Scatter Plots And Correlation Answer Key Manual

Scatter Plots and Correlation Answer Key

Introduction to Scatter Plots and Correlation

Scatter plots are powerful graphical tools used in statistics to visualize the relationship between two quantitative variables. They help in identifying patterns, trends, and potential correlations between the variables. The correlation coefficient, usually denoted as 'r', quantifies the strength and direction of the linear relationship observed in a scatter plot. Understanding how to interpret scatter plots and their corresponding correlation values is essential for data analysis, research, and decision-making processes.

What is a Scatter Plot?

A scatter plot, also known as a scatter diagram or scatter chart, is a graph that displays points representing two variables for a set of data. Each point on the plot corresponds to an individual data observation, with its position determined by its values on the x-axis and y-axis.

Components of a Scatter Plot

- Axes: Usually two perpendicular axes (x and y) representing the variables.
- Data Points: Markers (dots) plotted based on the data values.
- Title and Labels: Descriptive title and labels for axes to clarify what is being measured.
- Gridlines: Optional lines to help interpret the data points' positions.

Interpreting Scatter Plots

When analyzing a scatter plot, consider the following:

- Direction of the relationship: Is it positive (both variables increase), negative (one increases while the other decreases), or no apparent relationship?
- Form of the relationship: Is it linear, nonlinear, or random?
- Strength: How tightly are the data points clustered around a line or curve? The closer the points are to a line, the stronger the correlation.

- Outliers: Are there points that deviate significantly from the pattern?

Correlation Coefficient: The Answer Key

The correlation coefficient, denoted as 'r', measures the degree to which two variables are linearly related. Its value ranges from -1 to 1:

- r = 1: Perfect positive linear correlation.
- r = -1: Perfect negative linear correlation.
- r = 0: No linear correlation.

Interpreting the value of 'r':

- Strong correlation: |r| close to 1 (e.g., 0.8 to 1 or -0.8 to -1).
- Moderate correlation: |r| around 0.5 to 0.8.
- Weak correlation: |r| less than 0.5.
- No correlation: r near 0.

Answer Keys for Common Scatter Plot Scenarios

Understanding typical patterns helps in quickly determining the correlation:

- Positive linear relationship: Points tend to rise from left to right; r is close to 1.
- Negative linear relationship: Points tend to fall from left to right; r is close to -1.
- No apparent pattern: Points are scattered randomly; r is near 0.
- Nonlinear relationship: Points follow a curved pattern; correlation coefficient may be close to 0 despite a clear relationship.

Common Questions and Their Answers

Here are typical questions that may appear in exercises involving scatter plots and correlation, along with their answer keys:

- **What does a correlation coefficient of 0.9 indicate?**

It indicates a very strong positive linear relationship between the two variables.

- **What does a correlation coefficient of -0.6 suggest?**

It suggests a moderate negative linear relationship between the variables.

- **What can be concluded if the scatter plot shows no pattern?**

It suggests that there is little to no linear relationship between the variables, and the correlation coefficient is likely close to 0.

- **Why might a scatter plot show a clear nonlinear relationship, but the correlation coefficient be near zero?**

Because the correlation coefficient measures only linear relationships, a nonlinear pattern may not be reflected in the 'r' value, which could be near zero despite a strong nonlinear association.

- **How does outlier data affect the correlation coefficient?**

Outliers can significantly skew the correlation coefficient, making a strong relationship appear weaker or a weak/no relationship appear stronger.

Limitations of Scatter Plots and Correlation

While scatter plots and correlation coefficients are invaluable tools, they have limitations:

- Correlation does not imply causation: Just because two variables are correlated doesn?t mean one causes the other.
- Linear only: Correlation measures linear relationships; nonlinear relationships might go unnoticed.
- Outliers influence: Outliers can distort the correlation value.
- Range restriction: Limited data ranges can misrepresent the true relationship.

Practical Applications of Scatter Plots and Correlation

Scatter plots and correlation analysis are used across various fields:

- Economics: Analyzing the relationship between consumer spending and income.
- Medicine: Examining the correlation between dosage and treatment efficacy.
- Education: Studying the relationship between study hours and test scores.
- Environmental Science: Exploring the link between pollution levels and health outcomes.

