Infinite monkey theorem

From Wikipedia, the free encyclopedia

The **infinite monkey theorem** states that a monkey hitting keys at random on a typewriter keyboard for an infinite amount of time will almost surely type a given text, such as the complete works of William Shakespeare.

Given enough time, a hypothetical chimpanzee typing at random would, as part of its output, almost surely produce all of Shakespeare's plays. Note that a chimpanzee is not a monkey, but an ape.

In this context, "almost surely" is a mathematical term with a precise meaning, and the "monkey" is not an actual monkey, but a metaphor for an abstract device that produces a random sequence of letters *ad infinitum*. The theorem illustrates the perils of reasoning about infinity by imagining a vast but finite number, and vice versa. The probability of a monkey exactly typing a complete work such as Shakespeare's *Hamlet* is so tiny that the chance of it occurring during a period of time of the order of the age of the universe is minuscule, but not zero.

Variants of the theorem include multiple and even infinitely many typists, and the target text varies between an entire library and a single sentence. The history of these statements can be traced back to Aristotle's *On Generation and Corruption* and Cicero's *De natura deorum*, through Blaise Pascal and Jonathan Swift, and finally to modern statements with their iconic typewriters. In the early 20th century, Émile Borel and Arthur Eddington used the theorem to illustrate the timescales implicit in the foundations of statistical mechanics.

Popular interest in the typing monkeys is sustained by numerous appearances in literature, television, radio, music, and the Internet. In 2003, an experiment was performed with six Celebes Crested Macaques. Their literary contribution was five pages consisting largely of the letter 'S'.[1]

Contents

Solution

Direct proof

There is a straightforward proof of this theorem. If two events are statistically independent, then the probability of both happening equals the product of the probabilities of each one happening independently. For example, if the chance of rain in Montreal on a particular day is 0.3 and the chance of an earthquake in San Francisco on that day is 0.008, then the chance of both happening on that same day is $0.3 \times 0.008 = 0.0024$.

Suppose the typewriter has 50 keys, and the word to be typed is *banana*. If we assume that the keys are pressed randomly and independently, then the chance that the first letter typed is 'b' is 1/50, and the chance that the second letter typed is *a* is also 1/50, and so on, because events are independent. Therefore, the chance of the first six letters matching *banana* is

$$(1/50) \times (1/50) \times (1/50) \times (1/50) \times (1/50) \times (1/50) = (1/50)^6,$$

less than one in 15 billion. For the same reason, the chance that the next 6 letters match *banana* is also $(1/50)^6$, and so on.

From the above, the chance of *not* typing *banana* in a given block of 6 letters is $1 - (1/50)^6$. Because each block is typed independently, the chance X_n of not typing *banana* in any of the first n blocks of 6 letters is

$$X_n = \left(1 - \frac{1}{50^6}\right)^n.$$

As n grows, X_n gets smaller. For an n of a million, X_n is roughly 0.9999, but for an n of 10 billion X_n is roughly 0.53 and for an n of 100 billion it is roughly 0.0017. As n approaches infinity, the probability X_n approaches zero; that is, by making n large enough, X_n can be made as small as is desired,[2][note 1] and the chance of typing *banana* approaches 100%.

The same argument shows why at least one of infinitely many monkeys will produce a text as quickly as it would be produced by a perfectly accurate human typist copying it from the original. In this case $X_n = (1 - (1/50)^6)^n$ where X_n represents the probability that none of the first n monkeys types *banana* correctly on their first try. When we consider 100 billion monkeys, the probability falls to 0.17%, and as the number of monkeys n increases, the value of X_n – the probability of the monkeys failing to reproduce the given text – approaches zero arbitrarily closely. The limit, for n going to infinity, is zero.

However, for physically meaningful numbers of monkeys typing for physically meaningful lengths of time the results are reversed. If there are as many monkeys as there are particles in the observable universe (10^{80}), and each types 1,000 keystrokes per second for 100 times the life of the universe (10^{20} seconds), the probability of the monkeys replicating even a short book is nearly zero. See Probabilities, below.

Infinite strings

The two statements above can be stated more generally and compactly in terms of strings, which are sequences of characters chosen from some finite alphabet:

- Given an infinite string where each character is chosen uniformly at random, any given finite string almost surely occurs as a substring at some position.
- Given an infinite sequence of infinite strings, where each character of each string is chosen uniformly at random, any given finite string almost surely occurs as a prefix of one of these strings.

