

Confidence interval and Hypothesis Testing

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IITU 2021



COURSE SCHEDULE

week	Mid Term (weeks 01-07)	End Term (weeks 08-14)	week
01	Intro: Data Science Area and open source tools for Data Science	Post Feedback Week	08
02	NumPy package for data science	Correlation and Covariance	09
03	Pandas package for data science	Sampling and Estimation	10
04	Visualization with matplotlib	Hypothesis testing	11
05	Statistics: Distribution – Normal	Decision Tree	12
06	Exploratory Data Analysis (EDA)	Linear Regression	13
<u>07</u>	Summary for 6 weeks QA session	Summary for 6 weeks QA session	<u>14</u>
15	Course s	ummary	

PREVIOUSLY



- Correlation
- Sampling and Estimation

IDEA



- •The main question here is: are the effects we see in a sample likely to appear in the larger population?
- •Or if it might appear in the sample by chance (случайно).



CONFIDENCE INTERVAL

CONFIDENCE INTERVAL



- A confidence interval is how much uncertainty there is with any statistic.
- Confidence intervals are often used with a margin of error (погрешность).
- It tells you how confident you can be that the results from a poll or survey reflect what you would expect to find if it were possible to survey the entire population.

CONFIDENCE LEVELS



Widely used confidence levels:

- 90%
- 95%
- 99%

CONFIDENCE INTERVAL



• Confidence interval for mean

$$\frac{1}{x} \pm z_{\frac{\alpha}{2}} \left(\frac{\sigma}{\sqrt{n}} \right) \qquad \overline{X} \pm t \frac{S}{\sqrt{n}}$$

• Confidence interval for proportion

$$\hat{p} \pm z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

Z-score and T-score

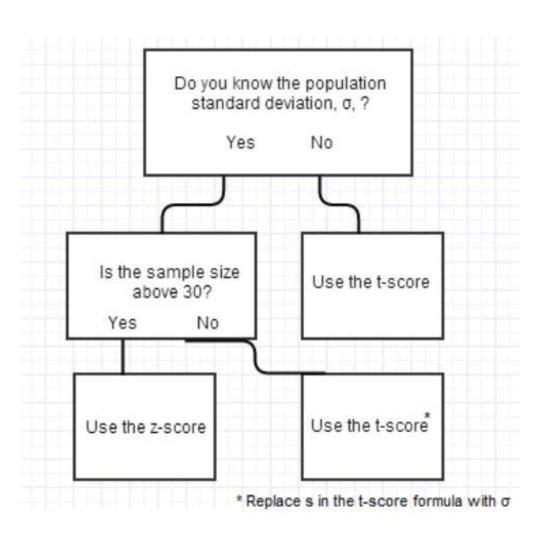


- **Z-score** Simply put, a z-score (also called a standard score) gives you an idea of how far from the mean a data point is. But more technically it's a measure of how many standard deviations below or above the population mean a raw score is.
- •t-score
- •z-score vs. t-score

