

Algorithmic information and artificial intelligence

Jean-Louis Dessalles

12 oct. 2026

*Chapter 5: AIT
& Cognition*

“It may be beyond the limits of human intelligence to understand how human intelligence works.”

(N. Chomsky)

TIME, “Academic Disciplines: The Scholarly Dispute Over The Meaning of Linguistics”, 16 February 1968.

- ~ Understanding human intelligence = one of the noblest challenges of Science
- Looking for mechanisms (=computation) rather than invoking mere statistical compilation.

Human intelligence as Compression

AIT and Cognition

Human intelligence as Compression

~ Structures

~ Unexpectedness

- **Simplicity and newsworthiness**
 - The South African lottery
 - Subjective probability
 - Locations
- **Surprise and Shannon's information**
- **Causal complexity**
 - Magic
 - Coincidences
 - Encounters
 - Plagiarism
- **Aesthetics**



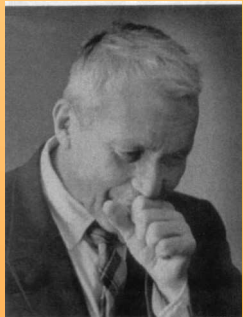
Structures



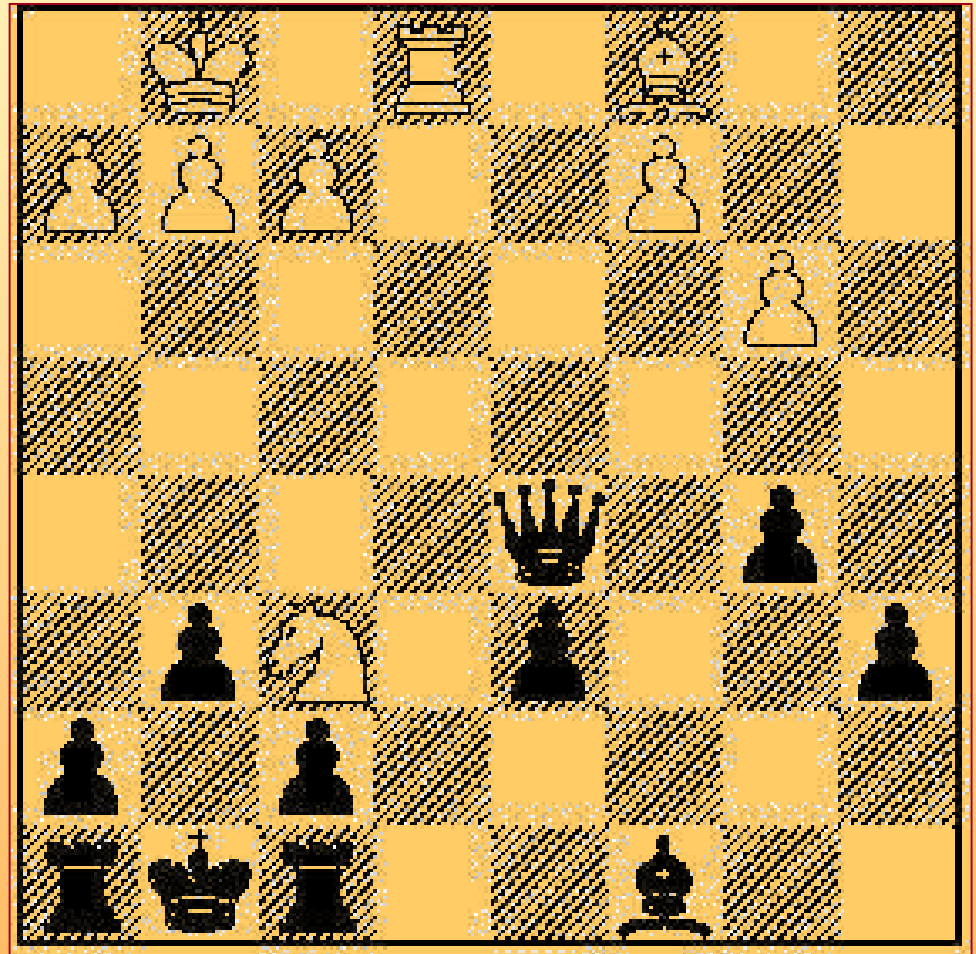
~ Analogies (D. Hofstadter)

a b c $\longrightarrow$ a b d

x y z $\longrightarrow$ w y z


$$\begin{array}{l} \alpha \rightarrow \beta \\ \gamma \rightarrow x \end{array}$$
$$x = \operatorname{argmin}(C(\alpha, \beta, \gamma, x))$$