Both follow easily from the second Borel–Cantelli lemma. For the second theorem, let E_k be the event that the kth string begins with the given text. Because this has some fixed nonzero probability p of occurring, the E_k are independent, and the below sum diverges,

$$\sum_{i=1}^{\infty} P(E_k) = \sum_{i=1}^{\infty} p = \infty,$$

the probability that infinitely many of the E_k occur is 1. The first theorem is shown similarly; one can divide the random string into nonoverlapping blocks matching the size of the desired text, and make E_k the event where the kth block equals the desired string.[note 2]

Probabilities

Ignoring punctuation, spacing, and capitalization, a monkey typing letters uniformly at random has a chance of one in 26 of correctly typing the first letter of *Hamlet*. It has a chance of one in 676 (26 × 26) of typing the first two letters. Because the probability shrinks exponentially, at 20 letters it already has only a chance of one in 26^{20} = 19,928,148,895,209,409,152,340,197,376 (almost 2×10^{28}). In the case of the entire text of *Hamlet*, the probabilities are so vanishingly small they can barely be conceived in human terms. The text of Hamlet contains approximately 130,000 letters.[note 3] Thus there is a probability of one in $3.4 \times 10^{183,946}$ to get the text right at the first trial. The average number of letters that needs to be typed until the text appears is also $3.4 \times 10^{183,946}$,[note 4] or including punctuation, $4.4 \times 10^{360,783}$.[note 5]

Even if the observable universe were filled with monkeys typing from now until the heat death of the universe, their total probability to produce a single instance of *Hamlet* would still be less than one in $10^{183,800}$. As Kittel and Kroemer put it, "The probability of *Hamlet* is therefore zero in any operational sense of an event…", and the statement that the monkeys must eventually succeed "gives a misleading conclusion about very, very large numbers." This is from their textbook on thermodynamics, the field whose statistical foundations motivated the first known expositions of typing monkeys.[3]

History

Statistical mechanics

In one of the forms in which probabilists now know this theorem, with its "dactylographic" [i.e., typewriting] monkeys (French: *singes dactylographes*; the French word *singe* covers both the monkeys and the apes), appeared in Émile Borel's 1913 article "*Mécanique Statistique et Irréversibilité*" (*Statistical mechanics and irreversibility*),[4] and in his book "Le Hasard" in 1914. His "monkeys" are not actual monkeys; rather, they are a metaphor for an imaginary way to produce a large, random sequence of letters. Borel said that if a million monkeys typed ten hours a day, it was extremely unlikely that their output would exactly equal all the books of the richest libraries of the world; and yet, in comparison, it was even more unlikely that the laws of statistical mechanics would ever be violated, even briefly.

The physicist Arthur Eddington drew on Borel's image further in *The Nature of the Physical World* (1928), writing:

> If I let my fingers wander idly over the keys of a typewriter it might happen that my screed made an intelligible sentence. If an army of monkeys were strumming on typewriters they might write all the books in the British Museum. The chance of their doing so is decidedly more favourable than the chance of the molecules returning to one half of the vessel.[5]

These images invite the reader to consider the incredible improbability of a large but finite number of monkeys working for a large but finite amount of time producing a significant work, and compare this with the even greater improbability of certain physical events. Any physical process that is even less likely than such monkeys' success is effectively impossible, and it may safely be said that such a process will never happen.[3]

Origins and "The Total Library"

In a 1939 essay entitled "The Total Library", Argentine writer Jorge Luis Borges traced the infinite-monkey concept back to Aristotle's *Metaphysics*. Explaining the views of Leucippus, who held that the world arose through the random combination of atoms, Aristotle notes that the atoms themselves are homogeneous and their possible arrangements only differ in shape, position and ordering. In *De Generatione et Corruptione* (*On Generation and Corruption*), the Greek philosopher compares this to the way that a tragedy and a comedy consist of the same "atoms", *i.e.*, alphabetic characters.[6] Three centuries later, Cicero's *De natura deorum* (*On the Nature of the Gods*) argued against the atomist worldview:

> He who believes this may as well believe that if a great quantity of the one-and-twenty letters, composed either of gold or any other matter, were thrown upon the ground, they would fall into such order as legibly to form the *Annals* of Ennius. I doubt whether fortune could make a single verse of them.[7]