Summary and Tips for Using Scatter Plots and Correlation

- Always visualize data with a scatter plot before calculating correlation.
- Use the correlation coefficient as a quantitative measure but interpret it in context.
- Remember that a high correlation does not imply causality.
- Be cautious of outliers and nonlinear relationships.
- Combine scatter plots with other statistical analyses for comprehensive insights.

Conclusion

Understanding scatter plots and their correlation answer keys is fundamental for interpreting data accurately. They serve as initial tools for exploring relationships between variables, guiding further analysis and hypothesis testing. Mastery of these concepts enables analysts, researchers, and students to make informed decisions and draw meaningful conclusions from data. Remember to consider the context, data quality, and the nature of relationships when interpreting scatter plots and correlation coefficients to avoid misinterpretations.

Scatter plots and correlation answer key: An in-depth exploration of their significance, interpretation, and application in data analysis

Introduction

In the realm of data visualization and statistical analysis, scatter plots serve as a foundational tool for understanding the relationship between two continuous variables. Paired with the concept of correlation, these graphical and numerical measures provide vital insights into the strength, direction, and nature of associations within datasets. This article aims to dissect the intricacies of scatter plots and correlation, offering a comprehensive answer key for their interpretation, application, and limitations, with a focus on equipping readers with both theoretical understanding and practical skills.

Understanding Scatter Plots

What is a Scatter Plot?

A scatter plot (or scatter diagram) is a two-dimensional graph that displays data points representing two variables. Each point corresponds to one observation in the dataset, plotted according to its values for the x-axis (independent variable) and y-axis (dependent variable). This visualization allows analysts to observe patterns, clusters, trends, and anomalies that may not be apparent through raw data or summary statistics alone.

Components of a Scatter Plot

- Axes: Typically labeled with the variables' names and units.
- Data points: Individual observations plotted as dots.
- Trend line (optional): A line (like a line of best fit) that summarizes the overall trend.
- Gridlines: Facilitate precise reading of values.
- Outliers: Points that deviate markedly from the overall pattern.

How to Read a Scatter Plot

Interpreting a scatter plot involves examining several key features:

- Direction: Whether the points tend to slope upward (positive relationship) or downward (negative relationship).
- Form: The shape of the pattern?linear, nonlinear, or no discernible pattern.
- Strength: How tightly the points cluster around a line or curve.
- Outliers: Points that stand apart from the main cluster, potentially indicating anomalies or special cases.

The Role of Correlation in Data Analysis

Defining Correlation

Correlation quantifies the degree to which two variables are related. Specifically, it measures the strength and direction of a linear relationship between variables. The most common measure is the Pearson correlation coefficient (r), which ranges from -1 to +1.

- r = +1: Perfect positive linear relationship.
- r = -1: Perfect negative linear relationship.
- r = 0: No linear relationship.

Calculating the Correlation Coefficient

The Pearson correlation coefficient is computed as:

$$
r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2} \sqrt{\sum (y_i - \bar{y})^2}}
$$

where \(x_i\) and \(y_i\) are individual data points, and \(\bar{x}\) and \(\bar{y}\) are the means of the variables.

Interpreting the Correlation Coefficient

- Strong correlation: |r| > 0.7
- Moderate correlation: 0.3
- Weak correlation: |r| ? 0.3
- No correlation: r ? 0

However, correlation does not imply causation; two variables may be correlated due to coincidental or confounding factors.

Relationship Between Scatter Plots and Correlation

Visual and Numerical Complementarity

Scatter plots and correlation coefficients work hand-in-hand:

- The scatter plot provides a visual assessment of the relationship's form, direction, and strength.
- The correlation coefficient offers a quantitative measure of linear association.

This dual approach enables analysts to confirm patterns observed visually and quantify their significance.

Limitations of Correlation and Scatter Plots

While powerful, both tools have limitations:

- Nonlinear relationships: Scatter plots may reveal complex relationships not captured by correlation.
- Outliers: Can distort the correlation coefficient, exaggerating or diminishing the apparent relationship.
- Causality: Correlation does not establish cause-effect relationships.
- Spurious correlations: Variables may appear related due to confounding factors.

