

Reasoning and Sense Making in Data Analysis and Statistics

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Key Elements of Statistical Reasoning

- *Analyzing data.* Gaining insight about a solution to a statistical research question by representations and numerical summaries.
- *Modeling distributions.* Developing probability models to describe long-run behavior of observations of a random variable.
- *Connecting statistics and probability.* Recognizing variability as an essential focus of statistics and understanding the role of probability in statistical reasoning to make decisions under uncertainty.
- *Interpreting designed statistical studies.* Drawing appropriate conclusions from the data and interpreting results from designed statistical studies using inference.

Habits of Mind in Statistical Thinking

Analyzing a problem *Looking for patterns and relationships by—*

- describing overall patterns in the data;
- analyzing and explaining variation;
- looking for hidden structure in the data;
- making preliminary deductions and conjectures.

Implementing a strategy *Selecting representations or procedures by—*

- choosing and critiquing data collection strategies based on the question;
- creating meaningful graphical representations and numerical summaries;
- considering the random mechanisms behind the data;
- drawing conclusions beyond the data.

Monitoring one's progress *Evaluating a chosen strategy by—*

- comparing various graphical and numerical representations;
- comparing various interpretations of the data;
- evaluating the consistency of an observation with a model;
- questioning whether the observations make sense within the problem context;
- evaluating the consistency of different components of the analysis;
- applying the iterative statistical process to the investigation.

Seeking and using connections *Connecting different representations by—*

- noticing connections in a variety of graphical and numerical representations;
- identifying common components of analyses (e.g., standardization);
- understanding the sensitivity of an analysis to various components;
- connecting conclusions and interpretations to the context.

Reflecting on one's solutions *Checking the reasonableness of an answer by—*

- considering and evaluating alternative explanations;
- understanding the allowable scope of conclusions;
- determining whether a conclusion based on the data is plausible;
- justifying or validating the solution or conclusion by using inferential reasoning;
- analyzing and accounting for variability;
- looking for connections between the data and the context.

Example: Will Women Run Faster than Men in the Olympics?

Times for the Olympic 200-Meter Dash

Year	Male	Time (sec)	Female	Time (sec)
1900	Walter Tewksbury, USA	22.2		
1904	Archie Hahn, USA	21.6		
1908	Robert Kerr, Canada	22.6		
1912	Ralph Craig, USA	21.7		
1920	Allan Woodring, USA	22.0		
1924	Jackson Scholz, USA	21.6		
1928	Percy Williams, Canada	21.8		
1932	Eddie Tolan, USA	21.12		
1936	Jesse Owens, USA	20.70		
1948	Mel Patton, USA	21.10	Fanny Blankers-Koen, NED	21.88
1952	Andy Stanfield, USA	20.81	Marjorie Jackson, AUS	23.89
1956	Bobby Morrow, USA	20.75	Betty Cuthbert, AUS	23.53
1960	Livio Berruti, ITA	20.62	Wilma Rudolph, USA	24.13
1964	Henry Carr, USA	20.36	Edith McGuire, USA	23.05
1968	Tommie Smith, USA	19.83	Irena Szewinska, Poland	22.58
1972	Valeriy Borzov, USSR	20.00	Renate Stecher, GDR	22.40
1976	Don Quarrie, JAM	20.23	Barbel Eckert, GDR	22.37
1980	Pietro Mennea, ITA	20.19	Barbel Wockel (Eckert), GDR	22.06
1984	Carl Lewis, USA	19.80	Valerie Brisco-Hooks, USA	21.81
1988	Joe DeLoach, USA	19.75	Florence Griffith-Joyner, USA	21.71
1992	Mike Marsh, USA	20.01	Gwen Torrence, USA	21.71
1996	Michael Johnson, USA	19.32	Marie-Jose Perec, FRA	22.10
2000	Konstantinos Kenteris, GRE	20.09	Marion Jones, USA	21.84
2004	Shawn Crawford, USA	19.79	Veronica Campbell, JAM	22.05

Example: Old Faithful Data --Minutes Between Blast (each row represents about 1 day's eruptions)

1)	86 71 57 80 75 77 60 86 77 56 81 50 89 54 90 73 60 83
2)	65 82 84 54 85 58 79 57 88 68 76 78 74 85 75 65 76 58
3)	91 50 87 48 93 54 86 53 78 52 83 60 87 49 80 60 92 43
4)	89 60 84 69 74 71 108 50 77 57 80 61 82 48 81 73 62 79
5)	54 80 73 81 62 81 71 79 81 74 59 81 66 87 53 80 50 87
6)	51 82 58 81 49 92 50 88 62 93 56 89 51 79 58 82 52 88
7)	52 78 69 75 77 53 80 55 87 53 85 61 93 54 76 80 81 59
8)	86 78 71 77 76 94 75 50 83 82 72 77 75 65 79 72 78 77
9)	79 75 78 64 80 49 88 54 85 51 96 50 80 78 81 72 75 78
10)	87 69 55 83 49 82 57 84 57 84 73 78 57 79 57 90 62 87
11)	78 52 98 48 78 79 65 84 50 83 60 80 50 88 50 84 74 76
12)	65 89 49 88 51 78 85 65 75 77 69 92 68 87 61 81 55 93
13)	53 84 70 73 93 50 87 77 74 72 82 74 80 49 91 53 86 49
14)	79 89 87 76 59 80 89 45 93 72 71 54 79 74 65 78 57 87
15)	72 84 47 84 57 87 68 86 75 73 53 82 93 77 54 96 48 89
16)	63 84 76 62 83 50 85 78 78 81 78 76 74 81 66 84 48 93