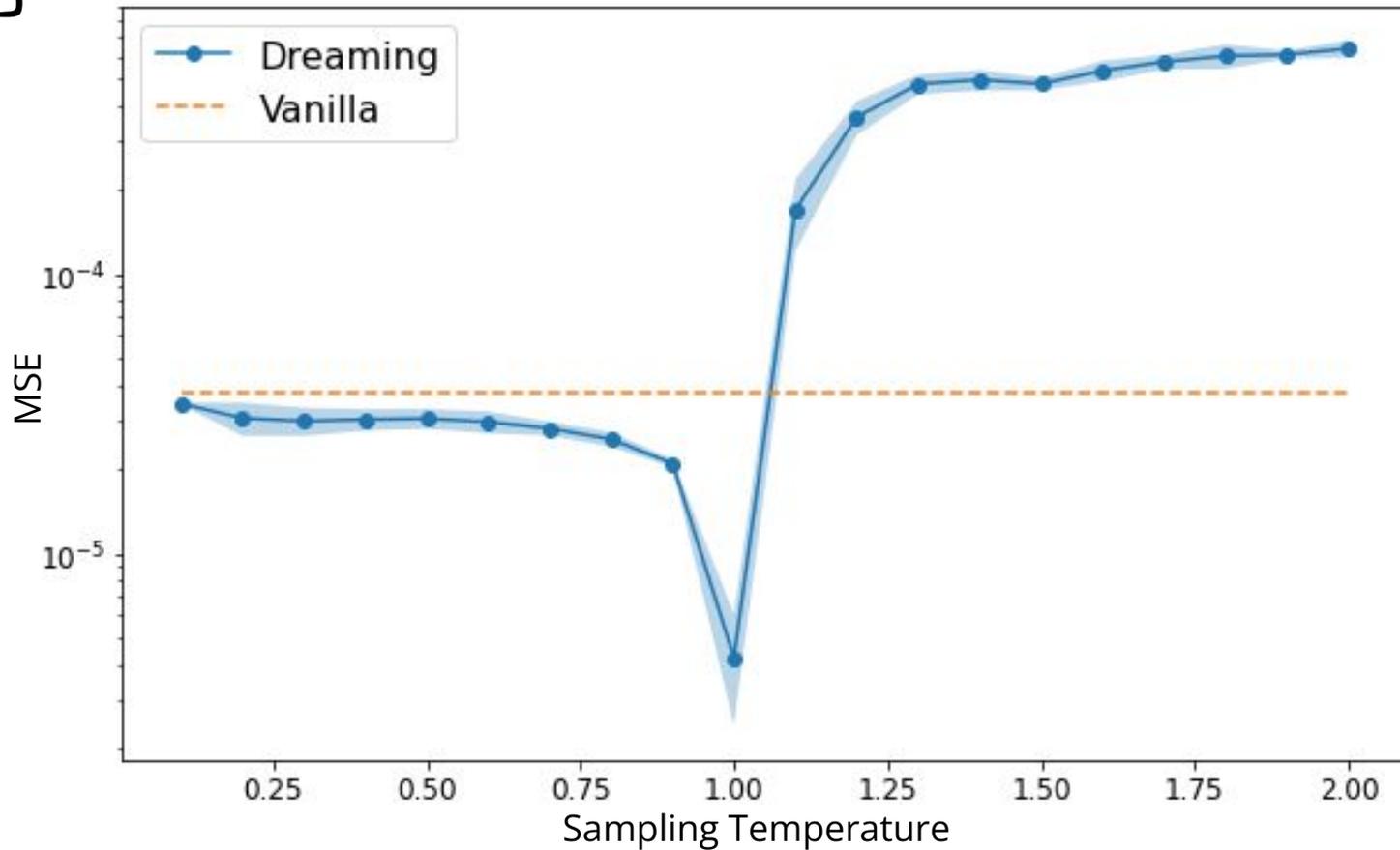
Dreaming training step



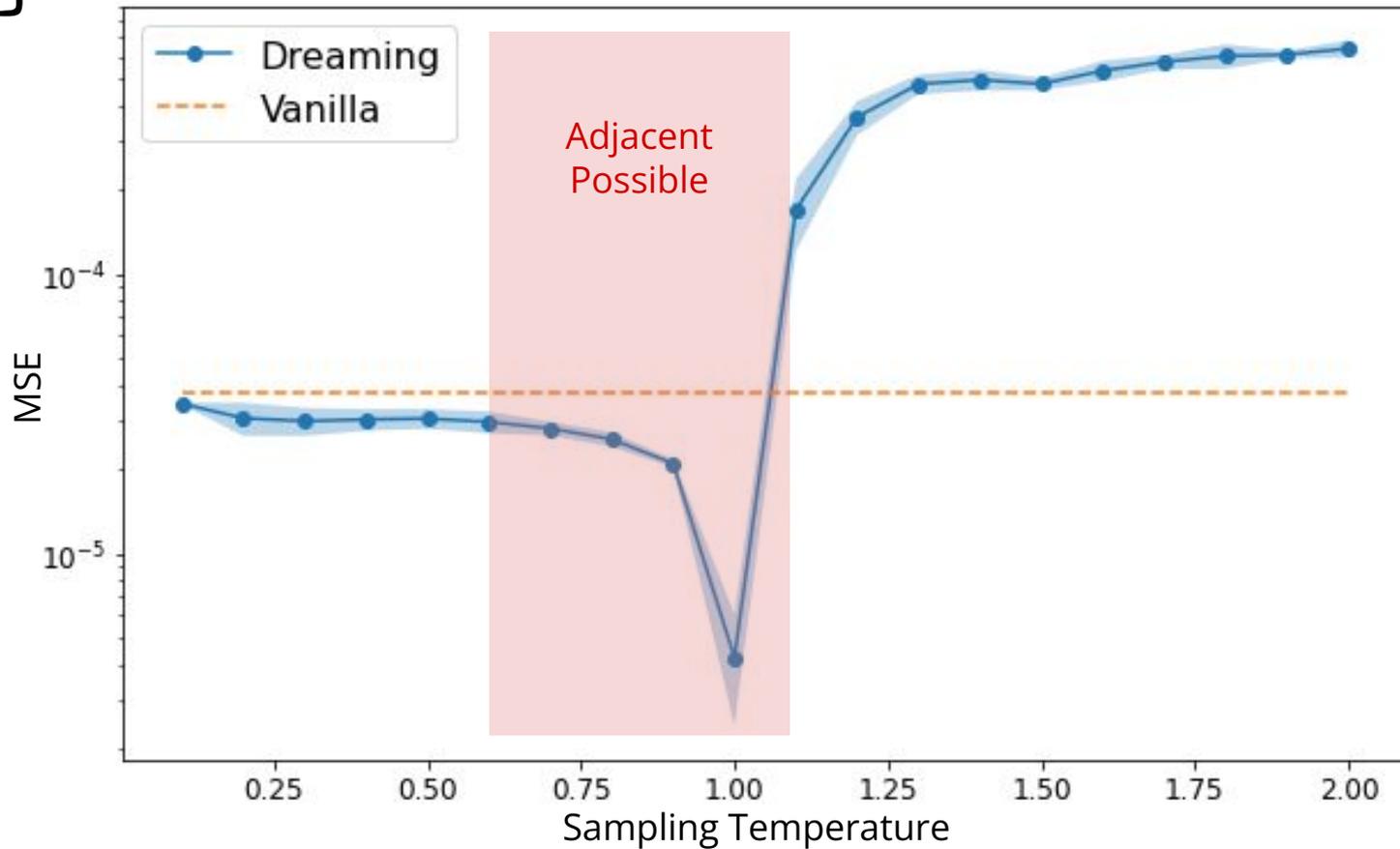
# Dreaming AI



# Dreaming AI - Adiacente Possibile

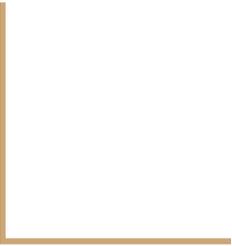


