

## **Probability, Random Numbers and the Law of Error**

### **Publication/Creation**

Mid-Late 19th Century

### **Persistent URL**

<https://wellcomecollection.org/works/q77e999m>

### **License and attribution**

You have permission to make copies of this work under a Creative Commons, Attribution, Non-commercial license.

Non-commercial use includes private study, academic research, teaching, and other activities that are not primarily intended for, or directed towards, commercial advantage or private monetary compensation. See the Legal Code for further information.

Image source should be attributed as specified in the full catalogue record. If no source is given the image should be attributed to Wellcome Collection.



Wellcome Collection  
183 Euston Road  
London NW1 2BE UK  
T +44 (0)20 7611 8722  
E [library@wellcomecollection.org](mailto:library@wellcomecollection.org)  
<https://wellcomecollection.org>



Game of Chance

As it may

It clears the mind to consider a game of chance that admits of exact mechanical analysis such as the toss of a coin. No one can doubt that if ~~it~~ it were possible to foresee the number of revolutions the coin would make in the air, it would be possible to foretell whether or no it would fall with the same face uppermost as that with which it started, the rare case being excluded of its falling exactly on its edge. Neither can any one doubt that the number of revolutions would be always the same, if the coin were always laid on the same place and struck upwards at the same spot, and with the same force, nor that the assurance with which these events could be predicted would increase with the completeness with which these conditions were fulfilled. Thinking it would be of interest in demonstrations to have an adjustable instrument by which a coin might be mechanically tossed under controllable influence, I obtained one, made in wood for me by an ingenious friend, but its action was disappointing. There was no apparent shake in its ~~move-~~

12  
9

(3)

movements but its arm was not rigid enough, the motive power was a rubber band and not constant enough, and the points between which the coin was adjusted were not removeable before the blow was given, and they appeared to give an uncertain jar to its flight. The best result was 48 successes out of 50 successive tosses, but these were little more than turnover. It was clear that minute changes of adjustment sufficed to produce great differences in result, and that the construction of a satisfactory machine <sup>or</sup> could require far <sup>more improvement</sup> better design and workmanship. The experiment left me with a profound respect for the ordinary game of patch and toss, as one in which no trick or unconscious bias could influence the result in a sensible degree-



Trial 1

On 11 and line  
 Random Numbers - being the last figures of the cube roots taken from chance  
 page in Barlow tables

line	1	2	3	4	5	6	7	8	9	0	
1	9	1	1	0	7	3	8	1	3	3	
2	4	4	2	9	4	8	2	3	4	1	
3	3	7	9	0	0	9	6	2	6	8	
4	0	2	0	7	3	7	0	2	2	1	
5	2	9	6	1	5	7	8	8	7	4	
6	3	8	1	2	1	9	6	2	7	0	
7	0	2	2	2	9	6	1	5	8	0	
8	5	0	9	7	3	8	2	4	6	6	
9	4	3	6	8	9	9	8	5	0	5	
10	2	3	0	8	0	8	5	1	5	2	
	32	39	36	37	41	74	46	33	48	30	total 416



occurrences  
 none 13  
 once 42  
 twice 13  
 three 5  
 4 times -  
 5 times 1

occurrences by  
 subtraction  
 13 x 0 = 0  
 42 x 1 = 42  
 13 x 2 = 26  
 5 x 3 = 15

line	1	2	3	4	5	6	7	8	9	0	Totals
1	+				1	-	-	-			10
2	1			1	-	-	1	1	1	1	10
3			-	-	-		-	-			10
4			-	-	-	-		1	1		10
5	1		1	1	-	-	1	1			10
6	-	-	1	-	-	1				-	10
7	1		1	-	1		-		-	1	10
8			1	1		-	-	1	-	-	10
9	-	1	1	1	1			1	-	1	10
10		1	1	1	1	1	-	1	-		10

1	2	3	4	5	6	7	8	9	10	
-	-	1	3	-	-	2	1	1	2	10
3	-	-	1	1	2	1	-	-	2	10
-	2	1	2	1	1	2	-	-	1	10
3	1	1	1	-	1	-	1	1	1	10
1	1	2	1	-	1	-	1	1	-	10
1	-	-	1	1	-	1	1	3	2	10
-	-	2	-	1	1	2	3	1	-	10
1	-	1	2	2	1	1	1	-	1	10
1	1	1	-	1	1	1	1	2	1	10