Practical Applications of Scatter Plots and Correlation

In Scientific Research

Scientists use scatter plots to visualize experimental data, assess the relationship between variables such as dosage and response, and detect anomalies. Correlation helps quantify these relationships, guiding hypotheses and further analysis.

In Business and Economics

Businesses analyze sales data against advertising spend, or stock prices relative to economic indicators, using scatter plots to identify trends and correlation coefficients to measure their strength.

In Medicine and Public Health

Researchers explore the association between lifestyle factors and health outcomes, visualizing data via scatter plots and measuring correlations to inform policy and interventions.

Constructing and Interpreting a Correlation Answer Key

Step-by-Step Approach

- Create the scatter plot:

- Plot the data points.
- Observe the overall pattern?direction, form, clusters, outliers.

- Assess the pattern:

- Is there an apparent linear trend?
- Is the pattern nonlinear or random?

- Calculate the correlation coefficient:

- Use statistical software or formulas.
- Interpret the magnitude and sign.

- Compare visual and quantitative findings:

- Confirm whether the correlation aligns with the visual pattern.
- Investigate anomalies or outliers.

- Draw conclusions:

- Determine the strength and nature of the relationship.
- Consider potential confounding variables or limitations.

Common Pitfalls and Misinterpretations

- Misreading correlation as causation: A high correlation does not mean one variable causes the other.
- Ignoring outliers: Outliers can significantly skew the correlation coefficient.
- Overlooking nonlinear relationships: Correlation measures linear association; nonlinear patterns may be missed or misinterpreted.
- Assuming causality from correlation: Additional analysis is required to establish causality.

Advanced Topics and Variations

Spearman's Rank Correlation

For data that do not meet the assumptions of Pearson?s correlation (e.g., ordinal data or non-normal distributions), Spearman's rank correlation assesses monotonic relationships.

Partial and Multiple Correlations

These measure the relationship between two variables while controlling for other variables, providing deeper insights in multivariate analysis.

Heatmaps and Correlation Matrices

When dealing with multiple variables, correlation matrices and heatmaps visualize pairwise relationships simultaneously, aiding in feature selection and multivariate analysis.

Conclusion

Scatter plots and correlation coefficients are indispensable tools in the arsenal of data analysts, researchers, and decision-makers. They enable intuitive visual understanding and precise quantification of relationships between variables, facilitating insights that drive scientific discovery, business strategy, and policy formulation. However, their effective use requires awareness of their limitations, careful interpretation, and complementary analyses. By mastering the art of reading scatter plots and computing correlation, analysts can uncover meaningful patterns within complex datasets, transforming raw numbers into actionable knowledge.

References and Further Reading

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This article aims to serve as a comprehensive guide for students, professionals, and enthusiasts seeking to deepen their understanding of scatter plots and correlation in data analysis.

QuestionAnswer What is a scatter plot and what does it typically display? A scatter plot is a graphical representation that displays data points on a two-dimensional coordinate plane, showing the relationship between two variables. How can you determine if there is a positive or negative correlation in a scatter plot? A positive correlation is indicated when the data points trend upward from left to right, while a negative correlation shows a downward trend; the pattern helps identify the type of relationship. What does a correlation coefficient near +1 or -1 signify? A correlation coefficient near +1 indicates a strong positive linear relationship, near -1 indicates a strong negative linear relationship, and near 0 suggests no linear correlation. Can a scatter plot show causation between two variables? No, a scatter plot can display correlation or association, but it does not prove causation between the variables. What are some signs of a strong correlation in a scatter plot? Signs of a strong correlation include data points closely clustered along a clear straight line, either upward or downward trend. How do outliers affect the interpretation of correlation in a scatter plot? Outliers can distort the perceived strength or direction of the correlation, making it appear weaker or stronger than it truly is. What is the difference between correlation and causation? Correlation measures the relationship between two variables, while causation indicates that one variable directly affects the other; correlation does not imply causation. What tools or methods can be used to measure the correlation in a scatter plot? The Pearson correlation coefficient is commonly used to quantify the strength and direction of the linear relationship between two variables. Why is it important to analyze scatter plots and correlation in data analysis? Analyzing scatter plots and correlation helps identify relationships, trends, and potential predictors, guiding further statistical analysis and decision-making. What should you consider when interpreting the

correlation in a scatter plot? Consider the strength and direction of the relationship, possible outliers, the presence of non-linear patterns, and whether correlation implies causation.