# Dreaming AI - Adjacent Possible





Innovazione come cambio di paradigma

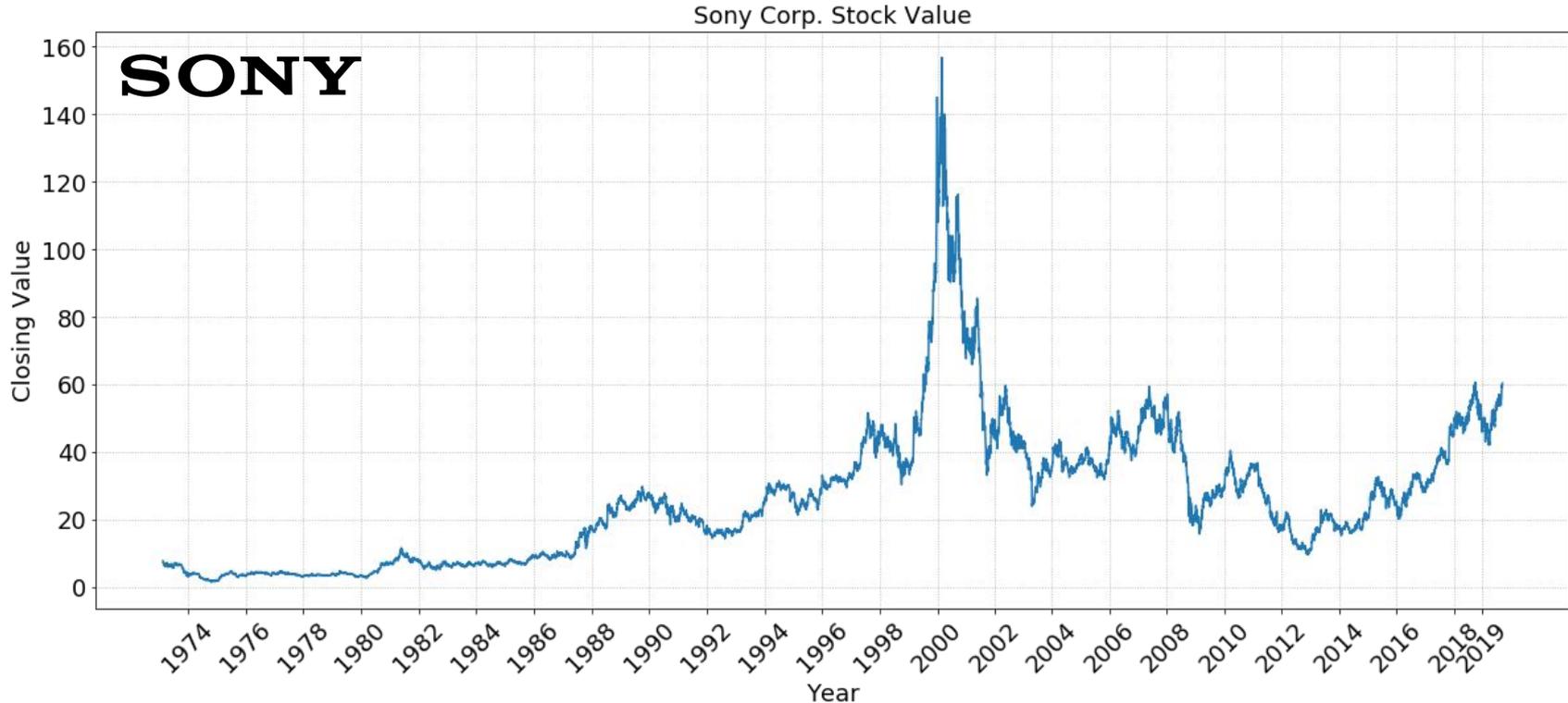


# Decision Making - Stock Market gambling

Stock Market: Sony Corporation (SNE)

NYSE - Nasdaq Real Time Price. Currency in USD.

Period: 1973 - 2019



# Decision Making - Stock Market gambling

Stock Market: Sony Corporation (SNE)

NYSE - Nasdaq Real Time Price. Currency in USD.