$$z_i = \frac{x_i - \bar{x}}{s}$$

Z-score and T-score





CONFIDENCE LEVELS



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

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2 0.000 0.816 1.061 1.386 1.886 2.920 4.303 3 0.000 0.765 0.978 1.250 1.638 2.353 3.182 4 0.000 0.741 0.941 1.190 1.533 2.132 2.776 5 0.000 0.727 0.920 1.156 1.476 2.015 5 0.000 0.718 0.996 1.134 1.440 1.943 2.447 7 0.000 0.711 0.896 1.119 1.415 1.895 2.365 8 0.000 0.706 0.889 1.108 1.397 1.860 2.306 9 0.000 0.706 0.889 1.108 1.397 1.860 2.306 9 0.000 0.700 0.8879 1.083 1.372 1.812 2.228 11 0.000 0.697 0.876 1.088 1.363 1.796 2.201 12 0.000 0.695 0.873 1.083 1.356 1.782 2.179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.865 1.076 1.345 1.771 2.160 15 0.000 0.699 0.865 1.074 1.341 1.753 2.131 16 0.000 0.699 0.865 1.074 1.341 1.753 2.131 16 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.689 0.865 1.074 1.334 1.759 2.093 20 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.862 1.066 1.328 1.729 2.093 20 0.000 0.688 0.862 1.066 1.328 1.729 2.093 20 0.000 0.688 0.865 1.066 1.328 1.722 2.096 21 0.000 0.688 0.865 1.066 1.328 1.722 2.096 22 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.686 0.858 1.066 1.328 1.722 2.098 24 0.000 0.685 0.858 1.061 1.321 1.717 2.074 25 0.000 0.684 0.856 1.058 1.316 1.708 2.066 26 0.000 0.684 0.856 1.058 1.316 1.708 2.066 27 0.000 0.684 0.856 1.058 1.316 1.708 2.066 28 0.000 0.684 0.856 1.058 1.316 1.708 2.056 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.683 0.854 1.055 1.311 1.699 2.045 40 0.000 0.667 0.848 1.045 1.042 1.290 1.660 1.984 40 0.000 0.667 0.848 1.045 1.042 1.290 1.660 1.984	-52 00	55 56	Kitherini	orecos:	eens	556	e de la companya de	000000000	MR1.50	8577750	63863	NO TOTAL	COST-ST
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5 0.000 0.727 0.920 1.156 1.476 2.015 2.571 6 0.000 0.718 0.966 1.134 1.440 1.943 2.447 7 0.000 0.711 0.896 1.119 1.415 1.860 2.366 8 0.000 0.706 0.889 1.108 1.397 1.860 2.306 9 0.000 0.700 0.879 1.093 1.372 1.812 2.228 10 0.000 0.695 0.873 1.083 1.363 1.796 2.201 12 0.000 0.695 0.873 1.083 1.363 1.796 2.2179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.691 0.866 1.074 1.341 1.753 2.131 16 0.000 </td <td>()</td> <td>50 1</td> <td>1.250</td> <td>1.250</td> <td>250</td> <td>1</td> <td>1.638</td> <td>2.353</td> <td>3.182</td> <td>4.541</td> <td>5.841</td> <td>10.215</td> <td>12.924</td>	()	50 1	1.250	1.250	250	1	1.638	2.353	3.182	4.541	5.841	10.215	12.924
8 0.000 0.706 0.889 1.108 1.397 1.880 2.306 9 0.000 0.703 0.883 1.100 1.383 1.833 2.262 10 0.000 0.700 0.879 1.093 1.372 1.812 2.228 11 0.000 0.695 0.873 1.083 1.366 1.782 2.179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.694 0.866 1.074 1.341 1.753 2.131 16 0.000 0.699 0.865 1.074 1.347 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000		90 1	1,190	1,190	.190	1	1.533	2.132	2.776	3,747	4.604	7.173	8.610
8 0.000 0.706 0.889 1.108 1.397 1.880 2.306 9 0.000 0.703 0.883 1.100 1.383 1.833 2.262 10 0.000 0.700 0.879 1.093 1.372 1.812 2.228 11 0.000 0.695 0.876 1.088 1.366 1.782 2.201 12 0.000 0.695 0.873 1.083 1.356 1.782 2.179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.691 0.866 1.074 1.341 1.753 2.131 16 0.000 0.699 0.863 1.069 1.333 1.740 2.110 17 0.000 0.688 0.862 1.067 1.330 1.734 2.101 18 0.000										3.365	4.032	5.893	6.869
8 0.000 0.706 0.889 1.108 1.397 1.880 2.306 9 0.000 0.703 0.883 1.100 1.383 1.833 2.262 10 0.000 0.700 0.879 1.093 1.372 1.812 2.228 11 0.000 0.695 0.873 1.083 1.366 1.782 2.179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.694 0.866 1.074 1.341 1.753 2.131 16 0.000 0.699 0.865 1.074 1.347 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000									2.447	3.143	3.707	5.208	5.959