Related keywords: scatter plots, correlation, data visualization, statistical analysis, trend analysis, data points, Pearson correlation, regression analysis, graphical representation, data interpretation

an introduction to statistics correlation

An introduction to statistics correlation is essential for anyone seeking to understand the relationships between different variables in data analysis. Correlation is a statistical measure that describes the extent to which two or more variables fluctuate together. It provides insights into whether an increase or decrease in one variable is associated with a similar change in another, and how strong that association might be. Recognizing and interpreting correlations is fundamental across various fields such as economics, psychology, healthcare, and social sciences, enabling researchers and analysts to make informed decisions, predict trends, and identify underlying patterns within complex datasets.

Understanding the Concept of Correlation

What is Correlation?

Correlation refers to a statistical relationship between two variables. When variables are correlated, changes in one are systematically related to changes in the other. This relationship can be positive, negative, or nonexistent (no correlation).

- Positive correlation: As one variable increases, the other tends to increase as well.
- Negative correlation: As one variable increases, the other tends to decrease.
- No correlation: No discernible pattern exists between the variables.

For example, there is often a positive correlation between education level and income: generally, higher education levels are associated with higher income levels.

Correlation vs. Causation

A critical distinction in statistics is understanding that correlation does not imply causation. Just because two variables are correlated does not mean that one causes the other to change. For instance, ice cream sales and drowning incidents may both increase during summer, but one does

not cause the other. Recognizing this difference prevents misinterpretation of data and supports more accurate analysis.

Measuring Correlation

Correlation Coefficient

The most common numerical measure of correlation is the correlation coefficient, often represented by the letter r. The correlation coefficient quantifies the strength and direction of a linear relationship between two variables.

- Values of r range from -1 to +1.
- An r of +1 indicates a perfect positive linear relationship.
- An r of -1 indicates a perfect negative linear relationship.
- An r of 0 indicates no linear relationship.

Calculating the Correlation Coefficient

The Pearson correlation coefficient (r) is calculated using the formula:

$$ r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}} $$

Where:

- X_i, Y_i are individual data points,
- $\bar{X}, \bar{Y}$ are the means of the variables.

This formula measures the covariance of the variables normalized by their standard deviations, providing a standardized measure of linear association.

Types of Correlation

Positive and Negative Correlation

- Positive correlation: Both variables increase together. For example, height and weight in humans.
- Negative correlation: One variable increases while the other decreases. For example, the amount of time spent watching TV and physical activity levels.

Linear and Nonlinear Correlation

While the Pearson correlation coefficient measures linear relationships, some variables might have a nonlinear relationship that this measure cannot capture. For example, the relationship between the speed of a vehicle and fuel consumption might be nonlinear.

Spearman?s Rank Correlation

When data do not meet the assumptions of linearity or are ordinal, Spearman's rank correlation coefficient (\(\rho\)) is used. It assesses the monotonic relationship between variables based on ranked data, making it suitable for non-parametric data.

Interpreting Correlation Results

Strength of Correlation

The magnitude of the correlation coefficient indicates the strength of the relationship:

- 0.0 ? 0.1: Negligible
- 0.1 ? 0.3: Weak
- 0.3 ? 0.5: Moderate
- 0.5 ? 1.0: Strong

Similarly, negative values indicate the same levels of strength but in the opposite direction.

Significance Testing

To determine if an observed correlation is statistically significant, hypothesis testing is performed. The null hypothesis states that there is no correlation between the variables. A p-value is calculated, and if it falls below a predetermined threshold (commonly 0.05), the correlation is considered statistically significant.

Applications of Correlation in Real-World Scenarios

In Economics

Economists analyze correlations between variables like interest rates and inflation or unemployment rates and GDP growth to understand economic dynamics.

In Healthcare

Researchers study correlations between lifestyle factors and health outcomes, such as smoking and lung disease or diet and heart health.

In Marketing

Marketers examine correlations between advertising spend and sales figures to optimize marketing strategies.

In Education

Educational researchers analyze the correlation between study hours and academic performance to identify effective learning habits.