Borges follows the history of this argument through Blaise Pascal and Jonathan Swift, then observes that in his own time, the vocabulary had changed. By 1939, the idiom was "that a half-dozen monkeys provided with typewriters would, in a few eternities, produce all the books in the British Museum." (To which Borges adds,

"Strictly speaking, one immortal monkey would suffice.") Borges then imagines the contents of the Total Library which this enterprise would produce if carried to its fullest extreme:

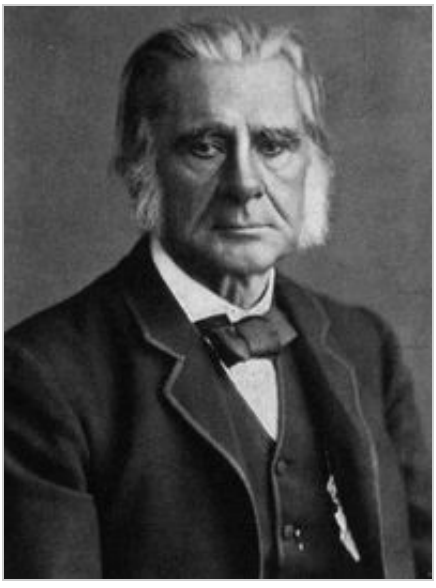
> Everything would be in its blind volumes. Everything: the detailed history of the future, Aeschylus' *The Egyptians*, the exact number of times that the waters of the Ganges have reflected the flight of a falcon, the secret and true nature of Rome, the encyclopedia Novalis would have constructed, my dreams and half-dreams at dawn on August 14, 1934, the proof of Pierre Fermat's theorem, the unwritten chapters of *Edwin Drood*, those same chapters translated into the language spoken by the Garamantes, the paradoxes Berkeley invented concerning Time but didn't publish, Urizen's books of iron, the premature epiphanies of Stephen Dedalus, which would be meaningless before a cycle of a thousand years, the Gnostic Gospel of Basilides, the song the sirens sang, the complete catalog of the Library, the proof of the inaccuracy of that catalog. Everything: but for every sensible line or accurate fact there would be millions of meaningless cacophonies, verbal farragoes, and babblings. Everything: but all the generations of mankind could pass before the dizzying shelves—shelves that obliterate the day and on which chaos lies—ever reward them with a tolerable page.[8]

Borges's total library concept was the main theme of his widely read 1941 short story "The Library of Babel", which describes an unimaginably vast library consisting of interlocking hexagonal chambers, together containing every possible volume that could be composed from the letters of the alphabet and some punctuation characters.

Applications and criticisms

Evolution

In his 1931 book *The Mysterious Universe*, Eddington's rival James Jeans attributed the monkey parable to a "Huxley", presumably meaning Thomas Henry Huxley. This attribution is incorrect.[9] Today, it is sometimes further reported that Huxley applied the example in a now-legendary debate over Charles Darwin's *On the Origin of Species* with the Anglican Bishop of Oxford, Samuel Wilberforce, held at a meeting of the British Association for the Advancement of Science at Oxford in June 30, 1860. This story suffers not only from a lack of evidence, but the fact that in 1860 the typewriter itself had yet to emerge.[10]



Thomas Huxley is sometimes misattributed with proposing a variant of the theory in his debates with Samuel Wilberforce.

Despite the original mix-up, monkey-and-typewriter arguments are now common in arguments over evolution. For example, Doug Powell argues as a Christian apologist that even if a monkey accidentally types the letters of *Hamlet*, it has failed to produce *Hamlet* because it lacked the intention to communicate. His parallel implication is that natural laws could not produce the information content in DNA.[11] A more common argument is represented by Reverend John F. MacArthur, who claims that the genetic mutations necessary to produce a tapeworm from an amoeba are as unlikely as a monkey typing Hamlet's soliloquy, and hence the odds

against the evolution of all life are impossible to overcome.[12]

Evolutionary biologist Richard Dawkins employs the typing monkey concept in his 1986 book *The Blind Watchmaker* to demonstrate the ability of natural selection to produce biological complexity out of random mutations. In a simulation experiment Dawkins has his weasel program produce the Hamlet phrase *METHINKS IT IS LIKE A WEASEL*, starting from a randomly typed parent, by "breeding" subsequent generations and always choosing the closest match from progeny that are copies of the parent, with random mutations. The random choices furnish raw material, while cumulative selection imparts information.[13]