9 0.000 0.703 0.883 1.100 1.383 1.833 2.262 10 0.000 0.700 0.879 1.093 1.372 1.812 2.228 11 0.000 0.697 0.876 1.088 1.363 1.796 2.201 12 0.000 0.695 0.873 1.083 1.356 1.796 2.201 13 0.000 0.695 0.873 1.083 1.356 1.796 2.2179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.691 0.866 1.074 1.341 1.753 2.131 16 0.000 0.690 0.865 1.071 1.337 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.746 2.120 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.862 1.067 1.330 1.724 2.093 20 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.688 0.861 1.066 1.328 1.729 2.093 22 0.000 0.686 0.859 1.063 1.323 1.721 2.086 21 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.061 1.321 1.777 2.074 23 0.000 0.686 0.858 1.061 1.321 1.771 2.064 25 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.684 0.856 1.058 1.316 1.708 2.060 25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.856 1.058 1.314 1.708 2.060 27 0.000 0.684 0.856 1.058 1.315 1.706 2.056 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.687 0.848 1.055 1.310 1.697 2.042 40 0.000 0.687 0.848 1.055 1.310 1.697 2.042 40 0.000 0.687 0.848 1.055 1.310 1.697 2.042 40 0.000 0.687 0.848 1.055 1.310 1.697 2.042 40 0.000 0.687 0.848 1.055 1.310 1.697 2.042 40 0.000 0.687 0.848 1.045 1.296 1.671 2.000 80 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.677 0.845 1.042 1.290 1.666 1.984										2.998	3.499	4.785	5.408
10										2.896	3.355	4.501	5.04
11 0.000 0.697 0.876 1.088 1.363 1.796 2.201 12 0.000 0.695 0.873 1.083 1.356 1.782 2.179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.751 2.145 15 0.000 0.691 0.866 1.074 1.341 1.753 2.131 16 0.000 0.690 0.865 1.071 1.337 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.064 1.328 1.729 2.093 20 0.000 0.687 0.860 1.063 1.323 1.721 2.080 21 0.0										2.821	3.250	4.297	4.78
12 0.000 0.695 0.873 1.083 1.356 1.782 2.179 13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.691 0.866 1.074 1.341 1.753 2.131 16 0.000 0.689 0.865 1.071 1.337 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.686 0.859 1.063 1.323 1.725 2.086 21 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.0										2.764	3.169	4.144	4.587
13 0.000 0.694 0.870 1.079 1.350 1.771 2.160 14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.691 0.868 1.074 1.341 1.753 2.131 16 0.000 0.699 0.865 1.071 1.337 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.688 0.859 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.063 1.321 1.771 2.074 23 0.000 0.685 0.858 1.061 1.321 1.771 2.074 24 0.0										2.718	3.106	4.025	4.437
14 0.000 0.692 0.868 1.076 1.345 1.761 2.145 15 0.000 0.691 0.866 1.074 1.341 1.753 2.131 16 0.000 0.689 0.863 1.069 1.333 1.746 2.120 17 0.000 0.688 0.862 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.687 0.860 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.0										2.681	3.055	3.930	4.318
15 0.000 0.691 0.868 1.074 1.341 1.753 2.131 16 0.000 0.690 0.865 1.071 1.337 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.066 1.328 1.725 2.086 20 0.000 0.687 0.860 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.684 0.856 1.058 1.316 1.708 2.066 25 0.0						. 1	1.350	1.771	2.160	2.650	3.012	3.852	4.22
16 0.000 0.690 0.865 1.071 1.337 1.746 2.120 17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.724 2.101 19 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.687 0.860 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.684 0.856 1.058 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.315 1.706 2.056 26 0.0		76 1	1.076	1.076	.076	1	1.345		2.145	2.624	2.977	3.787	4.140
17 0.000 0.689 0.863 1.069 1.333 1.740 2.110 18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.687 0.860 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.063 1.323 1.721 2.090 22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.315 1.708 2.066 26 0.000 0.684 0.856 1.058 1.315 1.701 2.048 27 0.0								1.753	2.131	2.602	2.947	3.733	4.07
18 0.000 0.688 0.862 1.067 1.330 1.734 2.101 19 0.000 0.688 0.861 1.066 1.328 1.729 2.093 20 0.000 0.687 0.860 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.061 1.321 1.771 2.074 22 0.000 0.686 0.858 1.061 1.321 1.771 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.856 1.058 1.314 1.708 2.056 27 0.000 0.683 0.855 1.057 1.314 1.706 2.048 29 0.0		71 1	1.071	1.071	.071	1	1.337	1.746	2.120	2.583	2.921	3.686	4.013
19		69 1	1.069	1.069	.069	1	1.333	1.740	2.110	2.567	2.898	3.646	3.965