Structures

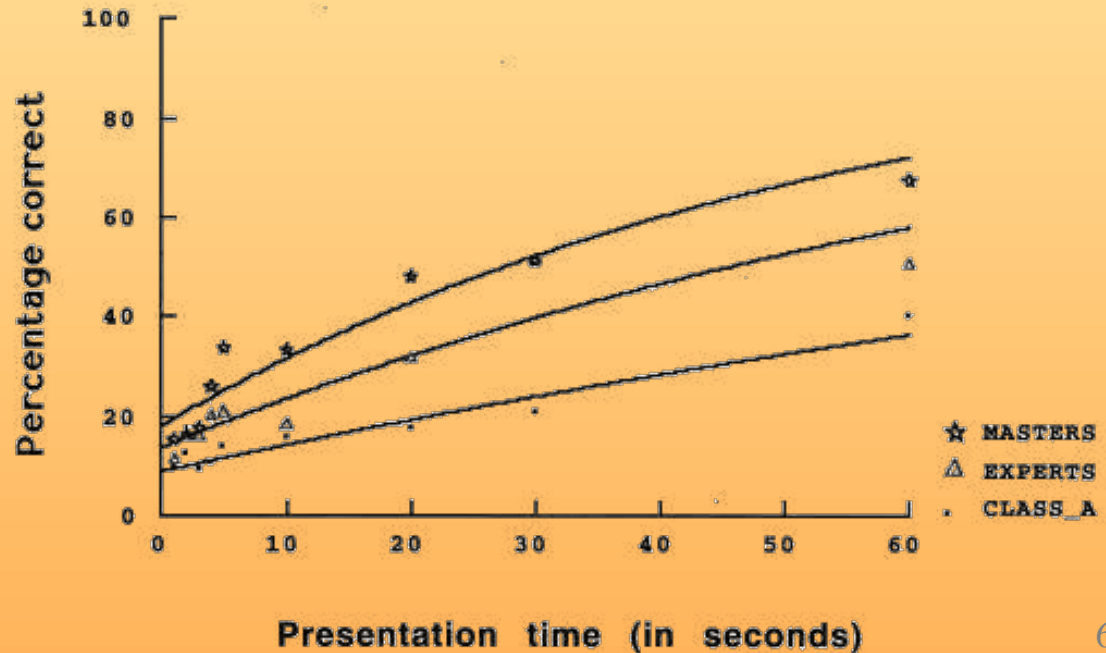
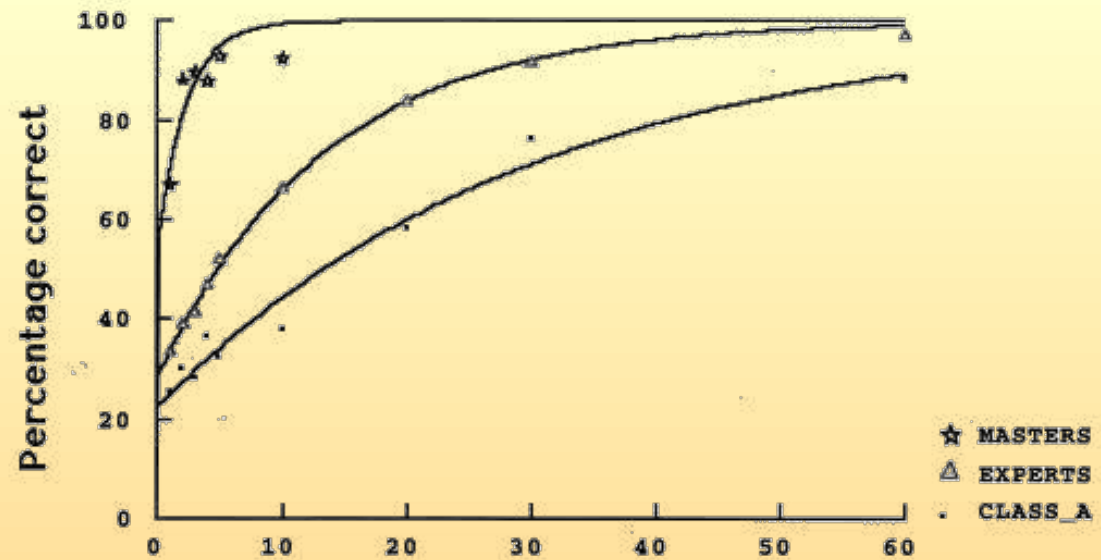


Structures

Nineteen game positions were selected from various chess books with the following criteria: (a) the position was reached after about 20 moves; (b) White is to move; (c) the position is "quiet" (i.e., is not in the middle of a sequence of exchanges); (d) the game was played by (Grand)masters, but is obscure. The mean number of pieces was 25.

Ten random positions were created by assigning the pieces from a game position to random squares on the chessboard.

« Five seconds or sixty? Presentation time in expert memory »
Fernand Gobet and Herbert A. Simon
Cognitive Science 24(4), 2000, 651-682



Structures

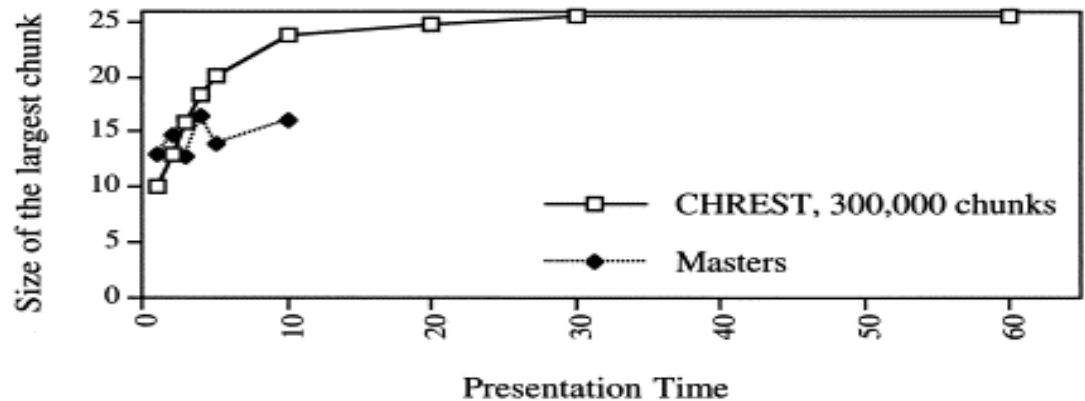
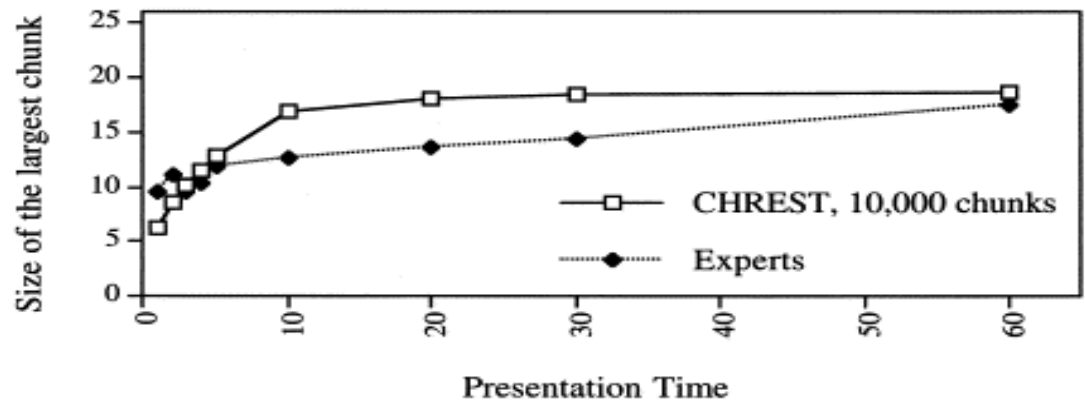
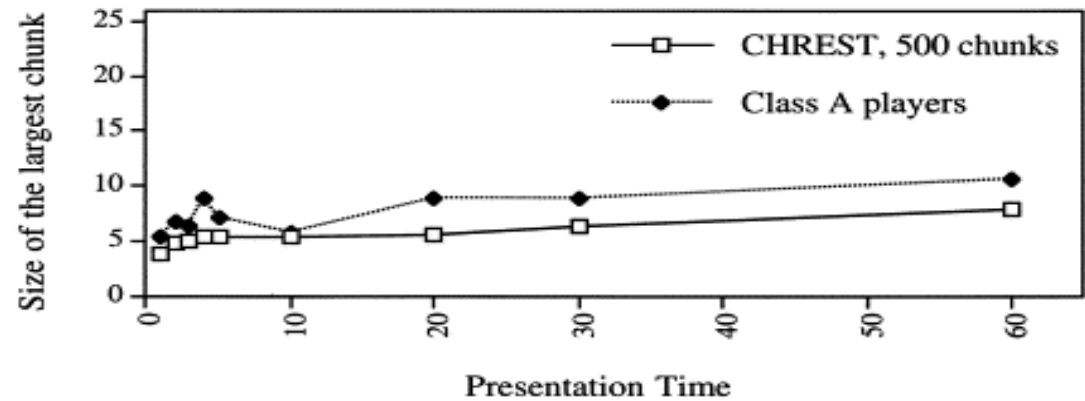
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A