Period: 1973 - 2019

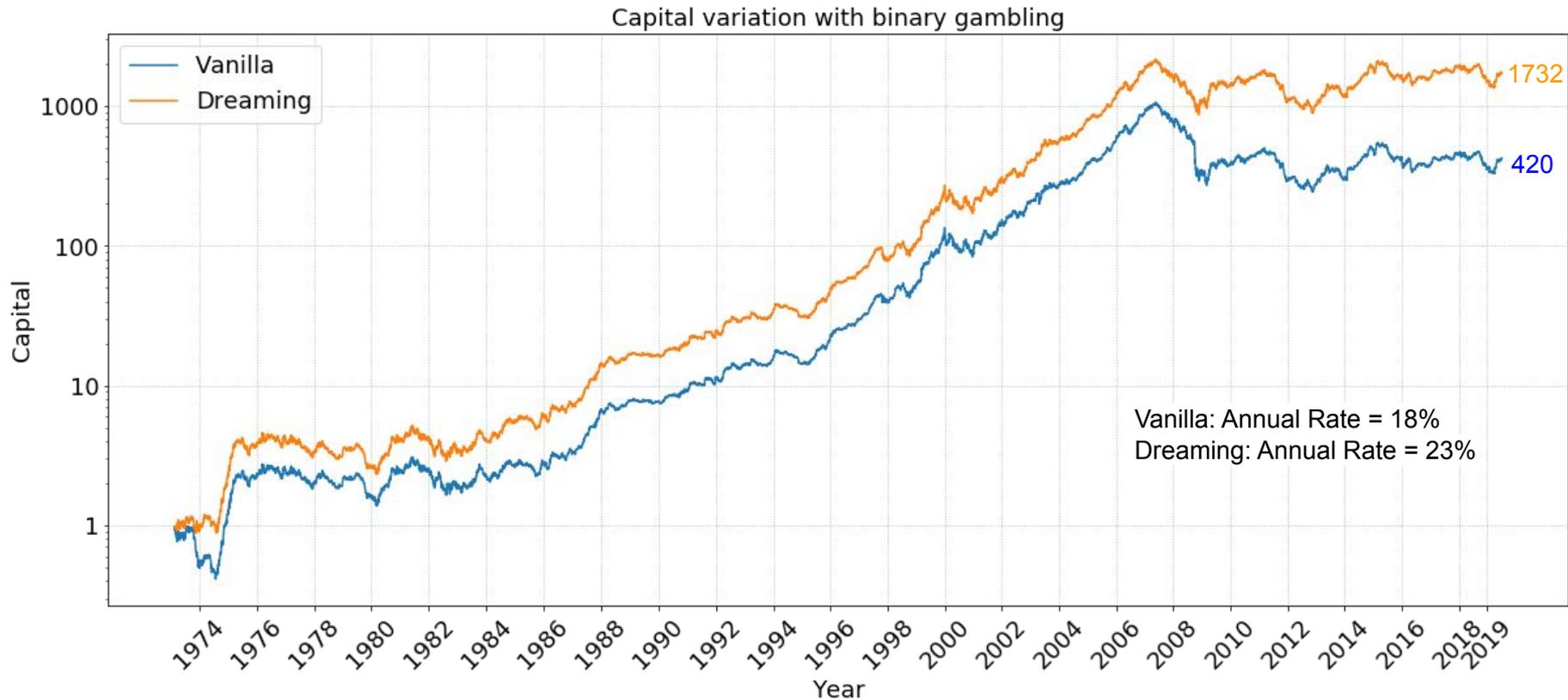


# Decision Making - Stock Market gambling

## Capital Comparison

## Binary Gambling

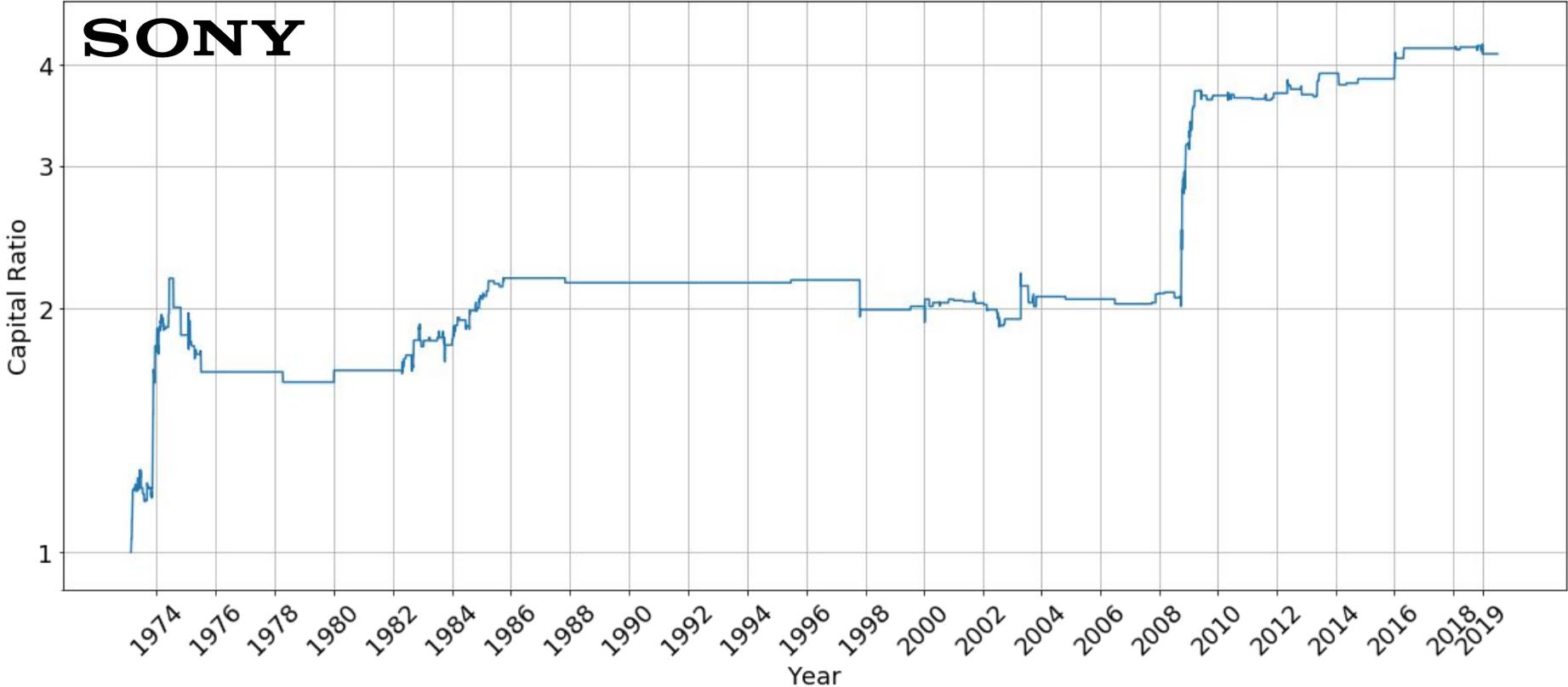
Investing capital if  $P_{NN}(\uparrow) > 0.5$



