Mean and Variance

Mean
\[ \bar{X} = \frac{\sum X}{N} \]

Variance
\[ s^2 = \frac{\sum (X - \bar{X})^2}{N - 1} \]

Standard deviation
\[ s = \sqrt{s^2} = \sqrt{\frac{\sum (X - \bar{X})^2}{N - 1}} \]
Mean and Variance

Coffee Grinds

![Graph showing comparison between Sharp vs. Dull grinder burrs in terms of particle size distribution.](image)
Correlation

Hypothetical Data of Time Spent on Exam and Grade on Exam
Correlation

Squaring correlation gives the percentage of shared variance between the two variables, $r^2$
Can be represented by a Venn diagram.
Correlation

Nonlinear relationship problem

Real Data of Time Spent on Exam and Grade on Exam
Correlation

Outlier problem

Values of $Y$

0 2 4 6 8 10

Values of $X$

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Correlation

Restriction of range problem
Correlation

\[ r = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}} \]

Covariance

\[ c_{xy} = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{N} \]
Correlation

Correlation

$$r = \frac{\sum(X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum(X - \bar{X})^2 \sum(Y - \bar{Y})^2}} = \frac{c_{xy}}{s_x s_y}$$

Covariance is the “unstandardized” version of the correlation

We standardize when we divide by the standard deviations
Normal Scores

Standardized scores are useful because we can estimate the percentile (percentage of respondents at or below) an individual’s score by using the properties of the normal curve.
Normal Scores

Variations on the standardized score include the following, computed by multiplying z-score by the desired standard deviation and adding the desired mean

<table>
<thead>
<tr>
<th>Type</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ Scores</td>
<td>100</td>
<td>15</td>
<td>Intelligence and some aptitude tests</td>
</tr>
<tr>
<td>T Scores (or McCall T scores)</td>
<td>50</td>
<td>10</td>
<td>MMPI, some aptitude tests</td>
</tr>
<tr>
<td>SAT</td>
<td>500</td>
<td>100</td>
<td>Some aptitude tests</td>
</tr>
<tr>
<td>Stanine (standard nine)</td>
<td>5</td>
<td>2</td>
<td>Military; 1-9 values</td>
</tr>
</tbody>
</table>
Normalized Scores

Common methods include

Percentile method

- Find percentiles for all cases in your sample
- Use the percentile to obtain z-score for all cases, $z_n$
- Compute the normalized score using desired mean ($\mu_n$) and standard deviation ($s_n$)

- e.g., $T_{normalized} = z_n (s_n) + \mu_n$

Box-Cox transformation – raises the score to a power ($\lambda$) and divides by that number; $\lambda$ can be estimated from the data

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