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## Statistical Literacy: Coincidence

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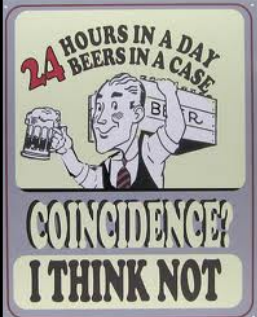

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*US Rep, International Statistical Literacy Project*  
*Member, International Statistical Institute*

January 7, 2012  
Paper at [www.StatLit.org/pdf/2012Schield-MAA.pdf](http://www.StatLit.org/pdf/2012Schield-MAA.pdf)  
Slides at [www.StatLit.org/pdf/2012Schield-MAA6up.pdf](http://www.StatLit.org/pdf/2012Schield-MAA6up.pdf)

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## Coincidence?


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Jan 2012 3


## Coincidence?


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$$3.14 \rightarrow \pi$$

$$\pi \rightarrow 3.14$$






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## The “Birthday” Problem

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Q. What is the chance that two people in a group will have the same birth-date: month and day?


A. One chance in 365?



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## The “Birthday” Problem

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Richard von Mises (1883-1953)

In a group of 28 people, a birthday match is “expected”.

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## The “Birthday” Problem Math Answer

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If the chance of an rare event is  $p$  and  $p = 1/k$ , then this event is “expected” in  $k$  trials.

In a group of size  $N$ , there are  $(N-1)(N/2)$  pairs.

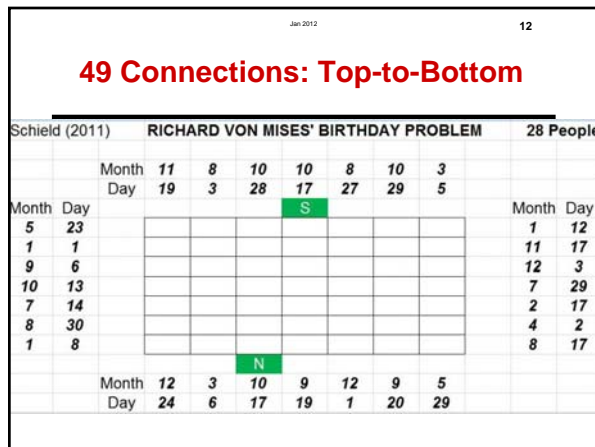
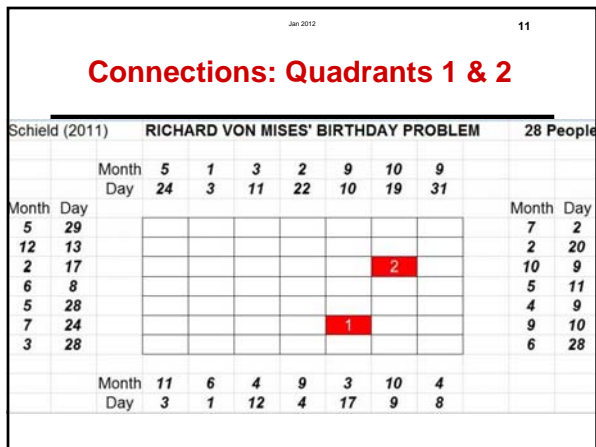
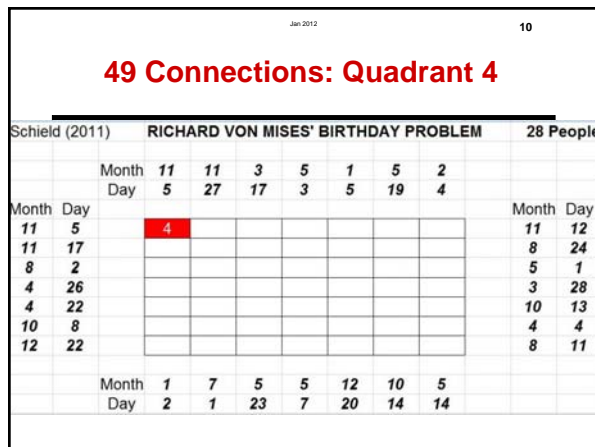
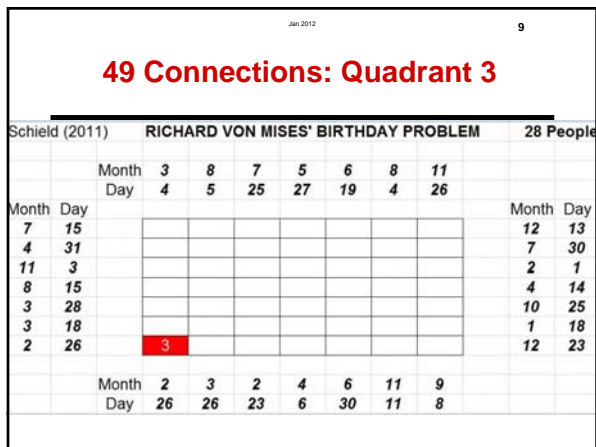
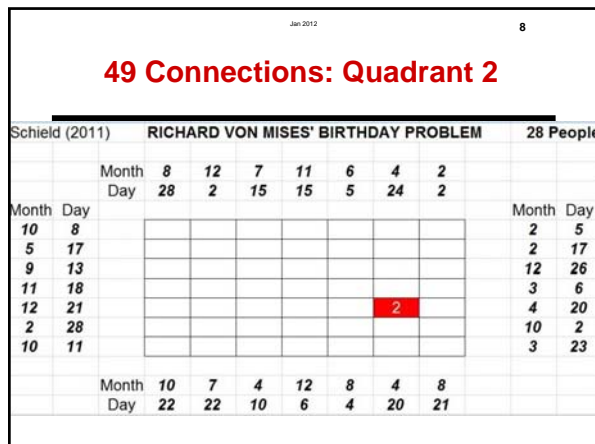
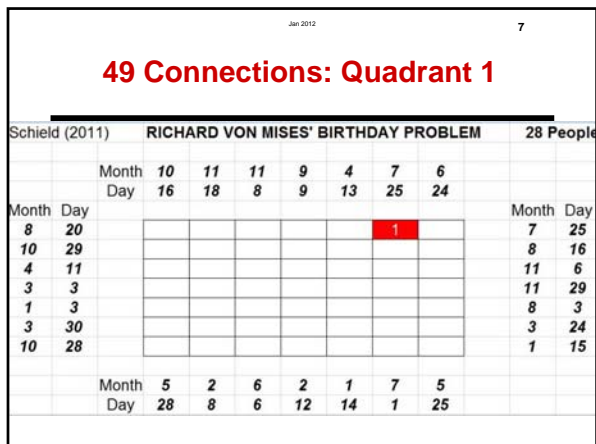
Solve for  $N(k)$ .  $k = (N-1)(N/2) = (N^2 - N)/2$

