

# **Exercise: Chi-Square Test**

**Human Computer Interaction** 

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# Portale della Didattica: A/B Testing

Will the "Community" link lead to significantly more students using the functionality versus the original "Forum" link?





Experimental Design: online A/B test, **randomly** show each student one version of the page. We are measuring the "engagement rate", i.e., how many students open that functionality

	Button on the page				
	Community	Forum			
Students use the functionality	30	20			
Students didn't use the functionality	70	100			

Total visitors: 100 120

	Button on the page				
	Community	Forum			
Students use the functionality	30 <b>(30</b> %)	20 <b>(17%</b> )			
Students didn't use the functionality	70	100			

Total visitors: 100 120

30% is higher than 17%, so we are done!

Right? "Community" is clearly better!

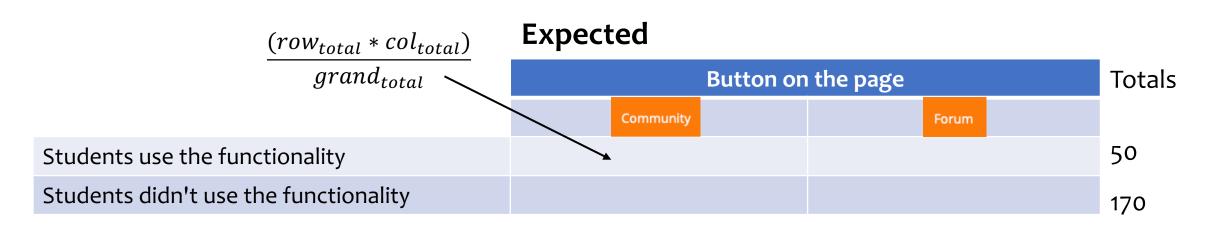
- Not so fast!
- What if this happened just by chance since we had quite few visitors?
- Let's use the Chi-square test to understand whether this difference is significant:
  - null hypothesis:
  - alternative hypothesis:

- Not so fast!
- What if this happened just by chance since we had quite few visitors?
- Let's use the Chi-square test to understand whether this difference is significant:
  - null hypothesis: the "Community" link will lead to no significant change in the number of students using the functionality versus the original "Forum" link
  - alternative hypothesis: the "Community" link will lead to significant more students using the functionality versus the original "Forum" link

	Button on the page			
	Community	Forum		
Students use the functionality	30	20	50	
Students didn't use the functionality	70	100	170	
Total visitors:	100	120	220	

What do we expect to have if the null hypothesis is true?

	Button on the page			
	Community	Forum		
Students use the functionality	30	20	50	
Students didn't use the functionality	70	100	170	
Total visitors:	100	120	220	



	Button on the page				
	Community	Forum			
Students use the functionality	30	20	50		
Students didn't use the functionality	70	100	170		

Total visitors: 100 120 220

### **Expected**

	Button on	Totals	
	Community	Forum	
Students use the functionality	(50/220)*100 = 22.7 $(50/220)*120 = 27.3$		50
Students didn't use the functionality	(170/220)*100 = 77.3	(170/220)*120 = 92.7	170

	Button on the page				
	Community	Forum			
Students use the functionality	30	20	50		
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Total visitors: 100 120 220

### **Expected**

	Button on the page					
	Community	Forum				
Students use the functionality	22.7	27.3	50			
Students didn't use the functionality	77.3	92.7	170			

#### 1. Calculate

$$0 \quad \chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

 $\circ$  where  $O_i$  is the i-th observation and  $E_i$  is the expected (theoretical) count of type i

$$\chi^2 = \frac{(30-22.7)^2}{22.7} + \frac{(20-27.3)^2}{27.3} + \frac{(70-77.3)^2}{77.3} + \frac{(100-92.7)^2}{92.7} = 2.34 + 1.95 + 0.69 + 0.57 = 5.55$$

- 2. Determine the degrees of freedom, df, of that statistic:
  - Test of independence, df = (Rows 1) \* (Cols 1)
- df = (2-1)\*(2-1) = 1

3. Look for the level of confidence (p-value) related to the  $\chi^2$  result (5.55) and df (1) in a Probability Table:

df	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1			0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750

from https://people.richland.edu/james/lecture/m170/tbl-chi.html

- Coin example:
  - first row,  $p \approx 0.025$

#### 4. Sustain or reject the null hypothesis

- $\circ$  we usually reject the null hypothesis at p < 0.05 or p < 0.01
- i.e., we are confident that 95% or 99% of the time the test result correctly applies to the entire population

#### In our case:

- we can reject the null hypothesis (if we choose p < 0.05)!</li>
- so, we can say that the (imaginary) "Community" link leads to significant more students using the functionality



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