20 0.000 0.687 0.860 1.064 1.325 1.725 2.086 21 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.856 1.058 1.315 1.708 2.056 27 0.000 0.684 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.0			1.067	1.067	.067			1.734	2.101	2.552	2.878	3.610	3.922
21 0.000 0.686 0.859 1.063 1.323 1.721 2.080 22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.701 2.064 25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.855 1.058 1.315 1.706 2.056 27 0.000 0.684 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.311 1.699 2.042 40 0.0		66 1	1.066	1.066	.066	. 1	1.328	1,729	2.093	2.539	2.861	3.579	3.883
22 0.000 0.686 0.858 1.061 1.321 1.717 2.074 23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.315 1.708 2.050 26 0.000 0.684 0.856 1.058 1.315 1.708 2.056 27 0.000 0.684 0.856 1.058 1.315 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.0								1.725	2.086	2.528	2.845	3.552	3.85
23 0.000 0.685 0.858 1.060 1.319 1.714 2.069 24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.856 1.058 1.315 1.703 2.052 27 0.000 0.684 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.0			1.063	1.063	.063				2.080	2.518	2.831	3.527	3.819
24 0.000 0.685 0.857 1.059 1.318 1.711 2.064 25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.856 1.057 1.314 1.703 2.052 27 0.000 0.683 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.291 1.664 1.990 80 0.0		61 1	1.061	1.061	.061	1	1.321	1.717	2.074	2.508	2.819	3.505	3.79
25 0.000 0.684 0.856 1.058 1.316 1.708 2.060 26 0.000 0.684 0.856 1.058 1.315 1.706 2.056 27 0.000 0.684 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.675 0.845 1.037 1.282 1.646 1.962 Z 0.0	0	60 1	1.060	1.060	.060	1	1.319	1.714	2.069	2.500	2.807	3.485	3.768
26 0.000 0.684 0.856 1.058 1.315 1.706 2.056 27 0.000 0.684 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.699 2.045 40 0.000 0.6831 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.645 1.960	8	59 1	1.059	1.059	.059	1	1.318	1.711	2.064	2.492	2.797	3.467	3.74
27 0.000 0.684 0.855 1.057 1.314 1.703 2.052 28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.687 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.645 1.960 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960	6 3	58 1	1.058	1.058	.058	1	1.316	1.708	2.060	2.485	2.787	3.450	3.72
28 0.000 0.683 0.855 1.056 1.313 1.701 2.048 29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.645 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960		58 1	1.058	1.058	.058	1	1.315	1.706	2.056	2.479	2.779	3.435	3.70
29 0.000 0.683 0.854 1.055 1.311 1.699 2.045 30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960		57 1	1.057	1.057	.057	- 1	1.314	1.703	2.052	2,473	2.771	3.421	3.69
30 0.000 0.683 0.854 1.055 1.310 1.697 2.042 40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960	19	56 1	1.056	1.056	.056	- 1	1.313	1.701	2.048	2.467	2.763	3.408	3.674
40 0.000 0.681 0.851 1.050 1.303 1.684 2.021 60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960	9	55 1	1.055	1.055	.055	1	1.311	1.699	2.045	2.462	2.756	3.396	3.659
60 0.000 0.679 0.848 1.045 1.296 1.671 2.000 80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960		55 1	1.055	1.055	.055	- 1	1.310	1.697	2.042	2.457	2.750	3.385	3.646
80 0.000 0.678 0.846 1.043 1.292 1.664 1.990 100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960		50 1	1.050	1.050	.050	1	1.303	1.684	2.021	2.423	2.704	3.307	3.55
100 0.000 0.677 0.845 1.042 1.290 1.660 1.984 1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960	11	45 1	1.045	1.045	.045	1	1.296	1.671	2.000	2.390	2,660	3.232	3.460
1000 0.000 0.675 0.842 1.037 1.282 1.646 1.962 Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960	5	43 1	1.043	1.043	.043	1	1.292	1.664	1.990	2,374	2.639	3.195	3.416
Z 0.000 0.674 0.842 1.036 1.282 1.645 1.960	6	42 1	1.042	1.042	.042	1	1.290	1.660	1.984	2.364	2.626	3.174	3.390
	31	37 1	1.037	1.037	.037	- 1	1.282	1.646	1.962	2.330	2.581	3.098	3.30
The state of the s		36 1	1.036	1.036	.036	- 1	1.282	1.645	1.960	2.326	2.576	3.090	3.29
0% 50% 60% 70% 80% 90% 95%	6. 34	% 8	70%	70%	0%	8	80%	90%	95%	98%	99%	99.8%	99.9%