A different avenue for rejecting the analogy between evolution and an unconstrained monkey lies in the problem that the monkey types only one letter at a time, independently of the other letters. Hugh Petrie argues that a more sophisticated setup is required, in his case not for biological evolution but the evolution of ideas:

> In order to get the proper analogy, we would have to equip the monkey with a more complex typewriter. It would have to include whole Elizabethan sentences and thoughts. It would have to include Elizabethan beliefs about human action patterns and the causes, Elizabethan morality and science, and linguistic patterns for expressing these. It would probably even have to include an account of the sorts of experiences which shaped Shakespeare's belief structure as a particular example of an Elizabethan. Then, perhaps, we might allow the monkey to play with such a typewriter and produce variants, but the impossibility of obtaining a Shakespearean play is no longer obvious. What is varied really does encapsulate a great deal of already-achieved knowledge.[14]

James W. Valentine, while admitting that the classic monkey's task is impossible, finds that there is a worthwhile analogy between written English and the metazoan genome in this other sense: both have "combinatorial, hierarchical structures" that greatly constrain the immense number of combinations at the alphabet level.[15]

Literary theory

R. G. Collingwood argued in 1938 that art cannot be produced by accident, and wrote as a sarcastic aside to his critics,

> …some … have denied this proposition, pointing out that if a monkey played with a typewriter … he would produce … the complete text of Shakespeare. Any reader who has nothing to do can amuse himself by calculating how long it would take for the probability to be worth betting on. But the interest of the suggestion lies in the revelation of the mental state of a person who can identify the 'works' of Shakespeare with the series of letters printed on the pages of a book…[16]

Nelson Goodman took the contrary position, illustrating his point along with Catherine Elgin by the example of Borges' “Pierre Menard, Author of the Quixote”,

> What Menard wrote is simply another inscription of the text. Any of us can do the same, as can printing presses and photocopiers. Indeed, we are told, if infinitely many monkeys … one would eventually produce a replica of the text. That replica, we maintain, would be as much an instance of the work, *Don Quixote*, as Cervantes' manuscript, Menard's manuscript, and each copy of the

book that ever has been or will be printed.[17]

In another writing, Goodman elaborates, "That the monkey may be supposed to have produced his copy randomly makes no difference. It is the same text, and it is open to all the same interpretations…." Gérard Genette dismisses Goodman's argument as begging the question.[18]

For Jorge J. E. Gracia, the question of the identity of texts leads to a different question, that of author. If a monkey is capable of typing *Hamlet*, despite having no intention of meaning and therefore disqualifying itself as an author, then it appears that texts do not require authors. Possible solutions include saying that whoever finds the text and identifies it as *Hamlet* is the author; or that Shakespeare is the author, the monkey his agent, and the finder merely a user of the text. These solutions have their own difficulties, in that the text appears to have a meaning separate from the other agents: what if the monkey operates before Shakespeare is born, or if Shakespeare is never born, or if no one ever finds the monkey's typescript?[19]

Random number generation

The theorem concerns a thought experiment which cannot be fully carried out in practice, since it is predicted to require prohibitive amounts of time and resources. Nonetheless, it has inspired efforts in finite random text generation.

One computer program run by Dan Oliver of Scottsdale, Arizona, according to an article in *The New Yorker*, came up with a result on August 4, 2004: After the group had worked for 42,162,500,000 billion billion monkey-years, one of the "monkeys" typed, "`VALENTINE. Cease toIdor:eFLP0FRjWK78aXzVOwm)-';8.t`" The first 19 letters of this sequence can be found in "The Two Gentlemen of Verona". Other teams have reproduced 18 characters from "Timon of Athens", 17 from "Troilus and Cressida", and 16 from "Richard II".[20]

A website entitled *The Monkey Shakespeare Simulator*, launched on July 1, 2003, contained a Java applet that simulates a large population of monkeys typing randomly, with the stated intention of seeing how long it takes the virtual monkeys to produce a complete Shakespearean play from beginning to end. For example, it produced this partial line from *Henry IV, Part 2*, reporting that it took "2,737,850 million billion billion billion monkey-years" to reach 24 matching characters:

```
RUMOUR. Open your ears; 9r"5j5&?OWTY Z0d...
```

Due to processing power limitations, the program uses a probabilistic model (by using a random number generator or RNG) instead of actually generating random text and comparing it to Shakespeare. When the simulator "detects a match" (that is, the RNG generates a certain value or a value within a certain range), the simulator simulates the match by generating matched text.