Game positions

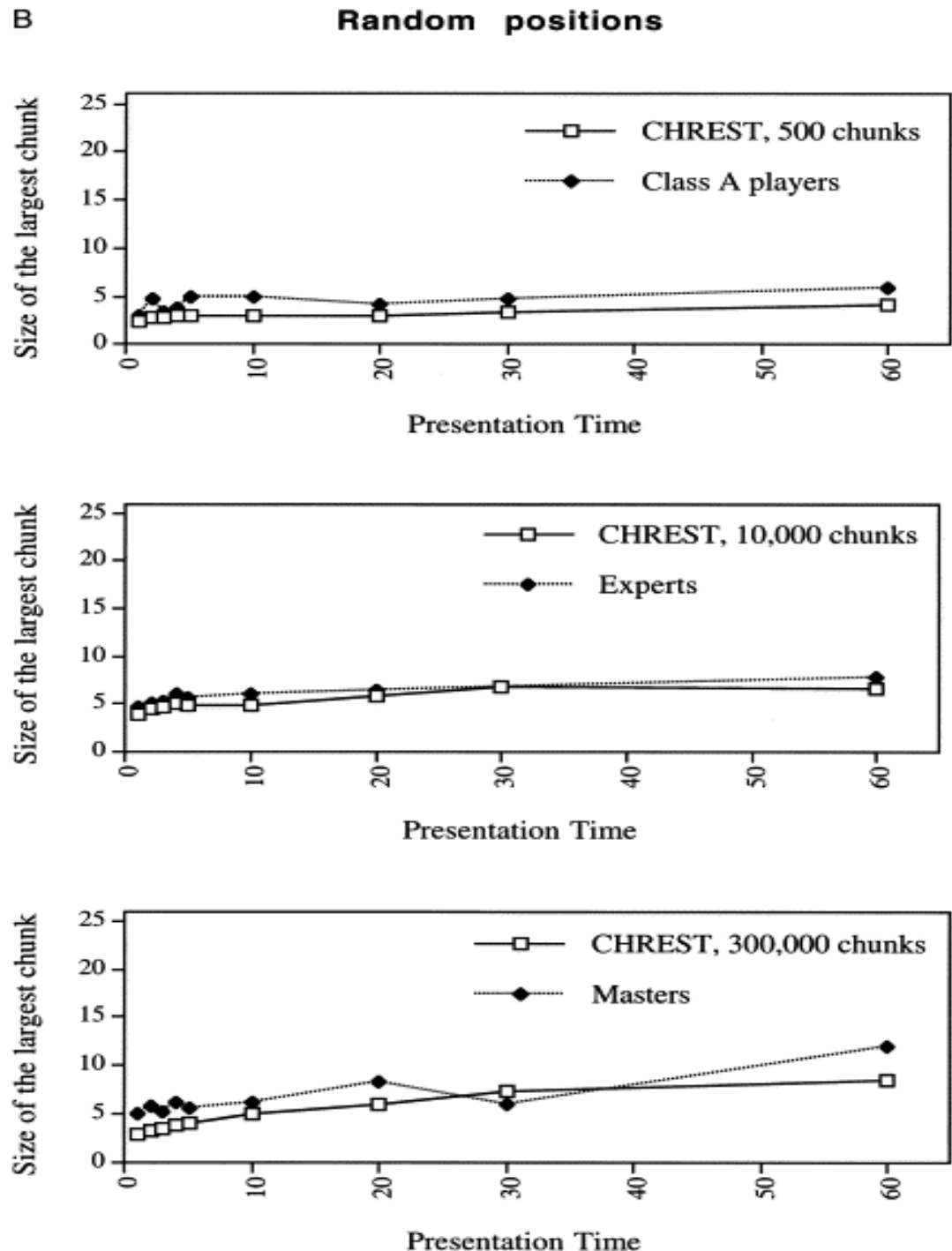


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➤ *Simplicity and newsworthiness*

- *The South African lottery*
- *Subjective probability*
- *Locations*

➤ *Surprise and Shannon's information*

➤ *Causal complexity*

- *Magic*
- *Coincidences*
- *Encounters*
- *Plagiarism*

➤ *Aesthetics*



intelligence

relevance

surprise

unexpectedness

compression

South Africa's lottery probed as 5, 6, 7, 8, 9 and 10 drawn and 20 win

🕒 2 December



South Africans have been questioning the result of the draw (file picture)

An unusual sequence of numbers drawn in South Africa's national lottery has sparked accusations of fraud after 20 people won a share of the jackpot.