Limitations of Correlation Analysis

Correlation Does Not Equal Causation

As highlighted earlier, a significant correlation does not imply that one variable causes changes in the other.

Outliers and Data Quality

Outliers can distort the correlation coefficient, leading to misleading conclusions. Ensuring data quality and proper analysis techniques is crucial.

Nonlinear Relationships

Standard correlation measures like Pearson's r only capture linear relationships. Nonlinear associations require different analytical approaches.

Conclusion: The Importance of Correlation in Data Analysis

Understanding the concept of correlation is fundamental for interpreting the relationships within data. It provides a quick snapshot of the strength and direction of linear associations, helping analysts identify patterns and generate hypotheses. However, it's vital to interpret correlations carefully, considering their limitations and ensuring they are complemented by other analyses to establish causality or explore complex relationships. Mastery of correlation analysis empowers researchers across disciplines to make data-driven decisions, ultimately leading to more accurate insights and effective strategies.

Key Takeaways:

- Correlation measures the association between two variables.
- The correlation coefficient r quantifies the strength and direction of a linear relationship.
- Correlation does not imply causation.
- Different types of correlation exist, including Pearson?s and Spearman?s.
- Proper interpretation requires understanding the context, strength, significance, and limitations of the correlation.

By grasping these fundamentals, anyone interested in data analysis can better understand how variables relate to each other, paving the way for more sophisticated statistical modeling and decision-making.

Introduction to Statistics Correlation: Understanding Relationships Between Variables

Statistics correlation is a fundamental concept in data analysis that helps us understand the relationship between two or more variables. Whether in economics, psychology, healthcare, or social sciences, identifying how variables move in relation to each other provides valuable insights for decision-making, forecasting, and hypothesis testing. This article offers a comprehensive introduction to correlation in statistics, exploring its definition, types, calculation methods, interpretation, applications, and limitations. By the end, you will gain a clear understanding of how correlation functions and its significance in various fields.

What Is Correlation in Statistics?

Correlation in statistics refers to a measure that describes the degree to which two variables are related to each other. It indicates whether the variables tend to increase or decrease together, or if there is no apparent relationship at all. Correlation does not imply causation; it simply measures the strength and direction of a linear relationship between variables.

For example, there might be a positive correlation between the number of hours studied and exam scores, meaning that generally, students who study more tend to perform better. Conversely, a negative correlation might exist between the amount of time spent watching TV and physical activity levels.

Types of Correlation

Correlation can be classified based on the nature of the relationship between variables:

Positive Correlation

- When two variables increase or decrease together.

- Example: Height and weight?generally, taller individuals tend to weigh more.
- Visual cue: The data points tend to slope upwards when plotted.

Negative Correlation

- When one variable increases while the other decreases.
- Example: The amount of time spent on leisure activities and workload?more leisure time might correspond to less work hours.
- Visual cue: Data points tend to slope downwards.

Zero or No Correlation

- When there is no discernible linear relationship.
- Example: Shoe size and intelligence quotient (IQ).
- Visual cue: Data points are scattered randomly without any clear trend.

Measuring Correlation: The Correlation Coefficient

The most common measure of correlation is the Pearson correlation coefficient, denoted as r. It quantifies the degree of linear relationship between two continuous variables.

Calculation of Pearson's r

The formula for Pearson's correlation coefficient is:

$$ r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2} \sqrt{\sum (y_i - \bar{y})^2}} $$

Where:

- x_i and y_i are individual data points,
- $\bar{x}$ and $\bar{y}$ are the means of the respective variables.

Alternatively, it can be computed using statistical software or calculators, simplifying the process.

Range of Values and Interpretation

- r ranges between -1 and +1.

- $r = +1$: Perfect positive linear correlation.
- $r = -1$: Perfect negative linear correlation.
- $r = 0$: No linear correlation.

Interpretation:

- 0.7 to 1.0 (or -0.7 to -1.0): Strong correlation.
- 0.4 to 0.7 (or -0.4 to -0.7): Moderate correlation.
- 0.1 to 0.4 (or -0.1 to -0.4): Weak correlation.
- Near zero: Very weak or no correlation.

Visualizing Correlation

Scatter plots are essential tools for visualizing the relationship between two variables. A clear linear pattern indicates potential correlation:

- Upward trend: Positive correlation.
- Downward trend: Negative correlation.
- No pattern: No correlation.