CONFIDENCE LEVELS







•The goal of classical hypothesis testing is to answer the question, "Given a sample and an apparent effect, what is the probability of seeing such an effect by chance?"



- -Fisher null hypothesis testing,
- -Newman-Pearson decision theory,
- -Bayesian inference



- •Hypothesis testing
 - -T Test
 - -Z Test
 - -ANOVA Test
 - -Chi-Square Test



Null vs. Alternative Hypothesis

Null Hypothesis

A statement about a population parameter.

We test the likelihood of this statement being true in order to decide whether to accept or reject our alternative hypothesis.

Can include =, ≤, or ≥ sign.

Alternative Hypothesis

A statement that directly contradicts the null hypothesis.

We determine whether or not to accept or reject this statement based on the likelihood of the null (opposite) hypothesis being true.

Can include a \neq , >, or < sign.

Thought Co.



STEP 01:

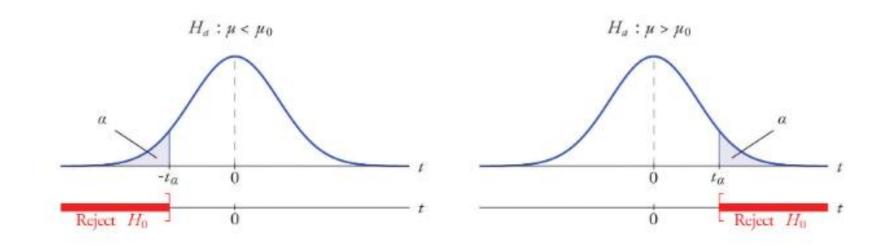
•Quantify the size of the apparent effect by choosing a test statistic.

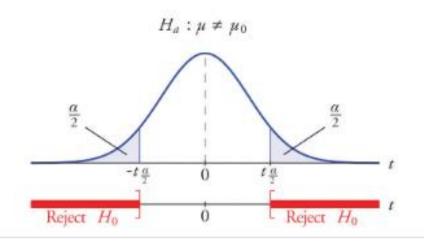


STEP 02:

•Define a null hypothesis, which is a model of the system based on the assumption that the apparent effect is not real.