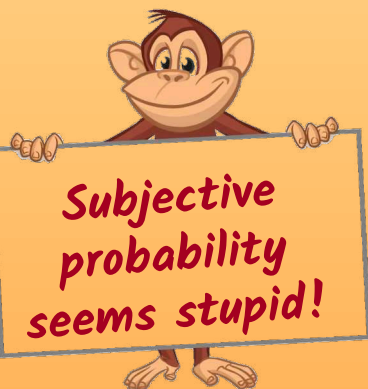
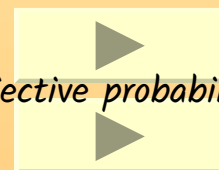
Tuesday's PowerBall lottery saw the numbers five, six, seven, eight and nine drawn, while the PowerBall itself was, you have guessed it, 10.

Abnormal simplicity



Low subjective probability

subjective probability



Distance effects



Voices > Comment

Our shameful hierarchy - some deaths matter more than others

Why is the slaughter in Boston more shocking or newsworthy than the deaths in Iraq?

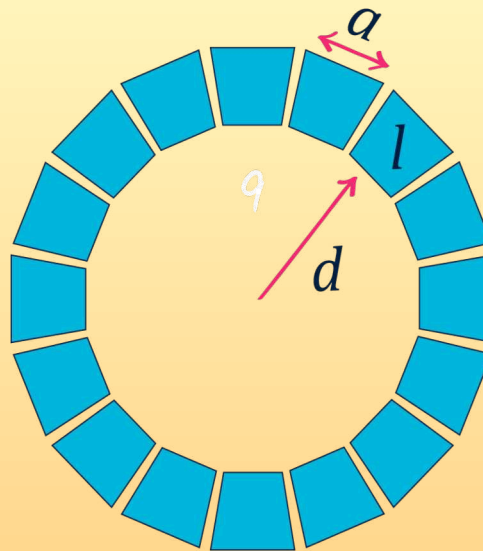
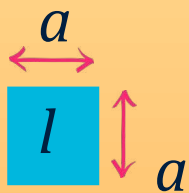
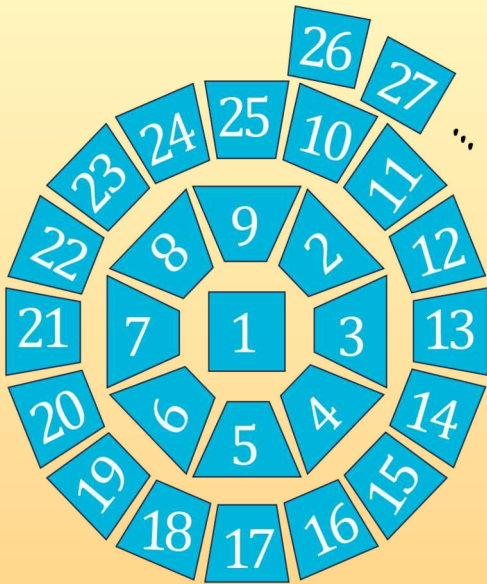
Owen Jones | @OwenJones84 | Sunday 21 April 2013 19:03 |

~ How does the complexity of events vary with distance?

- A. as $1/d$
- B. as $1/d^2$
- C. as $1/\sqrt{d}$
- D. as $-\log(d)$
- E. as $-2 \log(d)$
- F. as $-\log(d)/2$



Complexity of locations



#locations at
distance $\leq d$:

$$\pi d^2 / a^2$$

#locations at
distance d :

$$2\pi d / a$$

complexity of
a location l at
distance d :

$$\log_2(\pi d^2 / a^2)$$



Complexity of locations

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Complexity and entropy

Shannon, C. E. (1948).

[A mathematical theory of communication.](#)

The Bell System Technical Journal, 27, 379-423, 623-656.



Claude Elwood Shannon

information



$$I(s) = \log_2 \left(\frac{1}{p(s)} \right)$$

Shannon

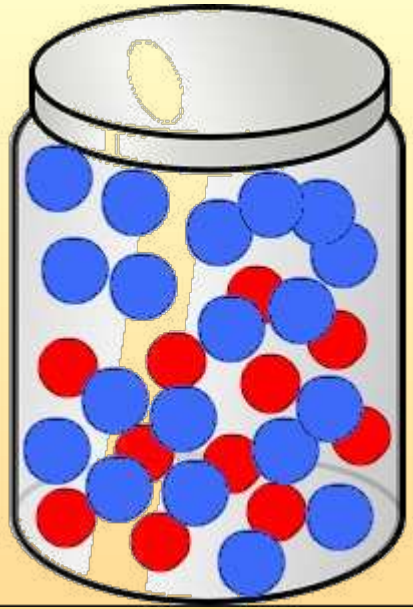
surprise



$$P(s) = 2^{-K(s)}$$

Solomonoff

Complexity gap and entropy



N_1 red balls

N_2 blue balls

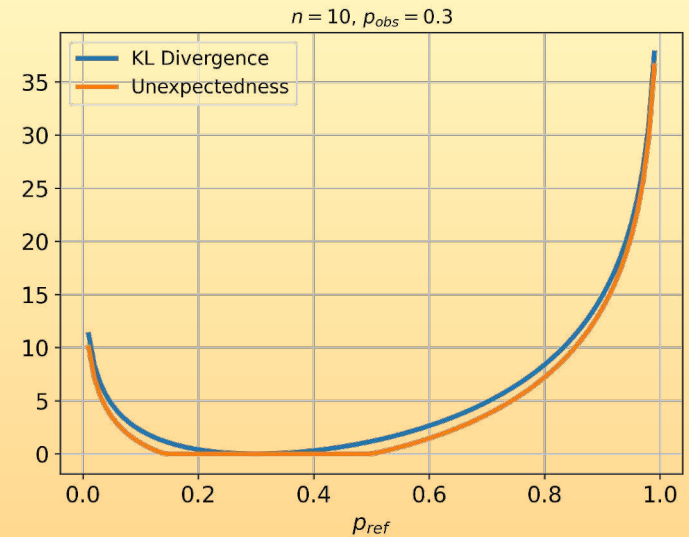
$N = N_1 + N_2$

One draw: s

n_1 red balls

n_2 blue balls

$n = n_1 + n_2$



$C_w(s) = n \log(N)$ if $N \gg n$ or if balls are put back

$C(s) \approx n + n_1 \log(N_1) + n_2 \log(N_2)$ (if order is 'random', n bits to locate colours)