Visualizations help detect outliers and assess whether the assumption of linearity holds.

Applications of Correlation in Real Life

Correlation analysis is widely used across disciplines:

- Economics: To examine the relationship between inflation and unemployment.
- Healthcare: To study the association between lifestyle factors and health outcomes.
- Psychology: To analyze the link between stress levels and sleep quality.
- Marketing: To measure the correlation between advertising expenditure and sales.
- Environmental Science: To explore the relationship between pollution levels and respiratory diseases.

Understanding these relationships helps in making informed decisions, developing models, and testing hypotheses.

Limitations of Correlation

While correlation is a powerful tool, it has notable limitations:

- Correlation Does Not Imply Causation
- Just because two variables are correlated does not mean one causes the other.
- Example: Ice cream sales and drowning incidents both increase in summer, but neither causes the other.

- Linear Relationships Only
- Pearson's r measures linear correlation; non-linear relationships may go unnoticed.
- Alternative measures like Spearman's rank correlation are used for non-linear associations.

- Affected by Outliers
- Extreme data points can distort the correlation coefficient.
- Outlier detection and management are essential before analysis.

- Restricted Range
- Limited data ranges can lead to underestimating the true correlation.
- Broader data collection enhances accuracy.

Other Measures of Correlation

Beyond Pearson's r, other correlation measures are used depending on data characteristics:

- Spearman?s Rank Correlation (?):
- Measures monotonic relationships (not necessarily linear).
- Suitable for ordinal data or non-parametric analysis.
- Kendall?s Tau:
- Measures the strength of association based on concordant and discordant pairs.
- Useful with small sample sizes or tied ranks.

Conclusion: The Significance of Correlation in Data Analysis

Correlation remains a cornerstone concept in statistics, offering insights into the relationships between variables. It helps researchers and analysts identify patterns, generate hypotheses, and build predictive models. However, it is crucial to interpret correlation coefficients carefully, considering their limitations and the context of the data.

By understanding the types, measurement techniques, and appropriate applications, you can leverage correlation analysis effectively in your own work. Remember, the power of correlation lies not only in quantifying relationships but also in guiding further investigation to uncover underlying causes and effects.

Features of Correlation in Brief:

- Quantifies the strength and direction of linear relationships.
- Easy to compute with statistical software.
- Visualized effectively using scatter plots.
- Widely applicable across disciplines.

Pros:

- Simple to understand and interpret.
- Useful for initial data exploration.
- Can guide decision-making and hypothesis formulation.

Cons:

- Does not establish causality.
- Limited to linear relationships (for Pearson?s r).
- Sensitive to outliers and data range.

In summary, correlation in statistics is a vital analytical tool that provides a window into how variables relate to each other. Mastery of its concepts and cautious interpretation can significantly enhance your data analysis skills and insights.

QuestionAnswer What is correlation in statistics? Correlation in statistics refers to a measure that indicates the extent to which two variables fluctuate together. It shows whether an increase in one variable tends to be associated with an increase or decrease in another variable. What are the common types of correlation? The most common types of correlation are positive correlation (both variables increase together), negative correlation (one increases while the other decreases), and no correlation (no apparent relationship). How is the correlation coefficient calculated? The most widely used measure is Pearson's correlation coefficient, calculated by dividing the covariance of the two variables by the product of their standard deviations, resulting in a value between -1 and 1. What does a correlation coefficient of 0 indicate? A correlation coefficient of 0 indicates that there is no linear relationship between the two variables. Can a high correlation imply causation? No, a high

correlation does not necessarily imply causation. It only indicates a relationship between variables, but other factors may be influencing both. What are the limitations of using correlation? Limitations include its inability to detect non-linear relationships, susceptibility to outliers, and the fact that it does not imply causality between variables. How can correlation analysis be used in real-world scenarios? Correlation analysis is widely used in finance to assess asset relationships, in healthcare to study risk factors, and in social sciences to explore relationships between variables such as education and income.

Related keywords: statistics, correlation coefficient, scatter plot, covariance, regression analysis, data analysis, statistical inference, linear relationship, Pearson's correlation, data visualization

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