STEP 03:

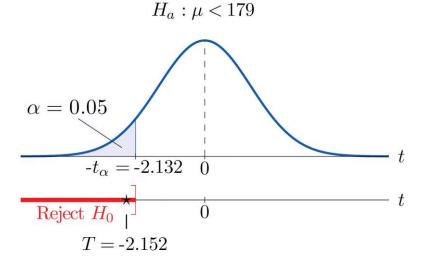
•Compute a **p-value/z-score**, which is the probability of seeing the apparent effect if the null hypothesis is true.

$$t = \frac{\overline{X} - \mu}{\frac{S}{\sqrt{N}}} \qquad T = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$



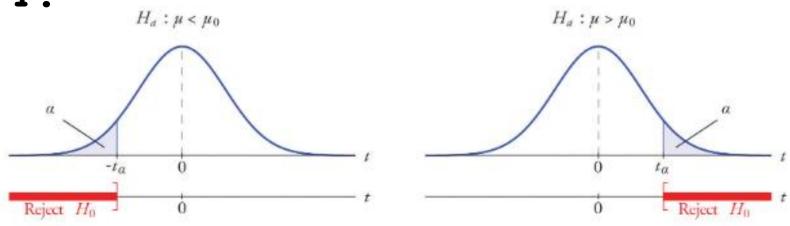
STEP 04:

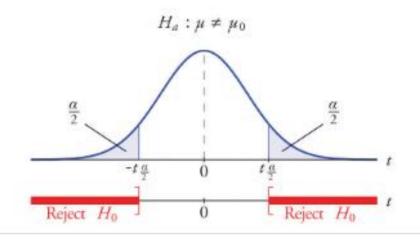
•Interpret the result. If the pvalue/z-score is low or too high, the effect is said to be statistically significant





STEP 04:







Example (Z-test)

Sample of heights

X = [1.60, 1.59, 1.69, 1.71, 1.55, 1.68, 1.67, 1.69, 1.70, 1.73, 1.63]

 $\overline{x} = 1.66$

S = 0.056

n = 11 (11<30 - we will use t-score)



Hypothesizes: We heard that usually girls'
height is 1.62 meters.

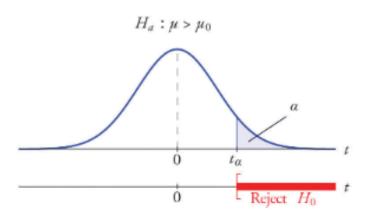
 H_0 : $\mu = 1.62$

we assume that effect in our dataset is by chance

 $H_a: \mu > 1.62$

we assume that effect in our dataset is not occasionally

 $\alpha = 0.05$ (test is one side - **right sided**)





 H_0 : $\mu = 1.62$

 $H_a: \mu > 1.62$

 $\alpha = 0.05$



 $\alpha = 0.05$ (test is one side - **right sided**)

$$T_{\alpha=0.05} = 1.812$$

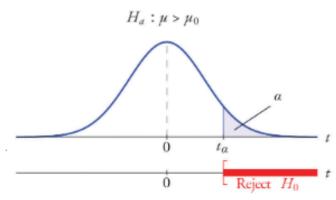
cum. prob one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	t.999 0.001	1 .995 0.0005
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df		1111					111				
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587



Let's calculate t score for our hypothesis -

$$t = \frac{\overline{X} - \mu}{\frac{S}{\sqrt{N}}} \qquad \frac{1.66 - 1.62}{\frac{0.056}{\sqrt{11}}} = 2,35$$

$$t_{\alpha}$$
 = 1,812 and t_{H0} = 2,35
H0 – should be rejected



Chi-squared tests



Chi-squared tests are commonly used to test proportions.

When you have two categorical variables from a single population.

It is used to determine whether there is a significant association between the two variables.

Chi-squared tests



For example, in an election survey, voters might be classified by gender (male or female) and voting preference (Democrat, Republican, or Independent). We could use a chisquare test for independence to determine whether gender is related to voting preference

Chi-squared tests



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

Where Oi are the observed frequencies and Ei are the expected frequencies



Let's say we have a standardized test with possible answers A, B, C and D.

Are the chances to hit the right answer equally distributed?



Let's say we have a standardized test with possible answers A, B, C and D.