$U(s) \approx n [1 + (n_1/n) \log(1/p_1) + (n_2/n) \log(1/p_2)]$

← Cross-entropy

where $p_i = N_i/N$ prob. of drawing a ball with colour i

Unexpectedness

$$1 + U(s)/n - H(s) \approx KL(s)$$

$$U(s)/n \leq KL(s)$$

~ Situations are described using predicates

$$p(X, Y, a) \ \& \ q(Y, c)$$

~ Predicates have two facets

- *They have to be described* ← *description*
- *They have to be or become true* ← *generation*

~ Situations are described using predicates

$$p(X, Y, a) \& q(Y, c)$$

~ Predicates have two facets

➤ They have to be described

$$C(p) + C(a) + C(q) + C(c) + \log_2(|X|)$$

← description

➤ They have to be or become true

← generation

~ Structures

~ Unexpectedness

➤ Simplicity and newsworthiness

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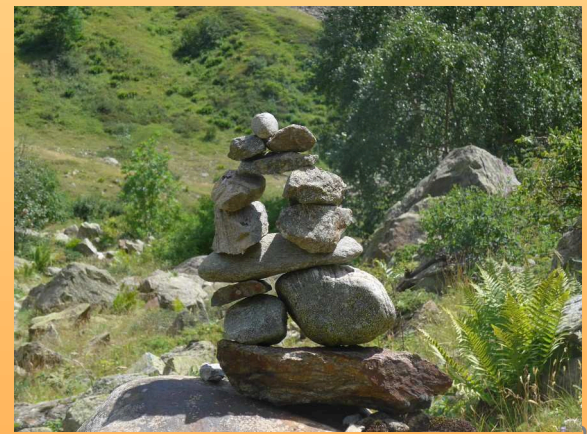
➤ Surprise and Shannon's information

➤ Causal complexity

- Magic
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➤ Aesthetics

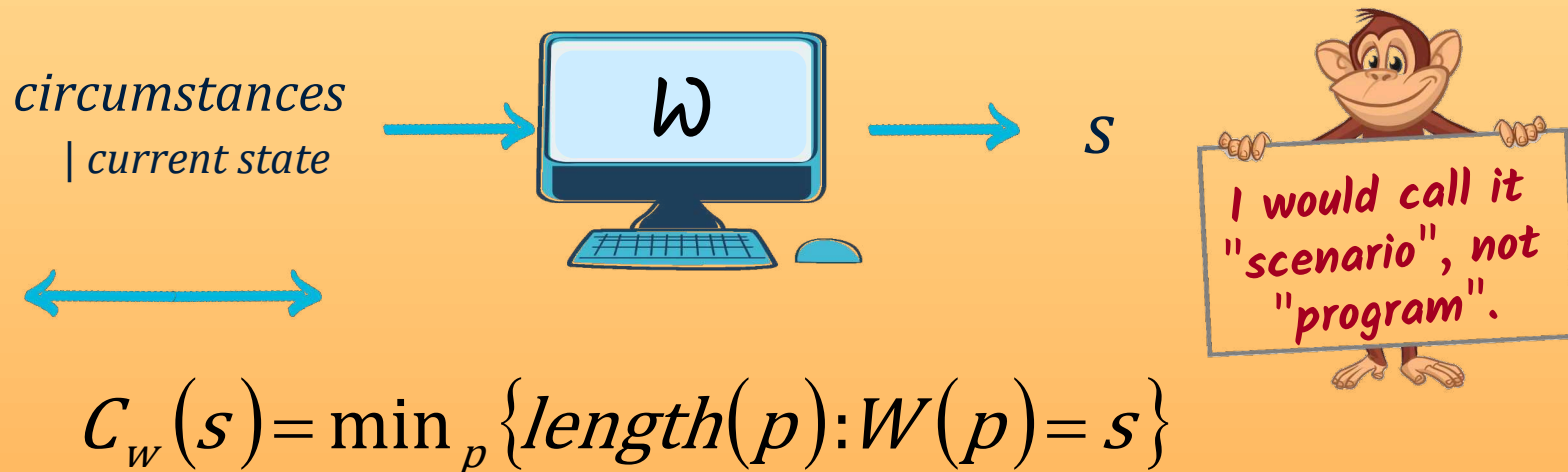




Causal complexity



The "world" seen as a machine.