Questions about the statistics describing how often an ideal monkey should type certain strings can motivate practical tests for random number generators as well; these range from the simple to the "quite sophisticated". Computer science professors George Marsaglia and Arif Zaman report that they used to call such tests "overlapping m-tuple tests" in lecture, since they concern overlapping m-tuples of successive elements in a random sequence. But they found that calling them "monkey tests" helped to motivate the idea with students.

They published a report on the class of tests and their results for various RNGs in 1993.[21]

Real monkeys

Primate behaviorists Cheney and Seyfarth remark that real monkeys would indeed have to rely on chance to have any hope of producing *Romeo and Juliet*. Unlike apes and particularly chimpanzees, the evidence suggests that monkeys lack a theory of mind and are unable to differentiate between their own and others' knowledge, emotions, and beliefs. Even if a monkey could learn to write a play and describe the characters' behavior, it could not reveal the characters' minds and so build an ironic tragedy.[22]

In 2003, lecturers and students from the University of Plymouth MediaLab Arts course used a £2,000 grant from the Arts Council to study the literary output of real monkeys. They left a computer keyboard in the enclosure of six Celebes Crested Macaques in Paignton Zoo in Devon in England for a month, with a radio link to broadcast the results on a website. One researcher, Mike Phillips, defended the expenditure as being cheaper than reality TV and still "very stimulating and fascinating viewing".[1]

Not only did the monkeys produce nothing but five pages[23] consisting largely of the letter S, the lead male began by bashing the keyboard with a stone, and the monkeys continued by urinating and defecating on it. Phillips said that the artist-funded project was primarily performance art, and they had learned "an awful lot" from it. He concluded that monkeys "are not random generators. They're more complex than that. … They were quite interested in the screen, and they saw that when they typed a letter, something happened. There was a level of intention there."[1][24]

Popular culture

Main article: Infinite monkey theorem in popular culture

The infinite monkey theorem and its associated imagery is considered a popular and proverbial illustration of the mathematics of probability, widely known to the general public because of its transmission through popular culture rather than because of its transmission via the classroom.[note 6]

This theorem was mentioned in part and used as a joke in the novel *The Hitchhiker's Guide to the Galaxy* by Douglas Adams: “Ford! There’s an infinite number of monkeys outside who want to talk to us about this script for *Hamlet* they’ve worked out” (chapter 9).

In the American cartoon *The Simpsons* episode "Last Exit to Springfield", Mr Burns states: "This is a thousand monkeys working at a thousand typewriters. Soon they'll have written the greatest novel known to man. Let's see. *(reading)* 'It was the best of times, it was the "blurst" of times'? You stupid monkey!"

The enduring, widespread popularity of the theorem was noted in the introduction to a 2001 paper, "Monkeys, Typewriters and Networks: The Internet in the Light of the Theory of Accidental Excellence" (Hoffmann and Hofmann).[25] In 2002, an article on the American newspaper *Washington Post* said: "Plenty of people have had fun with the famous notion that an infinite number of monkeys with an infinite number of typewriters and

an infinite amount of time could eventually write the works of Shakespeare."[26] In 2003, the previously mentioned Arts Council funded experiment involving real monkeys and a computer keyboard received widespread press coverage.[27] In 2007, the theorem was listed by *Wired* magazine in a list of eight classic thought experiments.[28]