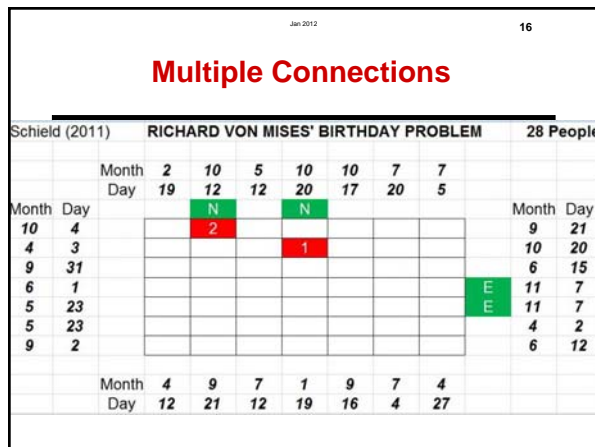
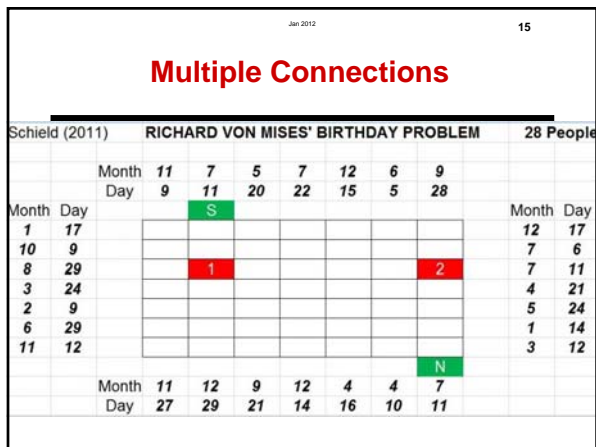
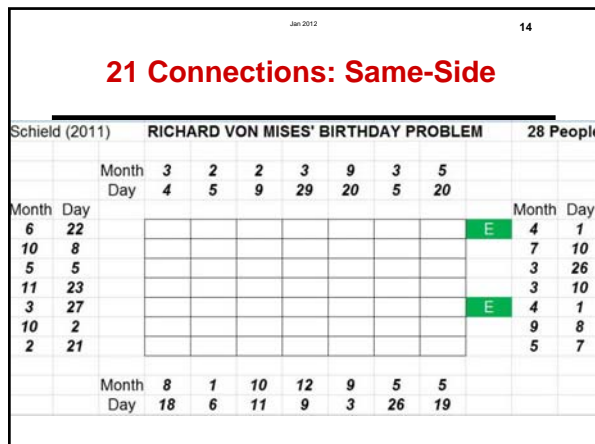
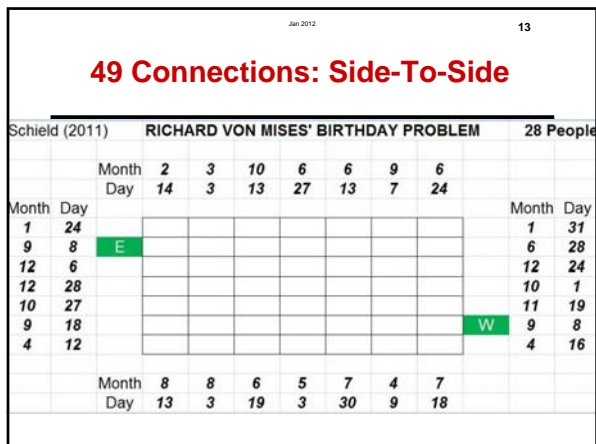
Quadratic:  $N^2 - N - 2k = 0$