# Decision Making - Stock Market gambling

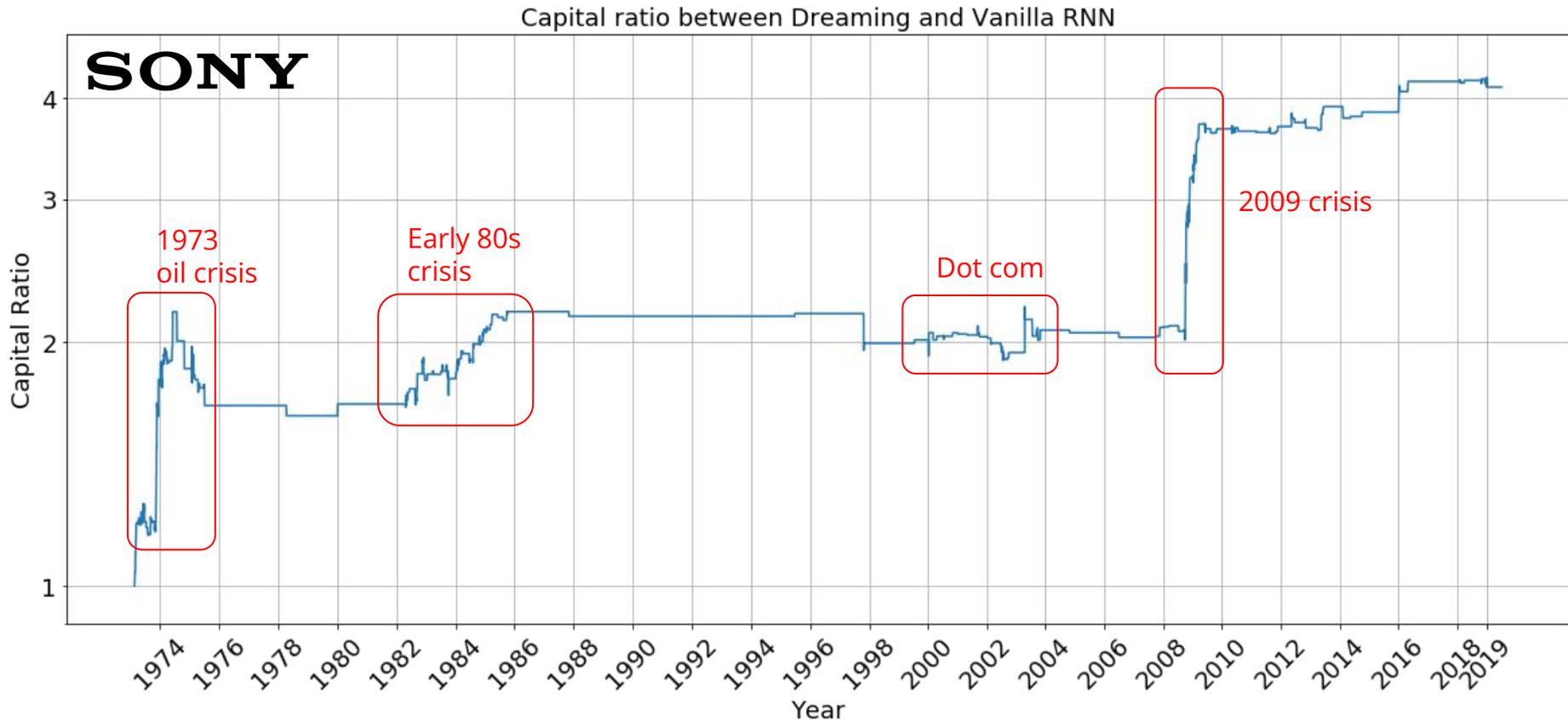
## Capital Ratio

Capital ratio between Dreaming and Vanilla RNN



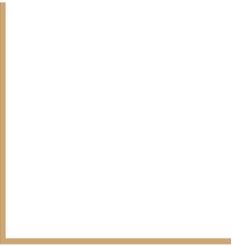
# Decision Making - Stock Market gambling

## Capital Ratio





AI e Creatività oggi  
Cosa manca?





AI e Creatività oggi  
Cosa manca?