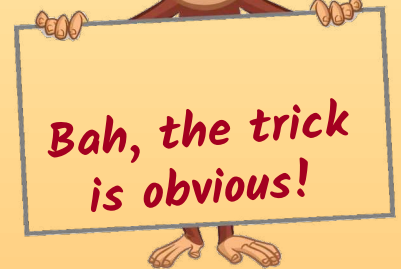


Causal complexity



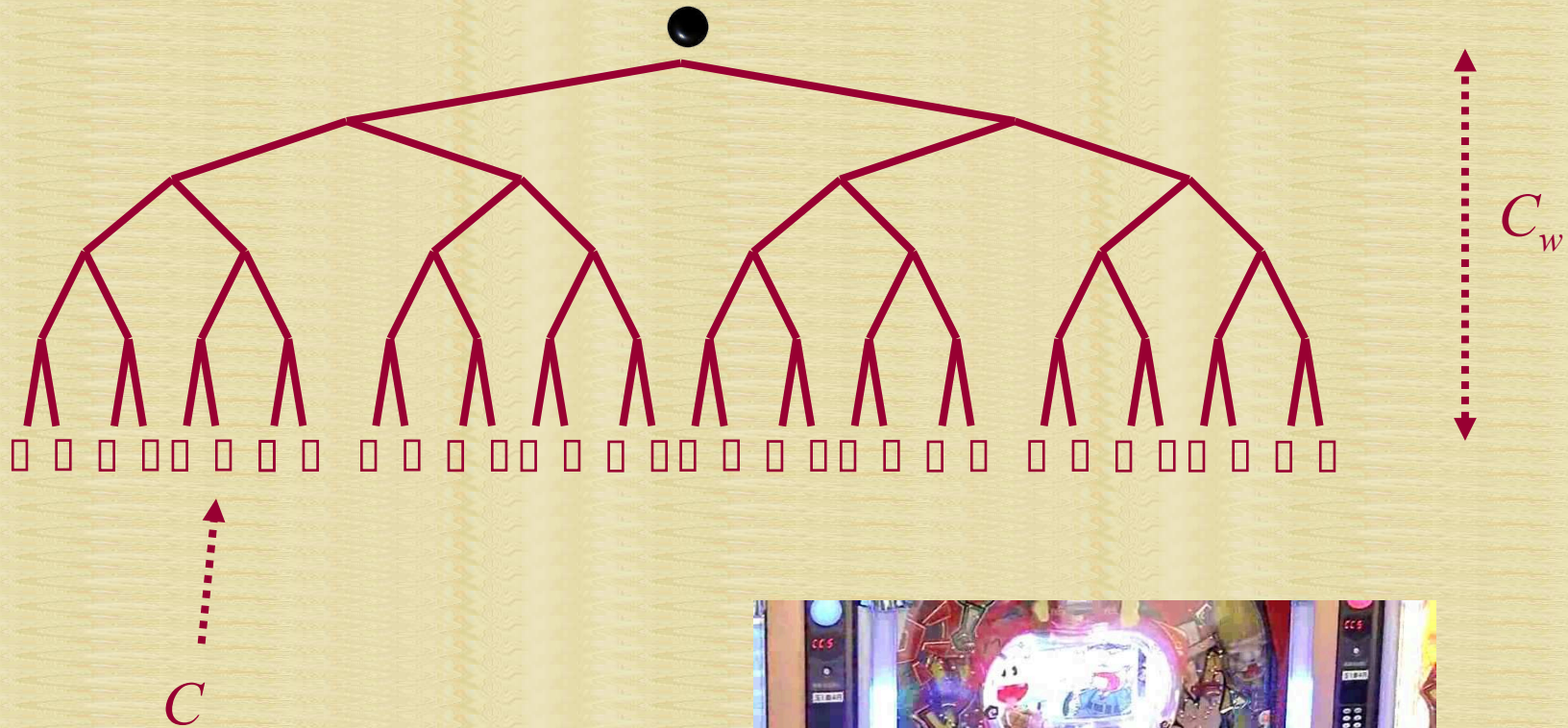
The "world" seen as a machine.

*Unexpectedness occurs
when causal complexity
exceeds description complexity*



Generation complexity

Generation complexity



Chauve-souris
Rabid Bat

Pachinko

Generation complexity

★ Measuring generation complexity

- ◉ Through probability?
- ◉ Choice points
- ◉ Uniform lottery
- ◉ LRO (last remembered occurrence)
- ◉ Scenarios

Generation complexity

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So la monoff

$$p = 2^{-c}$$

$$c = \log_2 1/p$$

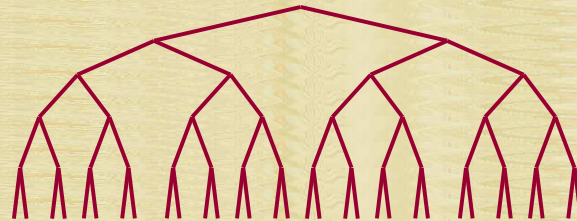
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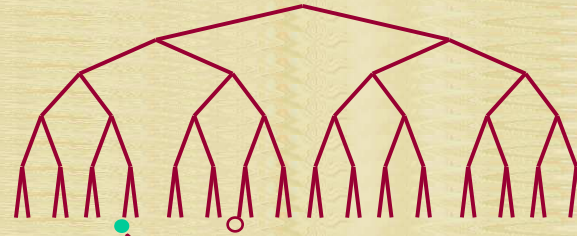
Scenarios



Generation complexity

★ Measuring generation complexity

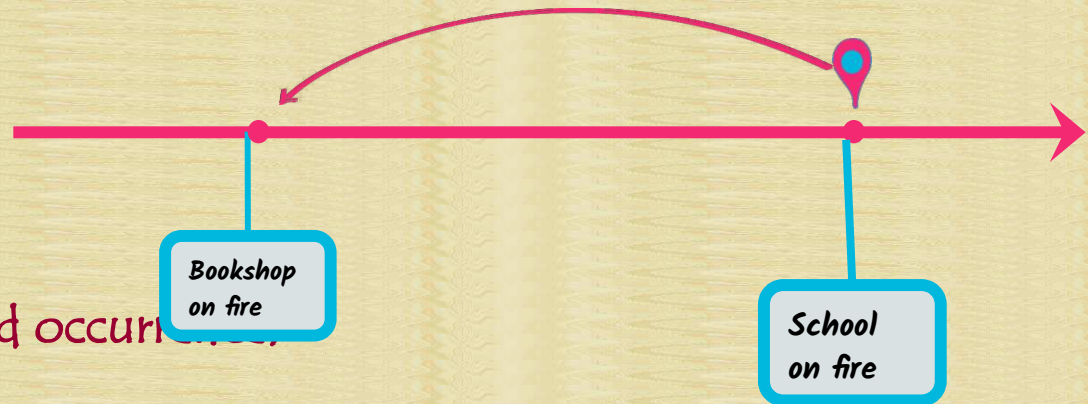
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Generation complexity