Notes

1. ^ This shows that the probability of typing "banana" in one of the predefined non-overlapping blocks of six letters tends to 1. In addition the word may appear across two blocks, so the estimate given is conservative.
2. ^ The first theorem is proven by a similar if more indirect route in Gut, Allan (2005). *Probability: A Graduate Course*. Springer. pp. 97–100. ISBN 0387228330.
3. ^ Using the Hamlet text from gutenberg (http://www.gutenberg.org/dirs/etext99/1ws2611.txt) , there are 132680 alphabetical letters and 199749 characters overall
4. ^ For any required string of 130,000 letters from the set a-z, the average number of letters that needs to be typed until the string appears is (rounded) $3.4 \times 10^{183,946}$, except in the case that all letters of the required string are equal, in which case the value is about 4% more, $3.6 \times 10^{183,946}$. In that case failure to have the correct string starting from a particular position reduces with about 4% the probability of a correct string starting from the next position (i.e., for overlapping positions the events of having the correct string are not independent; in this case there is a positive correlation between the two successes, so the chance of success after a failure is smaller than the chance of success in general). The figure $3.4 \times 10^{183,946}$ is derived from $n = 26^{130000}$ by taking the logarithm of both sides: $\log_{10}(n) = 1300000 \times \log_{10}(26) = 183946.5352$, therefore $n = 10^{0.5352} \times 10^{183946} = 3.429 \times 10^{183946}$.
5. ^ 26 letters ×2 for capitalisation, 12 for punctuation characters = 64, $199749 \times \log_{10}(64) = 4.4 \times 10^{360,783}$.
6. ^ Examples of the theorem being referred to as proverbial include: Why Creativity Is Not like the Proverbial Typing Monkey. Jonathan W. Schooler, Sonya Dougal, *Psychological Inquiry*, Vol. 10, No. 4 (1999); and *The Case of the Midwife Toad* (Arthur Koestler, New York, 1972, page 30): *"Neo-Darwinism does indeed carry the nineteenth-century brand of materialism to its extreme limits—to the proverbial monkey at the typewriter, hitting by pure chance on the proper keys to produce a Shakespeare sonnet."* The latter is sourced from Parable of the Monkeys (http://www.angelfire.com/in/hypnosonic/Parable_of_the_Monkeys.html) , a collection of historical references to the theorem in various formats.

References

1. ^ ***a*** ***b*** ***c*** "No words to describe monkeys' play" (http://news.bbc.co.uk/2/hi/3013959.stm) . BBC News. 2003-05-09. http://news.bbc.co.uk/2/hi/3013959.stm. Retrieved 2009-07-25.
2. ^ Isaac, Richard E. (1995). *The Pleasures of Probability*. Springer. pp. 48–50. ISBN 038794415X. Isaac generalizes this argument immediately to variable text and alphabet size; the common main conclusion is on p.50.
3. ^ ***a*** ***b*** Kittel, Charles and Herbert Kroemer (1980). *Thermal Physics (2nd ed.)*. W. H. Freeman Company. pp. 53. ISBN 0-7167-1088-9.
4. ^ Émile Borel (1913). "*Mécanique Statistique et Irréversibilité*". *J. Phys. 5e série* **3**: 189–196.
5. ^ Arthur Eddington (1928). *The Nature of the Physical World: The Gifford Lectures*. New York: Macmillan. pp. 72. ISBN 0-8414-3885-4.
6. ^ Aristotle, *De Generatione et Corruptione*, 315b14.
7. ^ Marcus Tullius Cicero, *De natura deorum*, 2.37. Translation from *Cicero's Tusculan Disputations; Also, Treatises On The Nature Of The Gods, And On The Commonwealth*, C. D. Yonge, principal translator, New York, Harper & Brothers Publishers, Franklin Square. (1877). Downloadable text (http://www.gutenberg.org/etext/14988) .
8. ^ Borges, Jorge Luis. "*La biblioteca total*" (The Total Library), *Sur* No. 59, August 1939. Trans. by Eliot