I have an intuition that A has more chances to be right. Let's say:

A = 20%

B = 20%

C = 25%

D = 35%



Let's say we have a standardized test with possible answers A, B, C and D.

I have an intuition that A has more chances to be right. Let's say:

A = 20%

B = 2.0%

C = 25%

D = 35%

HOW CAN WE TEST THIS?



The null hypotheses is

H0: they are equally distributed

Ha: they are NOT equally distributed

A = 2.5%

B = 2.5%

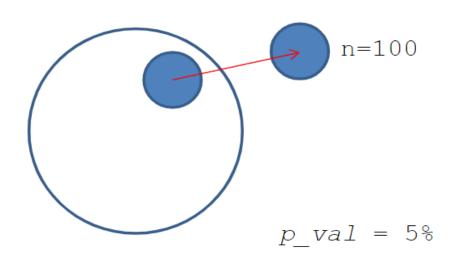
C = 2.5%

D = 25%



Let's say we take a sample from a

population:



Correct choice	Expected #	Actual #
А	25	20
В	25	20
С	25	25
D	25	35

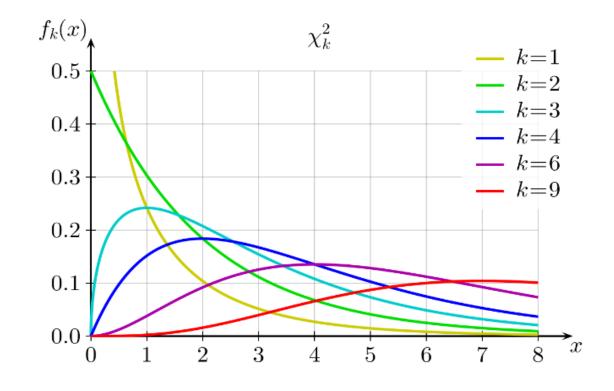
$$\chi^2 = \sum_{i} \frac{(O_i - E_i)^2}{E_i} = \frac{(20 - 25)^2}{25} + \frac{(20 - 25)^2}{25} + \frac{(25 - 25)^2}{25} + \frac{(25 - 35)^2}{25} = 6$$



Correct choice	Expected #	Actual #
А	25	20
В	25	20
С	25	25
D	25	35

$$p_val = 5%$$

$$\chi = 6$$

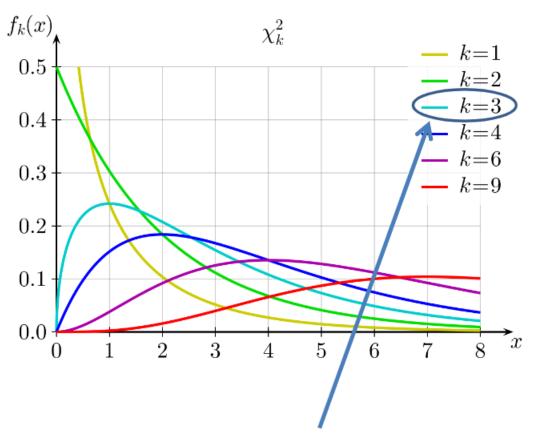




Correct choice	Expected #	Actual #
А	25	20
В	25	20
С	25	25
D	25	35

$$p_val = 5%$$

$$\chi = 6$$



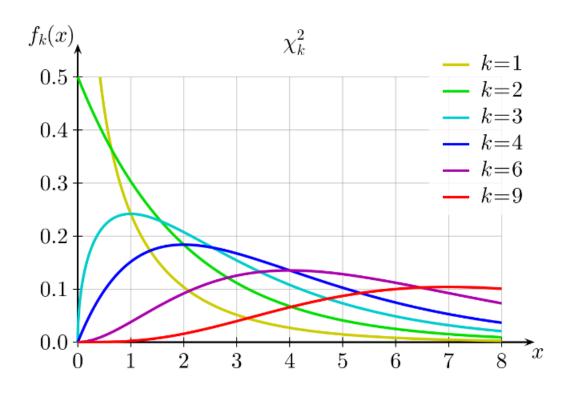
We have 4 possible outcomes, so our degree of freedom is 3



Correct choice	Expected #	Actual #
А	25	20
В	25	20
С	25	25
D	25	35

$$p_val = 5%$$

$$\chi = 6$$



Now we ask: what is the probability of getting $\chi=6$ given that our d.o.f is 3?