Estimate:  $\sim N^2/2 = 1/p$ .

Trial and error:  $[27^2]/2 = 364 = 1/p = k$

Q. Are students convinced? No!!!





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### Connections and Chance

Pairs	GROUP	Details
196	Quadrants 1-4	49 pairs each
49	Side-to-Side	
49	Top-to-Bottom	
84	Within each side	21 pairs each
378	TOTAL	


A "birthday" match has one chance in 365.  
 In a group of 28, we have 378 pairs:  $(N-1)(N/2)$ .  
 A match is expected: Match is more likely than not.

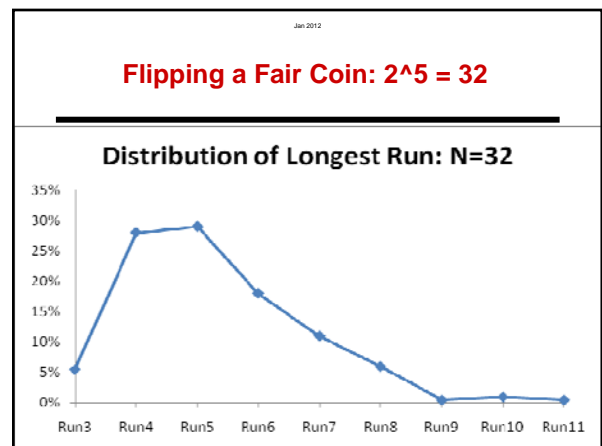
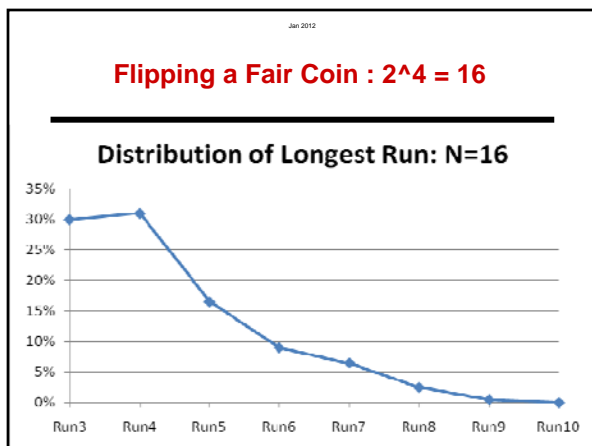
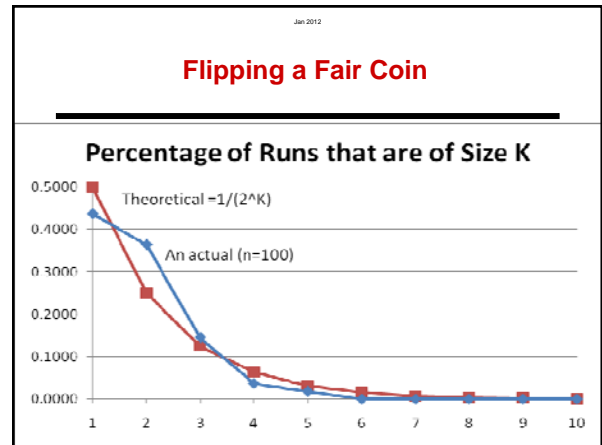
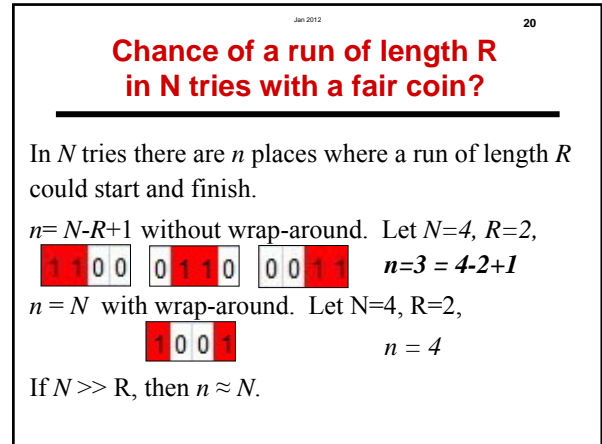
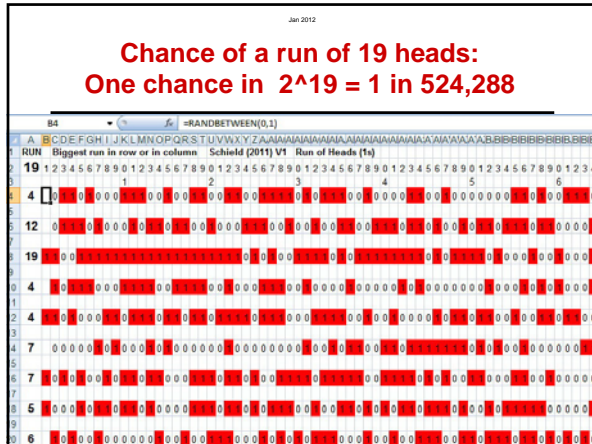
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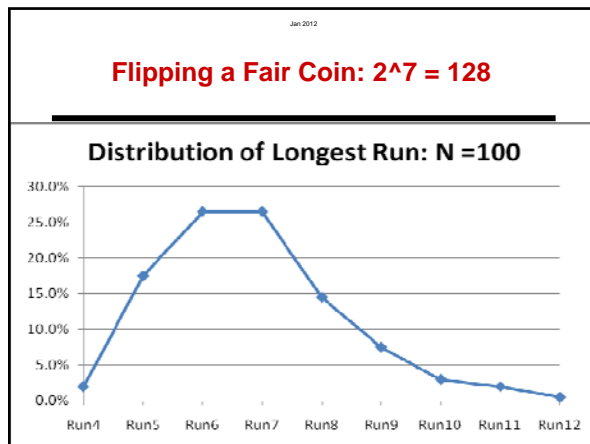
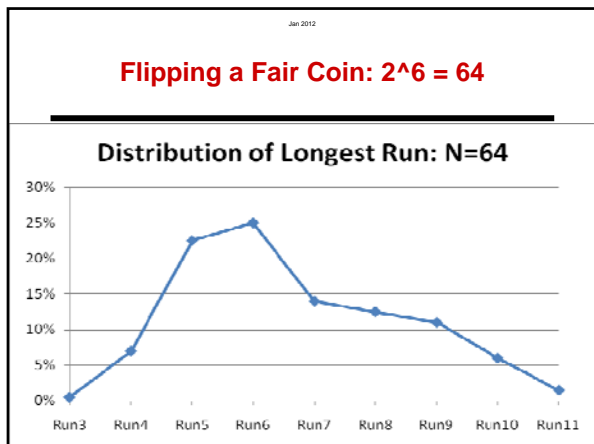
### Runs: Flipping Coins

Law of Very-Large Numbers (Qualitative):  
 The very unlikely is almost certain given enough tries

Law of Expected Values:  
 Events with 1 chance in k are "expected" in k tries.







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**Runs in Flipping a Fair Coin**

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1) Unlikely is expected given enough tries.  
 2) Unlikely (1 chance in k) is *expected* in k tries

Run of 6 is expected in 64 tries:  $2^6 = 64$ .  
 Run of 7 is expected in 128 tries:  $2^7 = 128$   
 Run of 8 is expected in 256 tries:  $2^8 = 256$

**k tries = k flips of a coin**



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**Patterns in Rice**

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With rice scattered in two dimensions, people can often see shapes that are very unlikely.