0  
 1  
 2  
 3  
 4  
 5  
 6  
 7  
 8  
 9  
 10

0  
 35  
 34  
 54  
 12  
 4  
 100

Trial 2

line	Numerals									
	1	2	3	4	5	6	7	8	9	0
1	3	4	0	4	9	2	4	6	7	8
2	7	7	6	4	2	8	4	9	4	8
3	1	1	4	5	6	7	6	5	3	1
4	4	8	4	9	3	7	0	3	4	5
5	5	3	5	7	8	8	8	7	5	3
6	7	0	6	1	6	0	3	5	7	8
7	7	8	8	7	6	3	0	6	2	6
8	7	1	4	7	9	0	1	1	0	8
9	6	6	3	9	5	0	4	7	0	2
0	4	4	2	9	6	1	7	1	5	8
	51	42	42	62	60	36	37	50	37	57



Total 474, mean 4.74

line	Number of occurrences										
	1	2	3	4	5	6	7	8	9	0	
1	-	1	1	111	-	1	1	1	1	1	10
2	-	1	-	111	-	1	11	11	1	-	10
3	111	-	1	1	11	11	1	-	-	-	10
4	-	-	11	111	1	-	1	1	1	1	10
5	-	-	11	-	111	-	11	111	-	-	10
6	1	-	1	-	1	11	11	1	-	11	10
7	-	1	1	-	-	111	11	11	-	1	10
8	111	-	-	1	-	-	11	1	1	11	10
9	-	1	1	1	1	11	1	-	1	11	10
10	11	1	-	11	1	1	1	1	1	-	10

	occurrences	frequency	Total
none	34	$\times 0$	= 0
single	40	$\times 1$	= 40
double	18	$\times 2$	= 36
triple	8	$\times 3$	= 24
<u>cases</u>	<u>100</u>		<u>100</u>

	9	5	9	14	9	12	15	12	6	9	100
4	1	5	5	3	4	3	5	5	6	3	40
2	1	2	1	1	3	5	2	-	-	3	18
3	2	-	-	3	1	1	-	-	-	-	8
<u>Total</u>											<u>66</u>

add's add'e  
 less few of 2 or 9  
 lot more (4 x 7)  
 see 2 add's

(Tetotam) 3<sup>rd</sup> trial

45

line	1	2	3	4	5	6	7	8	9	0	
1	4	9	3	3	5	0	7	5	5	7	1
2	8	1	7	1	7	6	4	5	4	5	6
3	6	8	9	5	9	3	2	2	4	0	6
4	2	1	2	3	4	4	3	0	6	4	8
5	0	0	4	5	8	4	4	6	3	8	9
6	3	6	3	6	8	7	9	2	6	6	6
7	2	7	3	9	6	4	0	8	8	1	8
8	5	6	4	4	6	8	2	6	2	1	6
9	2	0	4	9	8	2	0	1	0	5	5
10	8	5	6	0	0	2	6	4	2	4	6
	40	41	45	45	61	40	37	39	40	41	429

470  
~~3~~  
~~61~~  
 429

line	1	2	3	4	5	6	7	8	9	0
1	-	11	1	1	1	1	-	11	-	1
2	11	-	-	-	1	11	11	1	-	11
3	-	1	11	11	-	1	1	-	1	-
4	1	-	11	1	11	1	-	-	11	1
5	-	-	-	1	1	11	1	11	1	1
6	-	11	1	11	-	1	1	1	-	1
7	-	11	1	11	-	1	1	-	1	11
8	1	11	-	1	11	11	-	1	-	1
9	-	11	1	11	1	11	-	1	-	1
10	11	-	-	11	11	1	1	1	-	1
	6	12	9	16	10	14	7	10	5	11

0	11	4	4	1	3	-	4	3	6	1	32	x 0 = 0
1	2	1	4	4	4	6	5	5	3	7	41	x 1 = 41
2	2	4	1	3	3	4	1	1	1	2	33	x 2 = 66
3	1	1	1	2				1			5	x 3 = 15
	10	10	10	10	10	10	10	10	10	10	100	100



line	1	2	3	4	5	6	7	8	9	10
1	0	3	1	6	4	4	4	0	0	3
2	2	4	3	2	0	7	9	0	0	2
3	3	9	0	3	1	7	0	8	9	3
4	7	4	1	2	0	3	1	7	5	2
5	8	5	9	6	5	3	3	5	8	7
6	6	6	6	0	2	2	4	2	1	5
7	2	7	9	4	4	1	0	6	4	6
8	8	8	3	7	8	9	1	5	1	4
9	0	6	3	3	5	4	8	6	2	7
10	5	1	2	6	7	5	6	0	6	0
	41	53	37	39	36	45	26	39	36	39



Calculated Equal chances for dice.