Degree of		Probability of Exceeding the Critical Value											
Freedom	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01				
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63				
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21				
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34				
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28				
5	0.554	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09				
6	0.872	1.635	2.204	3.455	5.348	7.84	10.64	12.59	16.81				
7	1.239	2.167	2.833	4.255	6.346	9.04	12.02	14.07	18.48				
8	1.647	2.733	3.490	5.071	7.344	10.22	13.36	15.51	20.09				
9	2.088	3.325	4.168	5.899	8.343	11.39	14.68	16.92	21.67				
10	2.558	3.940	4.865	6.737	9.342	12.55	15.99	18.31	23.21				
11	3.053	4.575	5.578	7.584	10.341	13.70	17.28	19.68	24.72				
12	3.571	5.226	6.304	8.438	11.340	14.85	18.55	21.03	26.22				
13	4.107	5.892	7.042	9.299	12.340	15.98	19.81	22.36	27.69				
14	4.660	6.571	7.790	10.165	13.339	17.12	21.06	23.68	29.14				
15	5.229	7.261	8.547	11.037	14.339	18.25	22.31	25.00	30.58				
16	5.812	7.962	9.312	11.912	15.338	19.37	23.54	26.30	32.00				
17	6.408	8.672	10.085	12.792	16.338	20.49	24.77	27.59	33.41				
18	7.015	9.390	10.865	13.675	17.338	21.60	25.99	28.87	34.80				
19	7.633	10.117	11.651	14.562	18.338	22.72	27.20	30.14	36.19				
20	8.260	10.851	12.443	15.452	19.337	23.83	28.41	31.41	37.57				
22	9.542	12.338	14.041	17.240	21.337	26.04	30.81	33.92	40.29				
24	10.856	13.848	15.659	19.037	23.337	28.24	33.20	36.42	42.98				
26	12.198	15.379	17.292	20.843	25.336	30.43	35.56	38.89	45.64				
28	13.565	16.928	18.939	22.657	27.336	32.62	37.92	41.34	48.28				
30	14.953	18.493	20.599	24.478	29.336	34.80	40.26	43.77	50.89				
40	22.164	26.509	29.051	33.660	39.335	45.62	51.80	55.76	63.69				
50	27.707	34.764	37.689	42.942	49.335	56.33	63.17	67.50	76.15				
60	37.485	43.188	46.459	52.294	59.335	66.98	74.40	79.08	88.38				
	5)		N	ot Significa	int			Signi	ficant				



	orrect hoice	Expected #	Actual #	$f_k(x)$		χ_k^2		<u> </u>	1
	Δ	25	20	$0.5\frac{1}{100}$				— k=	
Degree of			Prob	ability of E	xceeding ti	ne Critical	Value		
Freedom	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28

Now we ask: what is the probability of getting $\chi = 6$ given that our d.o.f is 3?



Degree of		10	Prob	ability of E	xceeding tl	ne Critical	Value		
Freedom	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
val =	F.0			0.1					

Now we ask: what is the probability of getting $\chi = 6$ or more, given that our d.o.f is 3? The table indicates that the probability is 10%. Which is higher that 5%.



We cannot reject our null hypothesis, because the p =10%.Our sample more likely occurred by chance.

READINGS



- https://towardsdatascience.com/hypothesis-testing-in-machine-learning-using-python-a0dc89e169ce
- https://en.wikipedia.org/wiki/Chi-squared test
- https://www.statsmodels.org/stable/generated/st atsmodels.stats.weightstats.ztest.html
- https://www.statisticshowto.com/probabilityand-statistics/hypothesis-testing/t-score-vs-zscore/