Statistical Inference & A/B Testing

1. Goal

Evaluate A/B testing results and decide which marketing strategy works the best.

2. Target metric

Average Weekly Sales by Promotion per Location. This target metric controls for market size and store-specific factors, allowing for a more accurate and unbiased assessment of the impact of each marketing campaign on sales performance.

3. Calculations.

a) In SQL, calculate the final numbers necessary to perform a test for a chosen metric. Describe the aggregations and data preparation you carried out.

- Grouped the data by both Location_ID and Promotion, with this the average sales are calculated specifically for each unique combination of store location and the marketing campaign it was exposed to.
- Aggregated Sales in Thousands by averaging them, calculating the average weekly sales for each Location_ID and Promotion group. This provides the core metric for the A/B test analysis.

b) Describe the statistical tests you carried out. Report the estimated treatment effect, confidence interval and p-value. For statistical tests use the Evan Miller A/B Test Calculator. Use the t-test for a continuous metric, and chi-square test for conversions.

1. **Decision**. Describe clearly what your calculations imply and which decision you recommend. Use visualizations or conditional formatting as you see fit.

To determine the best-performing promotion, we used the independent samples t-test to compare the average weekly sales of each store location across the three marketing campaigns. This allowed us to identify statistically significant differences in sales performance between the promotion groups.

H0: There is no significant difference in the average weekly sales per location across the three marketing campaigns.

H1: At least one of the three marketing campaigns has a significantly higher average weekly sales per location compared to the other one.
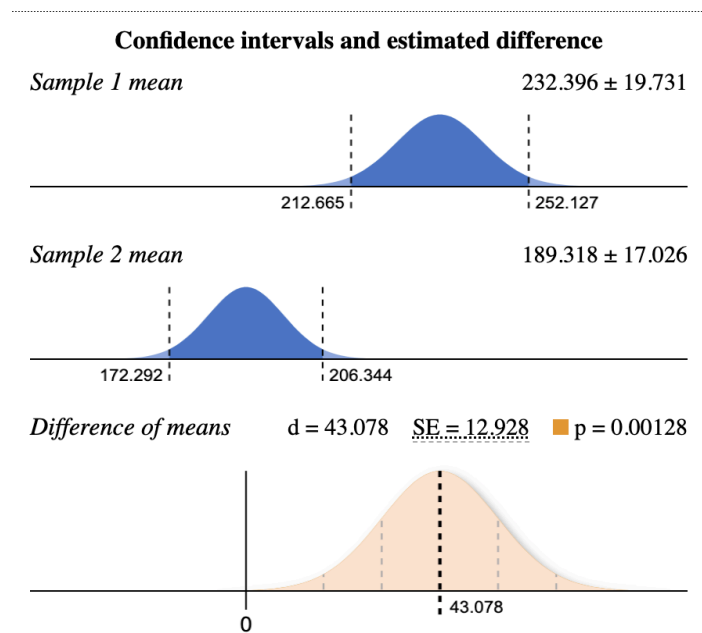
Results:

● **Samples summary**

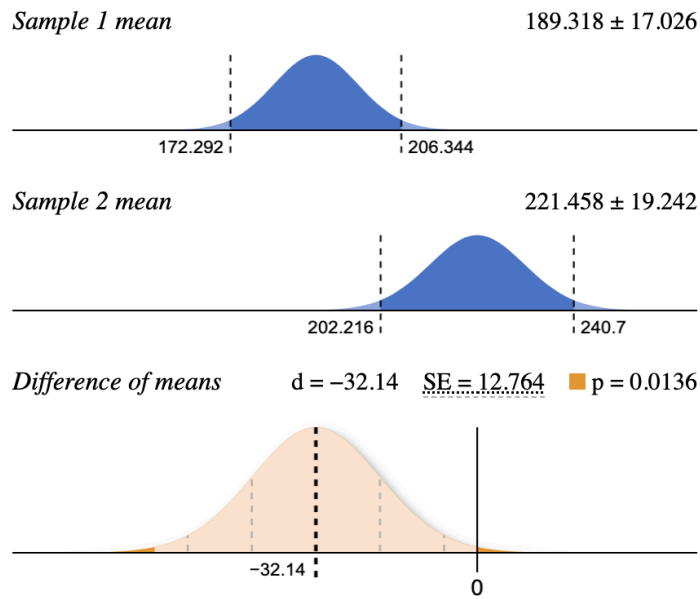|	P1	P2	P3
mean	232.3969	189.318	221.458
Std. Dev	64.113	57.988	65.535

n	43	47	47

- Promotion 1 vs. Promotion 2:

  - Estimated Difference: Promotion 1 has an estimated average weekly sales of 43.078 units higher than Promotion 2.
  - Confidence Interval: (9.1169, 76.0569)
  - Interpretation: We are 99% confident that the true difference in average weekly sales between Promotion 1 and Promotion 2 lies between 9.1169 and 76.0569 thousand units. Since the entire interval is above zero, this strongly suggests that Promotion 1 significantly outperforms Promotion 2.