For placing 24 equally likely <sup>sum</sup> ~~but~~ inscriptions of type,  $n$  a die

24 divisions in 5 inches = 48 in 10  $\frac{10}{48} = 208$   
 the ranks are at 0.5 1.5 2.5 - - - 99.5 to take 104 in the table for 1 2 3 4  
 good ~~table~~ grades in the Table of distribution which cover from 0-100

grades 0 to  $\pm 24$

# number of individuals	let us take from 50% of the scale 0-100	Corr. deviation	flag	with 3 dice	with 3 dice	with 3 dice	with 3 dice
1	56.10	0.0.3	0.0	.70	.02	3	19.26
2	.31	0.1.1	0.1	1.12	.04	4	19.72
3	52	0.1.2	0.2	1.62	.06	7	20.18
4	.73	0.2.6	0.3	2.04	.08	9	20.65
5	.94	0.3.5	0.4	2.55	.09	9	21.11
6	56.14	0.4.2	0.4	3.02	.12	3	21.58
7	6.35	0.5.0	0.5	3.48	.13	5	22.04
8	6.56	0.6.0	0.6	3.94	.15	7	22.50
9	6.77	0.6.8	0.7	4.41	.16	9	22.97
10	6.98	0.7.6	0.8	4.87	.18	10	23.43
11	7.18	0.8.5	0.9	5.34	.20	3	23.90
12	7.39	0.9.4	0.9	5.80	.21	10	24.36
13	7.60	1.0.4	1.0	6.26	.23	7	24.82
14	7.81	1.1.4	1.1	6.73	.25	9	25.29
15	8.02	1.2.6	1.3	7.19	.26	11	25.75
16	8.22	1.3.7	1.4	7.66	.28	3	26.22
17	8.43	1.5.0	1.5	8.12	.30	5	26.68
18	8.64	1.6.3	1.6	8.58	.32	7	27.14
19	8.85	1.7.8	1.8	9.05	.34	9	27.61
20	9.06	1.9.1	1.9	9.51	.36	12	28.07
21	9.26	2.1.4	2.1	9.98	.38	3	28.54
22	9.47	2.4.0	2.4	10.44	.40	5	29.00
23	9.68	2.7.4	2.7	10.90	.41	7	29.46
24	9.89	3.4.0	3.6	11.37	.43	9	29.93
25	5.07			11.83	.45	13	30.39
				12.30	.46	3	30.86
				12.76	.48	5	31.32
				13.22	.50	7	31.78
				13.69	.52	9	32.25
				14.15	.54	14	32.71
				14.62	.56	3	33.18
				15.08	.58	5	33.64
				15.54	.60	7	34.10
				16.01	.62	9	34.57
				16.47	.64	15	35.03
				16.94	.65	3	35.50
				17.40	.66	5	35.96
				17.86	.68	7	36.42
				18.33	.70	9	36.89

with 3 dice  $6 \times 6 \times 6 = 216$ ;  $n$  432 half spaces;  $\frac{100}{432} = .232$

$24 \times 109 = \frac{100}{224}$  for 100 grades =  $\frac{100}{432}$  for a half grade =  $.232$

1	52.08	0.08	9	11.19	.37	2.27
3	25.24	0.23	9	3.12	.72	3.00
5	36.04	0.37	5	9.20		
7	6.46	0.55	7	5.62		
9	6.87	.72				
11	7.29	.90				
13	7.70	1.12				
15	8.12	1.32				
17	8.54	1.55				
19	8.95	1.85				

