1. What is our independent variable? What is our dependent variable?

Independent variable: Whether words are congruent with their colors
Dependent variable: The time participants take to name the ink colors of words

2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

Null hypothesis: There is no difference in the time it takes to name the ink colors of words between two conditions

$$H_0: \mu_b - \mu_a \leq 0$$

Alternative hypothesis: It takes more time to name the ink colors with incongruent words condition than congruent words condition.

$$H_A: \mu_b - \mu_a > 0$$

Note: μ_a represents the mean time that people take to name the ink color under congruent condition. While μ_b represents the mean time that people take to name the ink color under incongruent condition.

I will use dependent samples t-test. I don't know the statistics of the population. Also, the experiment is within-subject designed, and is a kind of two condition study. So I should use dependent samples t-test.

The assumptions made by dependent samples t-test are:

(1) The dependent variable must be continuous (interval/ratio).

(2) The independent variable should consist of two categorical, "related groups" or "matched pairs".

(3) There should be no significant outliers in the differences between the two related groups.

(4) The distribution of the differences in the dependent variable between the two related groups should be approximately normally distributed.

(5) The variances between the groups are equal.

3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

Mean:
(1) Congruent group: $\overline{x_a} = 14.05$
(2) Incongruent group: $\overline{x_b} = 22.02$
(3) Difference: $\overline{x_\Delta} = 7.97$

Median:
(1) Congruent group: $Median_a = 14.36$
(2) Incongruent group: $Median_b = 21.02$
(3) Difference: $Median_\Delta = 7.67$

Standard deviation:

(1) Congruent group: $\sigma_a = 3.56$

(2) Incongruent group: $\sigma_b = 4.79$

(3) Difference: $\sigma_\Delta = 4.86$

Quartile

(1) Congruent group: $Q1_a = 11.90, Q3_a = 16.20, IQR_a = 4.30$

(2) Incongruent group: $Q1_b = 18.72, Q3_b = 24.05, IQR_b = 5.33$

(3) Difference: $Q1_\Delta = 3.65, Q3_\Delta = 10.26, IQR_\Delta = 6.61$

4. Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.

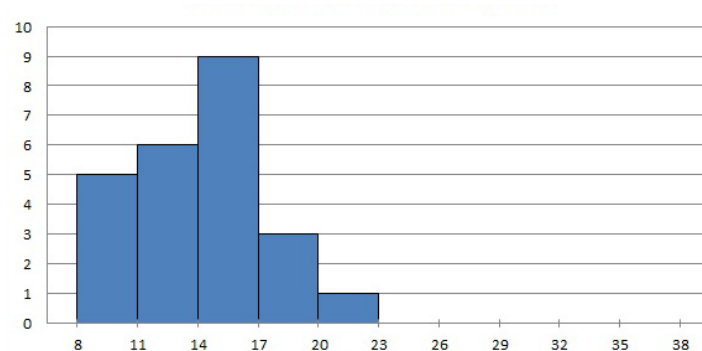The histograms of two groups are showed as follow.
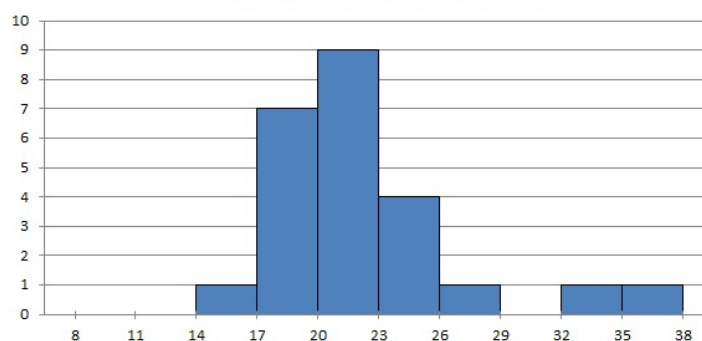

Figure 1: histogram of congruent group

Figure 2: histogram of incongruent group

From two histograms above, we can see that the distributions of two groups are both like positive skew. As a whole, data in incongruent group is larger than congruent group.

5. Now, perform the statistical test and report your results. What is your confidence level and your critical statistic value? Do you reject the null hypothesis or fail to reject it? Come to a conclusion in terms of the experiment task. Did the results match up with your expectations?

Hypothesis :

$$H_0: \mu_b - \mu_a \leq 0$$
$$H_A: \mu_b - \mu_a > 0$$

Set α level of 0.05. This is a one-tail t-test in positive direction.

Mean of difference: $\overline{x_\Delta} = 7.97$

Standard deviation of difference: $s_\Delta = 4.86$

t-statistic value: $t = \frac{\overline{x_\Delta} - 0}{s_\Delta/\sqrt{n}} = 8.03$

p-value: less than .00001

Degree of freedom: df=23

t-critical value: 1.714

Cohen's d: $d = \frac{\overline{x_\Delta}}{s_\Delta} = 1.64$

Correlation coefficient: $R^2 = \frac{t^2}{t^2+df} = 0.74$

Confidence interval: $\overline{x_\Delta} \pm t_{\frac{\alpha}{2}} \cdot (s_\Delta/\sqrt{n}) \rightarrow (5.92, 10.02)$

Conclusion: Obviously, t-statistic value is larger than t-critical value. P-value is far smaller than α level. On the other word, t-statistic has fallen into critical region. So we'll reject the null hypothesis. We can say that incongruent of word and its color will make people taking more time to name the ink color. It matches up with my expectation.

6. Optional: What do you think is responsible for the effects observed? Can you think of an alternative or similar task that would result in a similar effect? Some research about the problem will be helpful for thinking about these two questions!

The result above indicates that the incongruent of word and its color causes the effects observed.

There is a similar task would result in a similar effect:

In this task, participants are presented with a list of number's sequence like [1,1,1,1], [2,2], [3,3,3]… The participant's task is to say out loud the quantity of numbers in each sequence. The task has two conditions: a congruent number condition, and an incongruent number condition.

(1) In the congruent number condition, each number being displayed in a sequence match the quantity of number in the sequence. Which they are listed: for example [1], [2,2], [3,3,3], [4,4,4,4]….

(2) In the incongruent number condition, each number being displayed in a sequence match the quantity of number in the sequence. Which they are listed: for example [1,1,1], [2], [3,3,3,3,3], [4,4]…..

In each case, we measure the time it takes to point out the quantity of numbers of each sequence in equally-sized lists. Each participant will go through and record a time from each condition.

References

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