# Mass Academy SAT Scores based on section

Using the Wilcoxon Signed Ranks Test

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# An Introduction to the Wilcoxon Signed Test

- Used when you want to assume that the difference is ordinal, not interval
  - **Ordinal**: order is considered, but the difference between various levels is not
    - Ex: Socioeconomic status → “Lower Class = < $50k”, “Middle Class = Between $50K and 80K”
      - Value ranges differ between the levels
  - **Interval**: order exists, difference between two values is significant

# An Introduction to the Wilcoxon Signed Test

- This test is needed to determine whether or not the mean ranks differ
- It is typically presented in the form of a table that shows the differences between the data, the ranks, and the signed ranks
  - Additional analysis is then done based on the data in this table
- This test and the Mann Whitney test are useful when the data may not be suitable for a t-test
  - Ex. non-normal distribution for one or more of the data sets

# An Introduction to the Wilcoxon Signed Test

- Used on paired data
  - **Paired**: data from related samples, matched samples, or repeated measurements on a single sample
  - **Unpaired**: the data comes from different test subjects at the same point in time
    - Mann-Whitney U Test

# An Introduction to the Mann-Whitney Test

- This test should be used on unpaired data
  - Data comes from different test subjects at a single point in time
- Needed to compare two different data sets, and see if their population mean ranks differ

# Disadvantages of the Wilcoxon and Mann Whitney U Test

- These tests may be invalid if discrete or extremely skewed data are analyzed
  - Ex. In medicinal research there is often highly skewed data with many zeros
  - These types of data can cause researches to draw false conclusions when using the Wilcoxon or Mann Whitney tests
- In this case, regression models would give a more accurate analysis

# Example of the Wilcoxon Rank Sum Test

The study

- tested a new drug that was designed to reduce repetitive behaviors for kids with autism
- Researchers observed eight children with autism for three hour periods and recorded the number of times they engaged in repetitive behavior
- Then they gave the kids the medication for one week and recorded their behaviors after

| Observed Differences | | Ordered Absolute Values of Difference Scores | Ranks | Signed Ranks |
|---|---|---|---|---|
| 10 | | -5 | 1 | -1 |
| 20 | | 10 | 3 | 3 |
| -10 | | -10 | 3 | -3 |
| 25 | | 10 | 3 | 3 |
| 60 | | 15 | 5 | 5 |
| 10 | | 20 | 6 | 6 |
| 15 | | 25 | 7 | 7 |
| -5 | | 60 | 8 | 8 |

# Using the Wilcoxon Signed Ranks Test

# Analysis using the Wilcoxon Signed Test

| Year | Reading and Writing | Math |
|---|---|---|
| 18-19 | 718 | 771 |
| 17-18 | 700 | 757 |
| 16-17 | 696 | 750 |
| 15-16 | 1391 | 741 |
| 14-15 | 1354 | 734 |
| 13-14 | 1314 | 714 |
| 12-13 | 1331 | 710 |
| 11-12 | 1331 | 703 |
| 10-11 | 1337 | 726 |

- The Reading and Writing portion is skewed from 2016-2019 because of the updated SAT (2400 to 1600).
- The data is also from the same subject; MAMS students.
- Because of this, the Wilcoxon test can be used.

# Analysis using the Wilcoxon Signed Test

| Year | Reading and Writing | Math | x-y | \|x-y\| | Rank | Tied Ranks | Signed Ranks |
|---|---|---|---|---|---|---|---|
| 18-19 | 718 | 771 | -53 | 53 | 1 | 1.0 | -1.0 |
| 17-18 | 700 | 757 | -57 | 57 | 3 | 3.0 | -3.0 |
| 16-17 | 696 | 750 | -54 | 54 | 2 | 2.0 | -2.0 |
| 15-16 | 1391 | 741 | 650 | 650 | 9 | 9.0 | 9.0 |
| 14-15 | 1354 | 734 | 620 | 620 | 6 | 6.0 | 6.0 |
| 13-14 | 1314 | 714 | 600 | 600 | 4 | 4.0 | 4.0 |
| 12-13 | 1331 | 710 | 621 | 621 | 7 | 7.0 | 7.0 |
| 11-12 | 1331 | 703 | 628 | 628 | 8 | 8.0 | 8.0 |
| 10-11 | 1337 | 726 | 611 | 611 | 5 | 5.0 | 5.0 |