See over

23	.00	81	18.79	.72	1	3735	1.69
27	.02	3	19.26	.74	2	3782	1.73
31	.04	4	19.72	.76	3	3828	1.77
35	.06	7	20.18	.78	4	3874	1.80
39	.08	9	20.65	.80	5	3921	1.83
43	.09	9	21.11	.82	6	3967	1.87
47	.12	3	21.58	.84	3	4014	1.91
51	.13	5	22.04	.86	5	4060	1.95
55	.15	7	22.50	.88	7	4106	2.00
59	.16	9	22.97	.91	9	4153	2.04
63	.18	10	23.43	.93	1	4199	2.08
67	.20	3	23.90	.95	3	4246	2.13
71	.21	10	24.36	.97	5	4292	2.18
75	.23	7	24.82	.99	7	4338	2.23
79	.25	9	25.29	1.01	9	4385	2.29
83	.26	11	25.75	1.03	1	4431	2.35
87	.28	3	26.22	1.05	3	4478	2.41
91	.30	5	26.68	1.07	5	4524	2.48
95	.32	7	27.14	1.10	7	4570	2.55
99	.34	9	27.61	1.12	9	4617	2.63
103	.36	12	28.07	1.14	1	4663	2.72
107	.38	3	28.54	1.16	3	4710	2.80
111	.40	5	29.00	1.18	5	4756	2.94
115	.41	7	29.46	1.21	7	4802	3.06
119	.43	9	29.93	1.23	9	4849	3.25
123	.45	13	30.39	1.26	1	4895	3.44
127	.46	3	30.86	1.30	3	4942	3.75
131	.48	5	31.32	1.33	5	4988	4.50
135	.50	7	31.78	1.35	7	5011	
139	.52	9	32.25	1.38	9		
143	.54	14	32.71	1.40			
147	.56	3	33.18	1.42			
151	.58	5	33.64	1.45			
155	.60	7	34.10	1.48			
159	.62	9	34.57	1.51			
163	.64	15	35.03	1.53			
167	.65	3	35.50	1.56			
171	.66	5	35.96	1.60			
175	.68	7	36.42	1.62			
179	.70	9	36.89	1.66			



24 in 10 inches 1 grade in  $\frac{10}{24}$ , one half grade in  $\frac{10}{48} = .208$  inch

Rank	$.208 \times$	=	in center grade Cumulative	cor deviation	total	$.208 \times 3$	$\times 2$	$\times 1.5$
1	1	0.21	52.1	+0.07	+0.1	0.2	0.1	.1
2	3	0.62	56.2	0.22	+0.2	0.7	0.4	.3
3	5	1.04	60.4	0.40	+0.4	1.2	0.8	.6
4	7	1.46	64.6	0.54	+0.5	1.6	1.1	.8
5	9	1.87	68.7	0.72	+0.7	2.2	1.4	1.1
6	11	2.29	72.9	0.91	+0.9	2.7	1.8	1.4
7	13	2.70	77.0	1.10	+1.1	3.3	2.2	1.7
8	15	3.12	81.2	1.32	+1.3	4.0	2.6	2.0
9	17	3.54	85.4	1.57	+1.6	4.7	3.1	2.4
10	19	3.95	89.5	1.86	+1.9	5.6	3.7	2.8
11	21	4.37	93.7	2.27	+2.3	6.8	4.5	3.4
12	23	4.78	97.8	3.00	+3.0	9.0	6.0	4.5
13	25	5.20			-3.0			
14	26				-2.3			
15	27				-1.9			
16	28				-1.6			
17					-1.3			
18					-1.1			
19					-0.9			
20					-0.7			
21					-0.5			
22					-0.4			
23					-0.2			
24					-0.1			

see over for  
other calculations

Face of die along its front edges

1	+0.1	+1.1	-3.0	-0.9	1
	+0.1	+2.2	-1.0	-1.9	2
	+0.2	+3.3	-9.0	-2.7	3
	+0.1	+1.7	-4.5	-1.4	1.5
2	+0.2	+1.3	-2.3	-0.7	
	+0.4	+2.6	-2.5	-1.7	
	+0.3	+4.0	-6.2	-2.2	
	+0.1	+2.0	-3.2	-1.1	
3	+0.4	+1.6	-1.9	-0.5	
	+0.8	+3.1	-3.1	-1.5	
	+1.2	+4.7	-5.6	-0.8	
	+0.1	+2.4	-2.8	-1.1	
4	+0.5	+1.9	-1.6	-0.4	
	+1.1	+3.7	-3.1	-0.8	
	+1.6	+5.6	-4.7	-0.8	
	+0.8	+2.8	-1.3	-0.2	
5	+0.7	+2.3	-1.3	-0.2	
	+1.4	+4.5	-2.6	-0.4	
	+2.1	+6.8	-4.0	-0.7	
	+1.7	+3.4	-2.0	-0.7	
6	+0.9	+3.0	-1.1	-0.1	
	+1.9	+6.0	-2.2	-0.1	
	+2.7	+9.0	-3.3	-0.2	
	+1.4	+4.5	-1.7	-0.1	



first die 1 = 1 = - 2 = 2 = +

3 = - 4 = +

5 = - 6 = +



second die

	1	2	3	4	5	6
1	0.00	0.11	0.21	0.32	0.43	0.54
2	0.02	0.13	0.23	0.34	0.45	0.56
3	0.04	0.15	0.25	0.36	0.46	0.58
4	0.06	0.16	0.26	0.38	0.48	0.60
5	0.08	0.18	0.28	0.40	0.50	0.62
6	0.09	0.20	0.30	0.41	0.52	0.64