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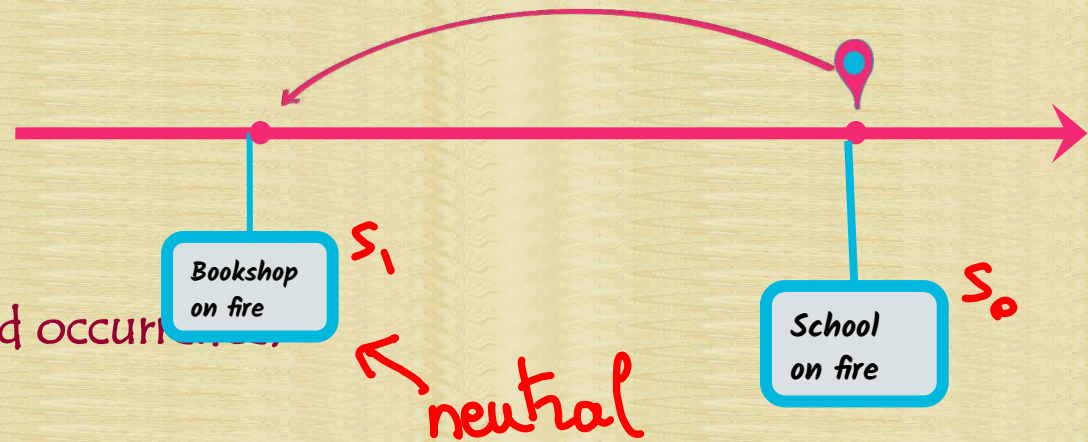
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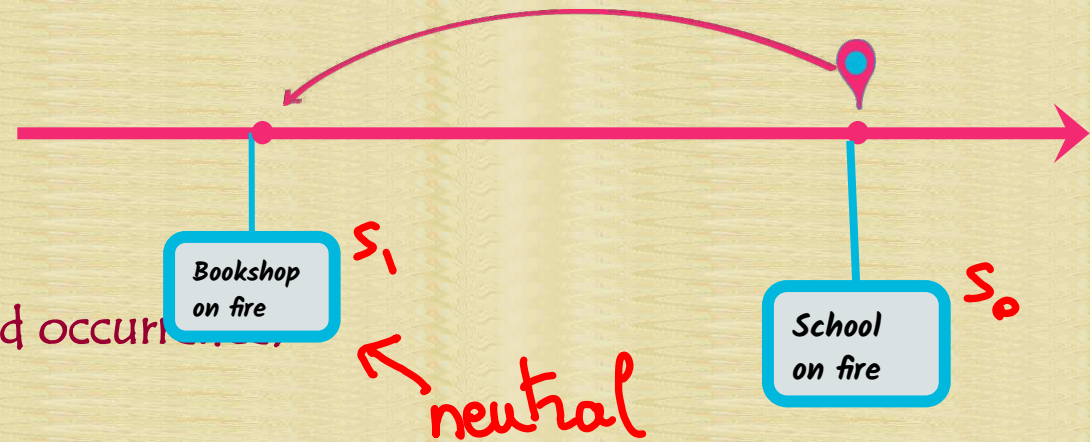
$$u(s_1) = 0$$
$$c_w(s_1) = c(s_1)$$

$$c_w(s_0) = c_w(s_1)$$

Generation complexity

★ Measuring generation complexity

- Through probability?
- Choice points
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$$u(s_1) = 0$$

$$c_w(s_1) = C(s_1)$$

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$$c_w(s_0) = C(s_1)$$

Generation complexity

★ Measuring generation complexity

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$$C_w(s_1 * s_2 * s_3 \dots) = C_w(s_1) + C_w(s_2) + C_w(s_3) \dots$$

Generation complexity and Logic

★ How can we define causal indepedance?

s_1 and s_2 are *independent* if $C_w(s_1 \wedge s_2) = C_w(s_1) + C_w(s_2)$

$$C_w(a \vee b) = \min(C_w(a), C_w(b))$$

$$C_w(a \wedge b) \leq C_w(a) + C_w(b)$$

If $(a \supset b)$, then $C_w(a) \geq C_w(b)$

Coincidences



en: https://www.youtube.com/watch?v=oo4Zl4g_4x4
fr: [cubes.wmv](https://www.youtube.com/watch?v=oo4Zl4g_4x4)

Coincidences

~ What makes coincidences interesting?

A. high causal complexity

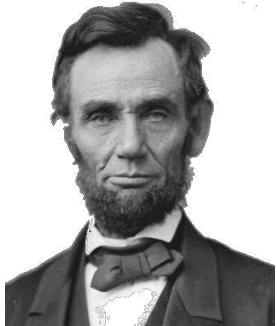
B. low description complexity

C. both

Lincoln & Kennedy

Kern, K. & Brown, K. (2001). Using the list of creepy coincidences as an educational opportunity. *The history teacher*, 34 (4), 531-536.

"creepy coincidences" between Abraham Lincoln and John F. Kennedy



"Lincoln was elected to Congress in 1846, Kennedy was elected to Congress in 1946."

"Lincoln was elected president in 1860, Kennedy was elected president in 1960."

"Both presidents have been shot in the head on a Friday in presence of their wives."

"Both successors were named Johnson, born in 1808 and 1908."

"Kennedy was shot in a car named Lincoln"

...



$$U(e_1 * e_2) = C_w(e_1 * e_2) - C(e_1 * e_2)$$

$$U(e_1 * e_2) \geq C_w(e_1) + C_w(e_2) - C(e_1) - C(e_2|e_1)$$

$$U(e_1 * e_2) = C(e_1) - C(e_2|e_1)$$

☀ To be explained:

- ◉ Role of close analogy
- ◉ Role of mere association
- ◉ Role of round numbers
- ◉ Role of prominence