SECONDO ME

# Dati/infrastrutture Vs. nuovi approcci sostenibili

Richard Sutton (Reinforcement Learning) - 2019

“...Dobbiamo imparare l'amara lezione che costruire nel modo in cui pensiamo non funziona nel lungo periodo. L'amara lezione si basa sull'osservazione storica che 1) i ricercatori di IA hanno spesso cercato di incorporare la conoscenza nei loro agenti, 2) questo aiuta sempre nel breve periodo ed è personalmente soddisfacente per il ricercatore, ma 3) nel lungo periodo si ferma e addirittura inibisce ulteriori progressi, e 4) **alla fine i progressi più importanti arrivano da un approccio opposto basato sulla scalabilità del calcolo tramite ricerca e apprendimento.**”

<http://incompleteideas.net/Incldeas/BitterLesson.html>

WILL KNIGHT

BUSINESS

APR 17, 2023

7:00 AM

<https://www.wired.com/story/openai-ceo-sam-altman-the-age-of-giant-ai-models-is-already-over/>

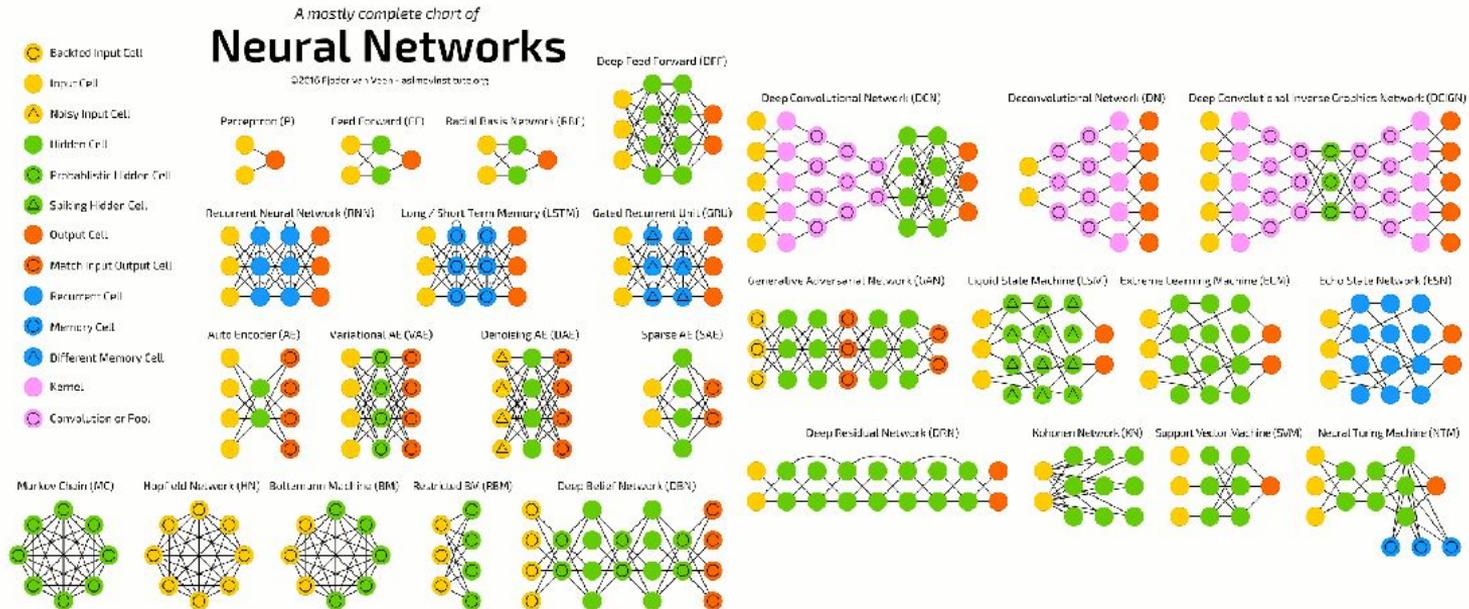
# OpenAI's CEO Says the Age of Giant AI Models Is Already Over

Sam Altman says the research strategy that birthed ChatGPT is played out and future strides in artificial intelligence will require new ideas.