	1	2	3	4	5	6
1	0.65	0.76	0.88	1.01	1.14	1.30
2	0.66	0.78	0.91	1.03	1.16	1.33
3	0.68	0.80	0.93	1.05	1.18	1.35
4	0.70	0.82	0.95	1.07	1.21	1.38
5	0.72	0.84	0.97	1.10	1.23	1.40
6	0.74	0.86	0.99	1.12	1.26	1.42

	1	2	3	4	5	6
1	1.45	1.63	1.83	2.08	2.41	2.94
2	1.48	1.66	1.87	2.13	2.48	3.06
3	1.51	1.69	1.91	2.18	2.55	3.25
4	1.53	1.73	1.95	2.23	2.63	3.44
5	1.56	1.77	2.00	2.29	2.72	3.75
6	1.60	1.80	2.04	2.35	2.80	4.50

third die

Mark the 4 highest figures on the old die red viz 2-15, 2-40, 2-75, 3-40  
 and whenever any one of these is turned take a throw with a die marked  
 as below. for the 4 highest figures - When any of them is thrown, throw again with  
 a die marked as below

$104 \times 42 = 43.68$   
 as 50  $93.68 = 100 - 6.32$   
 divide 6.32 into 48 parts & take the 1<sup>st</sup> 3<sup>5</sup> - ... 47<sup>th</sup>  $\frac{6.32}{48} = .132$

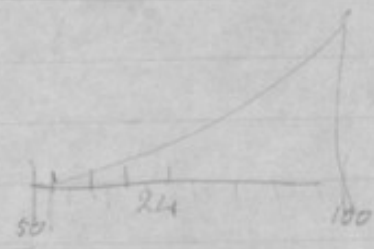
$0.132 \times$	$+93.68$	Subtr	
1	0.132	93.81	2.29
3	.396	94.08	2.32
5	.660	94.34	2.35
7	.924	94.60	2.39
9	1.19	4.87	2.43
11	1.45	5.13	2.47
13	1.72	5.40	2.51
15	1.98	5.66	2.55
17	2.24	5.92	2.59
19	2.51	6.19	2.64
21	2.77	6.45	2.68
3	3.04	6.72	2.72
5	3.30	6.98	2.77
7	3.56	7.24	2.83
9	3.83	7.51	2.90
31	4.09	7.77	2.98
3	4.36	8.04	3.06
5	4.62	8.30	3.15
7	4.88	8.56	3.25
9	5.15	8.83	3.36
41	5.41	9.09	3.49
3	5.68	9.36	3.65
5	5.94	9.62	4.00
7	6.20	9.88	4.55
48	6.36		
Sub	6.32		

f9v

Law of Error  
Dice



For die, 24 values w reduction of high



24 in the half = 48 in the whole       $2 \times 48 = 96$  half spaces out =  $\pi$   
 $96 : 100 :: 1 : x$        $x = \frac{100}{96} = 1.04$  to be multiplied by 1.35 = 1.405

$f_n^{100}$  + also for - values

	$104 \times$		+ deviation		micro to 100
591	1	57.04	0.03	.08	0.0
2	3	53.12	0.11	.08	0.1
3	5	55.20	0.19	.08	0.2
4	7	57.28	0.27	.08	0.3
5	9	59.36	0.35	.08	0.4
6	11	61.44	0.43	.08	0.4
7	13	63.52	0.51	.08	0.5
8	15	65.60	0.59	.08	0.6
9	17	67.68	0.67	.08	0.7
10	19	69.76	0.76	.09	0.8
11	21	71.84	0.85	.09	0.9
12	3	73.92	0.94	.09	0.9
13	5	76.00	1.04	10	1.0
14	7	78.08	1.14	10	1.1
15	9	80.16	1.25	11	1.3
16	31	82.24	1.37	12	1.4
17	3	84.32	1.50	13	1.5
18	5	86.40	1.63	13	1.6
19	7	88.48	1.78	15	1.8
20	9	90.56	1.95	17	2.0
21	41	92.64	2.15	20	2.2
22	3	94.72	2.40	26	2.4
23	5	96.80	2.75	35	2.8
24	7	98.88	3.40	75	3.6

day 3.60