Let's simulate rice in Excel where each cell has 1 chance in 10.

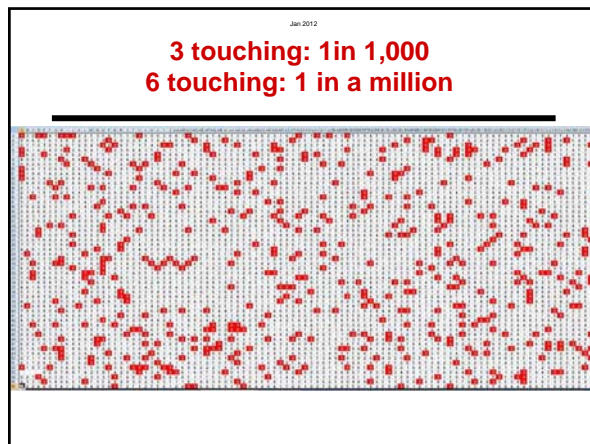
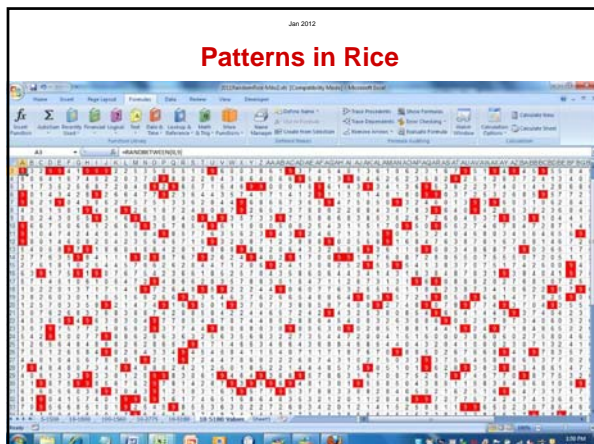
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**Patterns in Rice: # Touching**  
 2:1/100; 4:1/10,000; 6: 1/1,000,000

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A3      fx      =RANDBETWEEN(0,9)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
3	9	3	2	9	9	4	1	9	9	9	2	2	5	3	5	0	5	5
4	8	0	6	4	1	6	7	4	0	2	2	0	3	7	0	9	8	0
5	3	1	7	3	5	2	5	6	8	7	2	0	4	8	9	2	9	6
6	9	0	1	4	3	4	2	8	9	2	6	6	4	7	7	9	2	3
7	9	6	2	1	9	0	4	3	8	6	2	7	5	7	5	1	3	3
8	4	3	6	1	5	8	1	9	4	8	4	9	2	6	1	8	7	2
9	0	0	2	4	3	0	5	5	9	3	1	6	9	5	3	5	8	4
10	9	6	6	7	5	0	6	6	1	2	6	6	0	9	3	6	7	8
11	9	1	0	4	7	4	2	4	4	0	4	3	8	8	4	9	8	5
12	9	8	0	1	4	6	0	8	2	0	4	2	3	5	6	4	5	7



**Patterns in Rice**

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In 2D, there are more ways for cells to connect:

- 2 horizontally (left side or right side)
- 2 vertically (above and below)
- 4 vertices (NE, SE, SW and NW corners)
- 8 TOTAL ways two random cells can connect.

Chance that 6 cells with rice will touch:

- a. 1 in  $10^6$ : 1 in a million
- b.  $(8-1)^6 = 262,144$

**Conclusion**

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Students must “see” that coincidences

1. are more common than expected
2. depend on the context
3. compare ex-ante with ex-post
4. may be signs of causation.

*Example: Cholera outbreak in London around a particular pump.*

**Resources**

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**Full paper:**  
 Schield, Milo (2012). Coincidence in Runs and Clusters. Joint Mathematical Meeting, MAA. See [www.StatLit.org/pdf/2012Schield-MAA.pdf](http://www.StatLit.org/pdf/2012Schield-MAA.pdf)

**Downloadable spreadsheets:**

- Birthday problem: [www.statlit.org/Excel/2012Schield-Bday.xls](http://www.statlit.org/Excel/2012Schield-Bday.xls)
- Runs of Coins: [www.statlit.org/Excel/2012Schield-Runs.xls](http://www.statlit.org/Excel/2012Schield-Runs.xls)
- Clusters Grains of Rice: [www.statlit.org/Excel/2012Schield-Rice.xls](http://www.statlit.org/Excel/2012Schield-Rice.xls)