# Architetture neurali

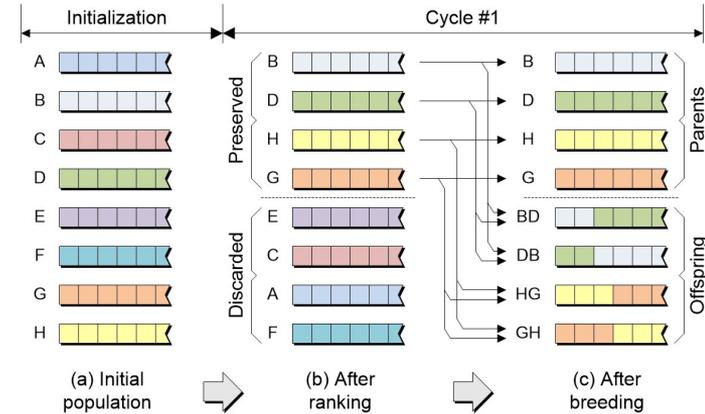
Nel Deep Learning le architetture sono **rigide** e non ammettono **feedback dinamici**



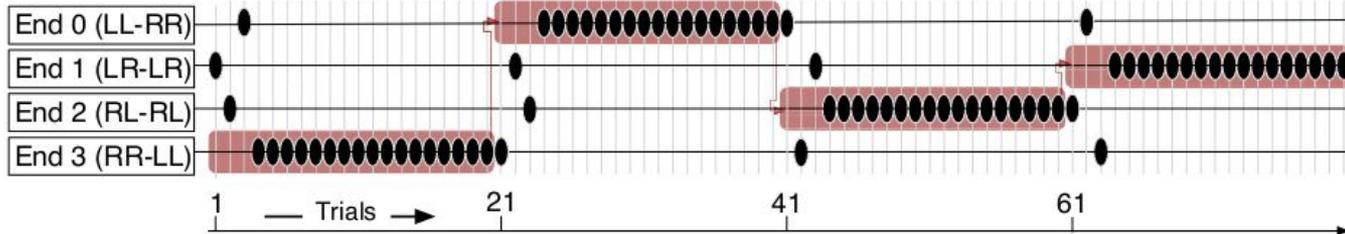
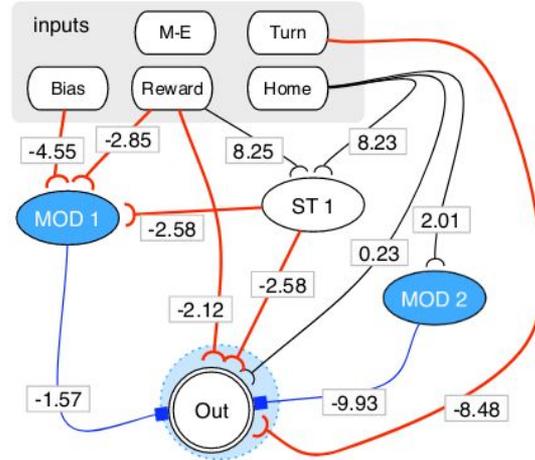
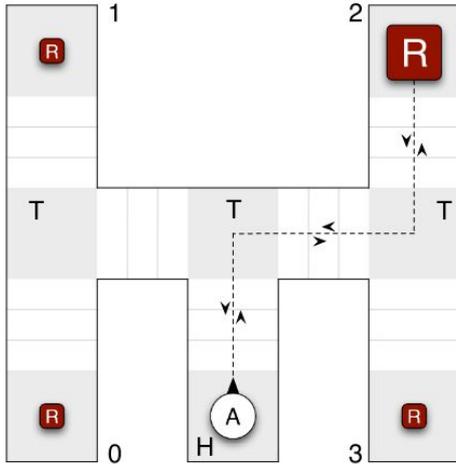
# Architetture neurali

Esistono tecniche per far **emergere** architetture specifiche per affrontare determinati task cognitivi

- Algoritmi genetici e approcci evolutivisti
- Maggiore affinità biologica
- Migliore efficienza in termini di numero di unità e affidabilità
- SCARSA INGEGNERIZZAZIONE
- (No Gradient Descent)