Weinberger. In *Selected Non-Fictions* (Penguin: 1999), ISBN 0-670-84947-2.
9. ^ Padmanabhan, Thanu (2005). "The dark side of astronomy". *Nature* **435**: 20–21. doi:10.1038/435020a (http://dx.doi.org/10.1038%2F435020a) . Platt, Suzy; Library of Congress Congressional Research Service (1993). *Respectfully quoted: a dictionary of quotations*. Barnes & Noble. pp. 388–389. ISBN 0880297689.
10. ^ Rescher, Nicholas (2006). *Studies in the Philosophy of Science*. ontos verlag. pp. 103. ISBN 3938793201.
11. ^ Powell, Doug (2006). *Holman Quicksource Guide to Christian Apologetics*. Broadman & Holman. pp. 60, 63. ISBN 080549460X.
12. ^ MacArthur, John (2003). *Think Biblically!: Recovering a Christian Worldview*. Crossway Books. pp. 78–79. ISBN 1581344120.
13. ^ Dawkins, Richard (1986). *The Blind Watchmaker*. Oxford UP.
14. ^ As quoted in Blachowicz, James (1998). *Of Two Minds: Nature of Inquiry*. SUNY Press. pp. 109. ISBN 0791436411.
15. ^ Valentine, James (2004). *On the Origin of Phyla*. University of Chicago Press. pp. 77–80. ISBN 0226845486.
16. ^ p.126 of *The Principles of Art*, as summarized and quoted by Sclafani, Richard J. (1975). "The logical primitiveness of the concept of a work of art". *British Journal of Aesthetics* **15** (1): 14. doi:10.1093/bjaesthetics/15.1.14 (http://dx.doi.org/10.1093%2Fbjaesthetics%2F15.1.14) .
17. ^ John, Eileen and Dominic Lopes, editors (2004). *The Philosophy of Literature: Contemporary and Classic Readings: An Anthology*. Blackwell. pp. 96. ISBN 1-4051-1208-5.
18. ^ Genette, Gérard (1997). *The Work of Art: Immanence and Transcendence*. Cornell UP. ISBN 0801482720.
19. ^ Gracia, Jorge (1996). *Texts: Ontological Status, Identity, Author, Audience*. SUNY Press. pp. 1–2, 122–125. ISBN 0-7914-2901-6.
20. ^ [1] (http://www.newyorker.com/arts/critics/books/2007/04/09/070409crbo_books_acocella?currentPage=all) Acocella, Joan, "The Typing Life: How writers used to write", *The New Yorker*, April 9, 2007, a review of *The Iron Whim: A Fragmented History of Typewriting* (Cornell) 2007, by Darren Wershler-Henry
21. ^ Marsaglia G. and Zaman A. (1993). "Monkey tests for random number generators". *Computers & mathematics with applications* (Elsevier, Oxford) **26**: 1–10. doi:10.1016/0898-1221(93)90001-C (http://dx.doi.org/10.1016%2F0898-1221%2893%2990001-C) . ISSN 0898-1221 (http://www.worldcat.org/issn/0898-1221)
22. ^ Cheney, Dorothy L. and Robert M. Seyfarth (1992). *How Monkeys See the World: Inside the Mind of Another Species*. University of Chicago Press. pp. 253–255. ISBN 0-226-10246-7.
23. ^ "Notes Towards the Complete Works of Shakespeare" (http://www.vivaria.net/experiments/notes/publication/NOTES_EN.pdf) (PDF). vivaria.net. 2002. http://www.vivaria.net/experiments/notes/publication/NOTES_EN.pdf. Retrieved 2006-06-13.
24. ^ Associated Press (2003-05-09). "Monkeys Don't Write Shakespeare" (http://www.wired.com/news/culture/0,1284,58790,00.html) . Wired News. http://www.wired.com/news/culture/0,1284,58790,00.html. Retrieved 2007-03-02.
25. ^ Monkeys, Typewriters and Networks (http://skylla.wz-berlin.de/pdf/2002/ii02-101.pdf) , Ute Hoffmann & Jeanette Hofmann, Wissenschaftszentrum Berlin für Sozialforschung gGmbH (WZB), 2001.
26. ^ "Hello? This is Bob" (http://www.washingtonpost.com/ac2/wp-dyn/A28521-2002Oct27?language=printer) , Ken Ringle, *Washington Post*, 28 October 2002, page C01.
27. ^ Notes Towards the Complete Works of Shakespeare (http://www.vivaria.net/experiments/notes/documentation/press/) – some press clippings.
28. ^ The Best Thought Experiments: Schrödinger's Cat, Borel's Monkeys (http://www.wired.com/science/discoveries/magazine/15-06/st_best) , Greta Lorge, Wired Magazine: Issue 15.06, May 2007.

External links

- Ask Dr. Math article (http://mathforum.org/library/drmath/view/55871.html) , August 1998, Adam Bridge

- The Parable of the Monkeys (http://www.angelfire.com/in/hypnosonic/Parable_of_the_Monkeys.html) , a bibliography with quotations
- Planck Monkeys (http://azureworld.blogspot.com/2007/04/planck-monkeys.html) , on populating the cosmos with monkey particles
- PixelMonkeys.org (http://www.pixelmonkeys.org) - Artist, Matt Kane's application of the Infinite Monkey Theorem on pixels to create images.

Retrieved from "http://en.wikipedia.org/wiki/Infinite_monkey_theorem"
Categories: Infinity | Literary theory | Mathematical theorems | Articles containing proofs | Probability theory | Randomness | Thought experiments | Biological evolution