Confidence intervals and estimated difference

Sample 1 mean   232.396 ± 19.731

212.665   252.127

Sample 2 mean   189.318 ± 17.026

172.292   206.344

Difference of means $d = 43.078$ $SE = 12.928$ $p = 0.00128$
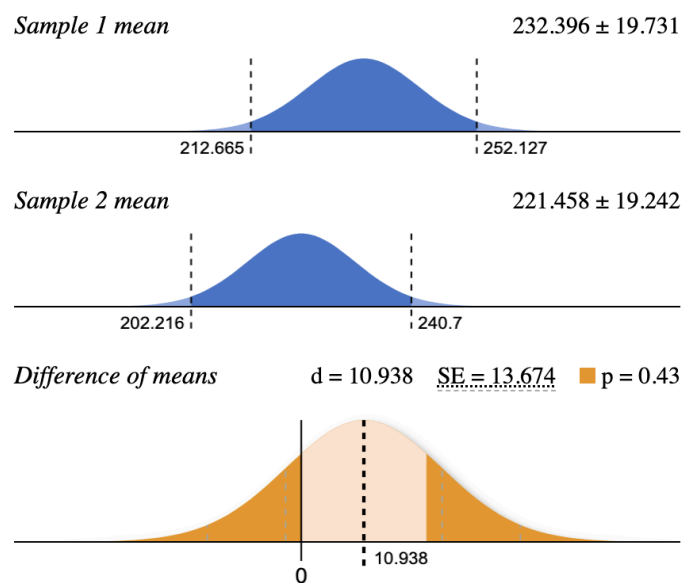
0   43.078

- Promotion 2 vs. Promotion 3:

  - Estimated Difference: Promotion 2 has an estimated average weekly sales of 32.14 thousand units lower than Promotion 3.
  - Confidence Interval: (-65.608, 1.312)
  - Interpretation: We are 99% confident that the true difference in average weekly sales between Promotion 2 and Promotion 3 lies between -65.608 and 1.312 thousand units. Since the interval includes zero, we cannot conclusively say that Promotion 3 significantly outperforms Promotion 2 at the 99% confidence level.

Confidence intervals and estimated difference

Sample 1 mean   189.318 ± 17.026

172.292   206.344

Sample 2 mean   221.458 ± 19.242

202.216   240.7

Difference of means   d = −32.14   SE = 12.764   ■ p = 0.0136

−32.14

0

- Promotion 1 vs. Promotion 3:

  - Estimated Difference: Promotion 1 has an estimated average weekly sales of 2.735 units higher than Promotion 3.
  - Confidence Interval: (-25.0411, 46.8209)
  - Interpretation: We are 99% confident that the true difference in average weekly sales between Promotion 1 and Promotion 3 lies between -25.0411 and 46.8209 thousand units. Since the interval includes zero, we cannot conclusively say that Promotion 1 significantly outperforms Promotion 3.

Confidence intervals and estimated difference

Sample 1 mean   232.396 ± 19.731

212.665   252.127

Sample 2 mean   221.458 ± 19.242

202.216   240.7

Difference of means   d = 10.938   SE = 13.674   ■ p = 0.43

0   10.938

Conclusion:

Based on the statistical analysis:

- Promotion 1 significantly outperforms Promotion 2.
- There is no statistically significant difference between Promotion 1 and Promotion 3, and between Promotion 2 and Promotion 3 at the 99% confidence level.

Therefore, it is recommended to choose Promotion 1 as the most promising marketing campaign. While it doesn't have a statistically significant advantage over Promotion 3, it consistently shows higher average sales and significantly outperforms Promotion 2.

2. **Appendix**. Put your queries and other relevant information.

- **Query**

```
WITH
    Total_Sales_Per_Location_Promotion AS (
        SELECT
            Location_ID,
            Promotion,
            SUM(Sales_In_Thousands) AS Total_Sales,
        FROM
            `tc-da-1.turing_data_analytics.wa_marketing_campaign`
        GROUP BY
            Location_ID,
            Promotion
    ),
    Avg_Sales_Per_Location_Promotion AS (
        SELECT
            Location_ID,
            Promotion,
            AVG(Total_Sales) AS Avg_Weekly_Sales_Per_Location
        FROM
            Total_Sales_Per_Location_Promotion
        GROUP BY
        Location_ID,
        Promotion
    )


SELECT
```

```sql
    Location_ID,
    Promotion,
    Avg_Weekly_Sales_Per_Location
FROM
    Avg_Sales_Per_Location_Promotion
ORDER BY
    Promotion,
    Location_ID;
```