# Architetture evoluzionistiche

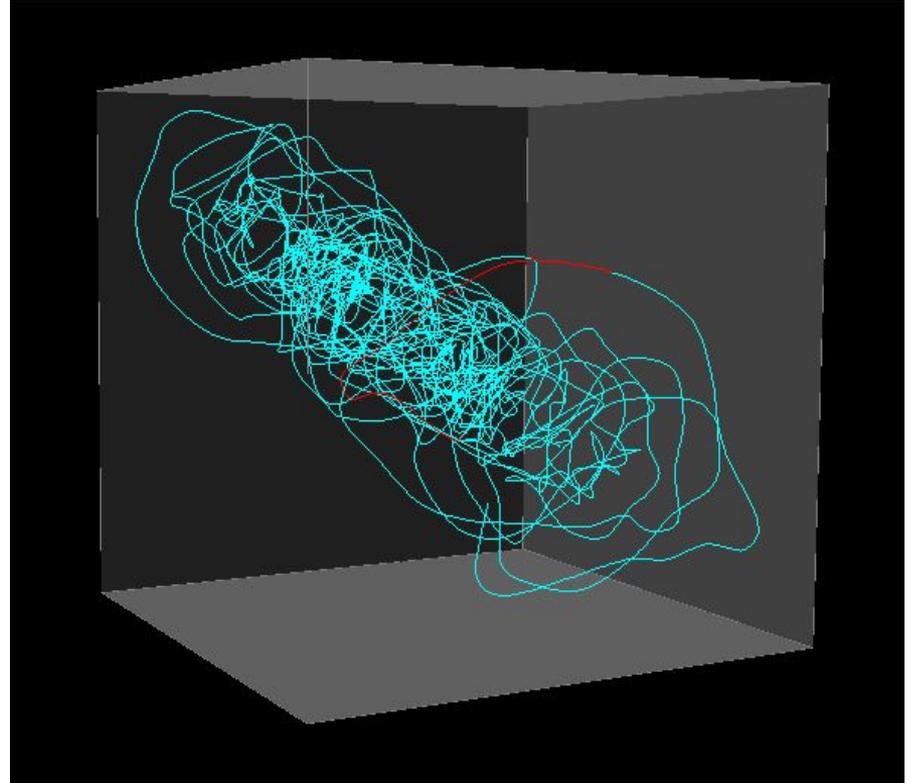


Legend:

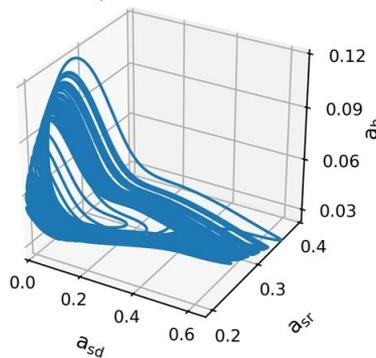
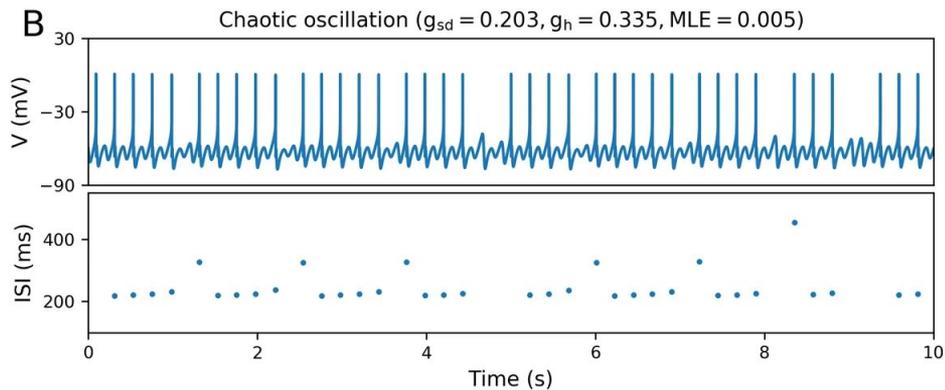
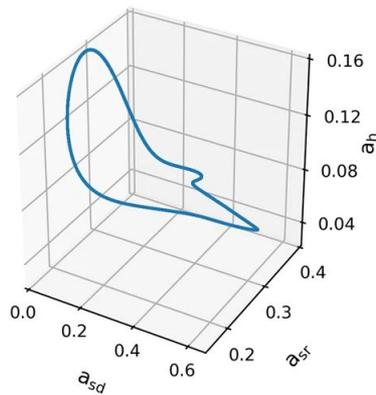
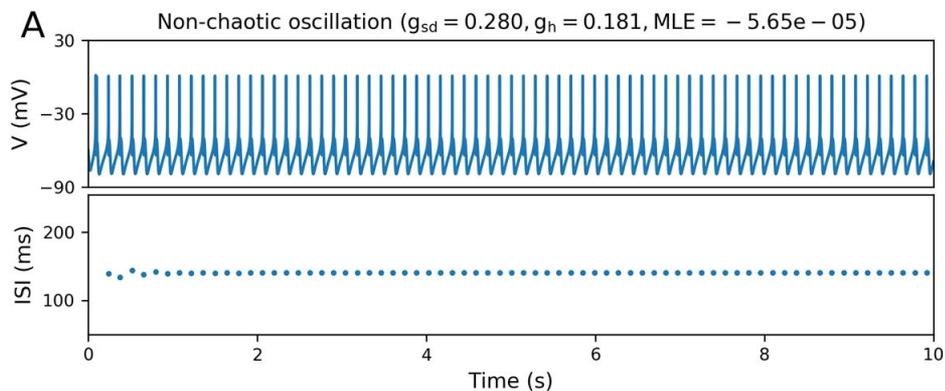
- Coloured area Location of the high reward
- Dot End explored by the agent

# Dinamiche temporali

- L'esplorazione delle novità è un processo casuale guidato da un contesto
- Caos deterministico?



# Dinamiche temporali



Grazie