# Analysis using the Wilcoxon Signed Test

| Year | R+W | Math | x-y | \|x-y\| | Rank | Tied Ranks | Signed Ranks |
|---|---|---|---|---|---|---|---|
| 18-19 | 718 | 771 | -53 | 53 | 1 | 1.0 | -1.0 |
| 17-18 | 700 | 757 | -57 | 57 | 3 | 3.0 | -3.0 |
| 16-17 | 696 | 750 | -54 | 54 | 2 | 2.0 | -2.0 |
| 15-16 | 1391 | 741 | 650 | 650 | 9 | 9.0 | 9.0 |
| 14-15 | 1354 | 734 | 620 | 620 | 6 | 6.0 | 6.0 |
| 13-14 | 1314 | 714 | 600 | 600 | 4 | 4.0 | 4.0 |
| 12-13 | 1331 | 710 | 621 | 621 | 7 | 7.0 | 7.0 |
| 11-12 | 1331 | 703 | 628 | 628 | 8 | 8.0 | 8.0 |
| 10-11 | 1337 | 726 | 611 | 611 | 5 | 5.0 | 5.0 |

$H_0$= if the median difference is 0

$H_1$= if the median difference is positive, a=0.05, otherwise, a=0.01

$W_+$=39

$W_-$=6

$W_{stat}$=6

$W_{crit}$=5

$W_{stat} < W_{crit}$

Therefore, we embrace the null hypothesis, that is, **MAMS students' reading and writing scores are unrelated to their math scores.**

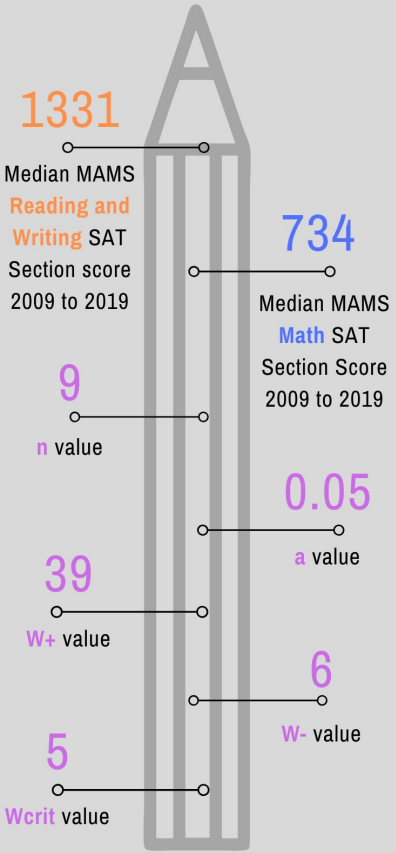
| n | Two-Tailed Test | | One-Tailed Test | |
|---|---|---|---|---|
| | α = .05 | α = .01 | α = .05 | α = .01 |
| 5 | -- | -- | 0 | -- |
| 6 | 0 | -- | 2 | -- |
| 7 | 2 | -- | 3 | 0 |
| 8 | 3 | 0 | 5 | 1 |
| 9 | 5 | 1 | 8 | 3 |
| 10 | 8 | 3 | 10 | 5 |
| 11 | 10 | 5 | 13 | 7 |
| 12 | 13 | 7 | 17 | 9 |
| 13 | 17 | 9 | 21 | 12 |
| 14 | 21 | 12 | 25 | 15 |
| 15 | 25 | 15 | 30 | 19 |
| 16 | 29 | 19 | 35 | 23 |
| 17 | 34 | 23 | 41 | 27 |
| 18 | 40 | 27 | 47 | 32 |
| 19 | 46 | 32 | 53 | 37 |
| 20 | 52 | 37 | 60 | 43 |
| 21 | 58 | 42 | 67 | 49 |
| 22 | 65 | 48 | 75 | 55 |
| 23 | 73 | 54 | 83 | 62 |
| 24 | 81 | 61 | 91 | 69 |
| 25 | 89 | 68 | 100 | 76 |
| 26 | 98 | 75 | 110 | 84 |
| 27 | 107 | 83 | 119 | 92 |
| 28 | 116 | 91 | 130 | 101 |
| 29 | 126 | 100 | 140 | 110 |
| 30 | 137 | 109 | 151 | 120 |

# Conclusion

- Can find whether or not the null hypothesis is supported by comparing the $W_+$ and $W_-$ values with table values .
- The critical z value shows the interesting areas under the normal curve. It is used when the sampling distribution is normal or close to normal, but still takes the 95% accuracy hypothesis into consideration.

# COMPARING SAT SCORES

MAMS SECTION SCORES



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