



Testing difference in two proportions using D2prop macro in SPSS

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Abstract ■ I introduce D2prop macro in SPSS that can be used to test difference in two proportions of two independent samples. The focus of this paper is to show how to use the macro and interpret its outputs.

Keywords ■ difference in two proportions, z-test, Wald interval, Yates's continuity correction, Agresti-Caffo interval. **Tools** ■ SPSS.

Acting Editor ■ Denis Cousineau (Université d'Ottawa)

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 [10.20982/tqmp.18.2.p181](https://doi.org/10.20982/tqmp.18.2.p181)

Introduction

Consider the following hypothetical scenario. Imagine that a group of individuals participated in a replication study aimed to test the effort-reward congruity hypothesis as postulated by Kivetz (2005). In one condition, a randomly selected participants were asked to review 10 novels and at the end of the experiment, they can choose to receive either a novel or a movie DVD as a reward in return for their participation. In the other condition, another randomly selected group of participant were asked to review 10 movies and to reward their participation, they can choose either a novel or a movie DVD. The results are shown in Table 1. Does the frequency data in Table 1 support the theory, according to which individuals are likely to choose reward that are congruent rather than incongruent with their efforts?

The table revealed that 61% of participants who evaluated novels, chose a novel over a movie DVD whereas 44% of participants evaluating movies, chose a novel over a movie DVD. The difference in proportion is 17% and the statistics seem to support the effort-congruity theory. The next task is to report a confidence interval associated for the proportion difference.

Testing difference in two proportions as described above are ubiquitous in scientific research in many disciplines such as medical, health, business, management, sociology, and psychology, among others. A majority of published papers provides only information on proportion of success and sample size such as Kivetz (2005). Unfortunately, SPSS does not offer an option that facilitates a quick

assessment of the difference in two proportions—SPSS provides a chi-square test where the resulting p-value is equivalent to the two-sided p-value that would have resulted from the z-test reported by D2prop. This is my aim in developing D2prop. The availability of this macro can save one's research time and efforts and also facilitates one's attempt to replicate findings of previous studies that typically report only proportion of success and sample size of two independent samples. Furthermore, the macro would be helpful as a classroom teaching tool in teaching differences in two proportions. For example, the above vignette resembles one of experiments in Kivetz's (2005) study that I used to explain the effort-reward congruity theory to one of my PhD students. D2prop had enabled her to check and document results of Kivetz's (2005) study as her attempts to understand the theoretical and technical insights of the paper.

Description of the D2prop macro

The D2prop macro written in .spd format can be installed on SPSS version 17 and above. The .spd file can be installed by simply double clicking the file if users have an administrator in full rights on their machines. Alternatively, users can install it via the SPSS pull-down menu by clicking: Extensions → Utilities → Install Custom Dialog. After a successful installation, the macro can be found by clicking: Analyze → D2prop — the macro window will appear on the users' screen as displayed in Figure 1.

As can be seen from Figure 1, the macro requires users to enter: (1) a variable containing frequency of success into the 'Success' box - users can enter multiple variables



Table 1 ■ Hypothetical frequency data

Effort	Choose novel	Choose movie	Total
Evaluating novels	60	38	98
Evaluating movies	45	57	102

and the proportion of success will be calculated for each of the variables; (2) a variable containing sample size into the ‘Total’ box, and (3) a confidence level into the ‘Confidence level (%)’ box, which allows the `D2prop` macro to calculate the confidence interval of proportion difference. The user-specified confidence level is printed out at the end of the macro’s outputs.

`D2prop` outputs input data and calculates the proportion of success in two independent samples (termed as groups in the outputs). The macro prints the name of the ‘success’ variable in the output. The input data must be set up in an SPSS data view according to a layout presented in Figure 2.

In the next part, the macro presents outputs regarding the statistical test of two proportions difference (i.e., z-test, see Figure 3)¹. The macro provides a one-sided and two-sided p-value associated with the test, sample proportion difference, and confidence interval: Wald (Fleiss, Levin, & Paik, 2013), Yates’s continuity correction (Yates, 1934), and Agresti-Caffo adjustment (Agresti & Caffo, 2000). The 100(1- α)% Wald confidence interval of the proportion difference is calculated based on the normal distribution approximation (see Equation (1)).

$$\hat{p}_1 - \hat{p}_2 \pm z_{\alpha/2} * se \tag{1}$$

$$se = \sqrt{\left(\frac{\hat{p}_1(1 - \hat{p}_1)}{n_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{n_2}\right)}$$

$$\hat{p}_1 - \hat{p}_2 \pm \left(z_{\alpha/2} * se + \frac{1}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right) \tag{2}$$

The Yates’s continuity correction (see Equation (2)) provide an adjustment for Wald confidence interval because a continuous distribution (i.e., normal distribution) is used to estimate the distribution of a discrete variable. However, Yates’s continuity correction can overestimate the confidence interval, which leads to inflated Type-1 error (Fagerland, Lydersen, & Laake, 2015). Therefore, the implementation of Yates’s continuity correction is less popular than the Agresti-Caffo adjustment— its inclusion in the macro is merely for its pedagogical reason. To calculate the Agresti-Caffo interval, the frequency of success in both samples are increased by one, and samples sizes

are increased by two (Agresti & Caffo, 2000). The Agresti-Caffo adjustment gives a better confidence interval than the Wald interval even for a small sample (Agresti & Caffo, 2000) (i.e., when the number of count in a cell is less than 10).