Lincoln & Kennedy

<https://en.wikipedia.org/wiki/Coincidence>

- Lincoln's name has 7 letters - Kennedy's name has 7 letters
- Lincoln was elected to Congress in **1846** - Kennedy was elected to Congress in **1946**
- Lincoln was elected president in **1860** - Kennedy was elected president in **1960**
- Kennedy had a secretary named Lincoln
- War was thrust upon Lincoln almost immediately after inauguration - War was thrust upon Kennedy almost immediately after inauguration
- Lincoln ordered the Treasury to print its own money - Kennedy ordered the Treasury to print its own money
- International bankers may have arranged the assassinations of Lincoln and Kennedy
- Lincoln gave negroes freedom and legalized equality - Kennedy enforced equality for negroes
- Lincoln delivered the Gettysburg Address on November 19, 1863 - Kennedy was assassinated on November 22, 1963
- Lincoln was loved by the common people and hated by the establishment - Kennedy was loved by the common people and hated by the establishment
- Lincoln was succeeded, after assassination, by **vice-president Johnson** - Kennedy was succeeded, after assassination, by **vice-president Johnson**
- Andrew Johnson was born in **1808** - Lyndon Johnson was born in **1908**
- Andrew Johnson's name has 13 letters - Lyndon Johnson's name has 13 letters
- Lincoln was sitting **beside his wife when he was shot** - Kennedy was sitting **beside his wife when he was shot**
- Lincoln was shot on a **Friday** - Kennedy was shot on a **Friday**
- Lincoln was shot in a theatre named **Ford** - Kennedy was shot in a car made by **Ford**
- Kennedy was shot in a **car named Lincoln**
- Lincoln's bodyguard was away from his post at the door of the President's box at the theatre - Kennedy's bodyguards were away from their posts on the running-boards of the President's car
- Lincoln was shot in a theatre and his assassin ran to a warehouse - JFK was shot from a warehouse and his alleged assassin ran to a theatre
- Lincoln's assassin had a three-worded name, John Wilkes Booth - Kennedy's alleged assassin had a three-worded name, Lee Harvey Oswald
- John Wilkes Booth has 15 letters - Lee Harvey Oswald has 15 letters
- John Wilkes Boothe was born in 1839 - Lee Harvey Oswald was born in 1939 (*false: Boothe was born in 1838*)
- Lincoln and Kennedy died in places beginning with the initials P and H - Lincoln died in Petersen's house - Kennedy died in Parkland Hospital
- Booth was shot and killed* in police custody before going to trial - Oswald was shot and killed in police custody before going to trial
- Kennedy's funeral was modelled on Lincoln's funeral
- Andrew Johnson was a heavy drinker with crude behaviour - Lyndon Johnson was a heavy drinker with crude behaviour
- There were conspiracy theories that Johnson was knowledgeable about Lincoln's assassination - There were conspiracy theories that Johnson was knowledgeable about Kennedy's assassination**
- Days before it happened Lincoln told his wife and friends about a dream he'd had of being shot by an assassin - Hours before it happened Kennedy told his wife and friends it would be easy for an assassin to shoot him from a crowd
- Shortly after Lincoln was shot the telegraph system went down - Shortly after Kennedy was shot the telephone system went down
- Kennedy's **father** had been the Ambassador to England at the Court of St James - Lincoln's **son** became the Ambassador to England at the Court of St James
- Lincoln and Kennedy were 2 of the greatest presidents of the nation
- Lincoln's wife tastefully and expensively re-decorated the White House - Kennedy's wife tastefully and expensively re-decorated the White House
- Lincoln loved great literature and could recite poetry by heart - Kennedy loved great literature and could recite poetry by heart
- Lincoln had young children while living at the White House - Kennedy had young children while living at the White House
- Lincoln's sons had ponies they rode on the White House grounds - Kennedy's daughter had a pony she rode on the White House grounds
- Lincoln **lost a child** (12 year old son) to death while President - Kennedy **lost a child** (newly born son) to death while President
- Lincoln let his children run and play in his office - Kennedy let his children run and play in his office
- After Lincoln's assassination the nation experienced an emotional convulsion - After Kennedy's assassination the nation experienced an emotional convulsion
- the whole world cried when Lincoln died - the whole world cried when Kennedy died
- Lincoln's funeral train travelled from Washington-DC to New York - Kennedy's brother's funeral train travelled from New York to Washington-DC
- Lincoln Assassination conspiracy theories are believed these 140 141 years later - Kennedy Assassination conspiracy theories are believed these 42 43 years later
- Abraham was the first name of the man who filmed Kennedy's murder in the Lincoln
- The man running alongside Kennedy's car snapping pictures with his 35mm camera was a salesman of Lincoln cars
- Kennedy bought a Virginia home that was the 1861 Civil War headquarters of Lincoln's first general-in-chief, McClellan
- Jefferson Davis was the name of the president of the Confederate states while Lincoln was president of the Union states - Jefferson Davis Tippit was the name of the police officer killed allegedly by Kennedy's alleged assassin
- Lincoln was famous for his wit and for telling hilarious stories and anecdotes - Kennedy was famous for his wit and for telling hilarious stories and anecdotes

Fortuitous encounters

☀ To be explained:

- ◉ The coincidence is more impressive if...
 - one meets a close friend
 - one meets a celebrity
- ◉ The coincidence is more impressive if...
 - the place is remote (hard to find)

$L(P)$ neutral: $C_w(L(P)) = C(L)$

$C_w(L(ego) \& L(P)) = 2 \times C(L)$

$C(L(ego) \& L(P)) = C(L) + C(P)$

$U(L(ego) \& L(P)) = C(L) - C(P)$



Example 4: coincidence of birthdays

☀ To be explained:

- ◉ Self-coincidences are more surprising than comparable coincidences that happen to others.



Falk, R. (1989). Judgment of coincidences: Mine versus yours. *The American Journal of Psychology*, 102 (4), 477-493.

Lincoln & Kennedy

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$$U(e_1 * e_2) = C(e_1) - C(e_2|e_1)$$

To be explained:

- Role of close analogy
- Role of mere association
- Role of round numbers
- Role of coincidences

Fortuitous encounters



encounters

$$U(L(\text{ego}) \& L(P)) = C(L) - C(P)$$

~ Narrative interest

~ Causal complexity

~ Probability



~ Coincidences

~ Fortuitous encounter

~ Plagiarism

~ Aesthetics

See:

www.simplicitytheory.science

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~ Unexpectedness

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- Near miss
- LRO
- topic connectedness



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(N. Chomsky)

TIME, “Academic Disciplines: The Scholarly Dispute Over The Meaning of Linguistics”, 16 February 1968.

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