`D2prop` tests and reports results of the absolute difference between two proportions denoted by $|p1 - p2|$ in the macro’s outputs. This means that the difference, its standard error (se) and its confidence interval are always non-negative. In an everyday conversation, one probably never expresses the difference between her exam mark and her friend’s using a negative number. The individual probably would say “The difference between my mark and hers is 10 points, hers is higher than mine”. For this rationale, `D2prop` reports the difference of two proportions in an absolute value. However, one can multiply the results with -1 if one wants to be consistent in reporting the results when $p1$ is smaller than $p2$. For example, if $p1 < p2$ and `D2prop` displays $|p1 - p2| = 0.12$ with a 95% confidence interval is $[0.11, 0.13]$, the results can be reported as: $p1 - p2 = -0.12$ with a 95% confidence interval is $[-0.13, -0.11]$.

For the hypothetical problem presented at the beginning of the paper above, the 17% proportion difference is significant (two-sided p-value = 0.015) with a 95% Agresti-Caffo confidence interval is $[3.3\%, 30.3\%]$.

Discussion

In this paper, I introduced the `D2prop` in SPSS, which can be used to test difference in two proportions. I also demonstrate how to interpret the outputs of the macro, which includes the p-value associated with the test and confidence interval of the proportion difference. The `D2prop` is aimed at assisting researchers who deal with proportion difference and facilitates researchers’ attempt to replicate findings of past research. Furthermore, `D2prop` would be invaluable tool for students that want to learn how to assess difference in proportion, which is commonly presented in any introductory statistics modules. As there are many approaches in calculating the confidence interval for proportion difference, further research can explore the inclusions of those techniques in the present macro and discuss the advantages and limitations of those approaches .

¹`D2prop` does not report the exact test for two proportion difference for which interested readers can consult Laurencelle (2021).



Figure 1 ■ Screen image of D2prop

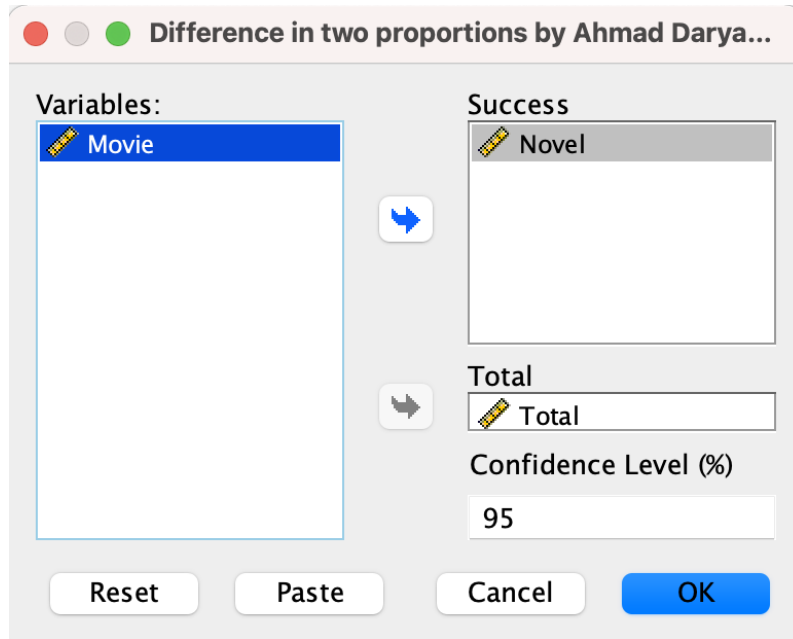
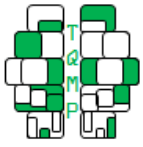


Figure 2 ■ An example of input data

	Novel	Movie	Total
1	60	38	98
2	45	57	102

References

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Citation

Daryanto, A. (2022). Testing difference in two proportions using d2prop macro in spss. *The Quantitative Methods for Psychology*, 18(2), 181–185. doi:[10.20982/tqmp.18.2.p181](https://doi.org/10.20982/tqmp.18.2.p181)

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Received: 16/03/2022 ~ Accepted: 22/03/2022

Figure 3 follows...

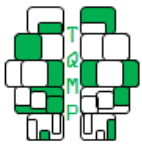


Figure 3 ■ D2prop's output

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D2prop: Testing the difference of two proportions
Written by Ahmad Daryanto - https://sites.google.com/view/ahmaddaryanto/
March, 2022

=====

Data
Novel Total
   60   98
   45  102

=====

Success variable:
Novel

          Novel Total
Group 1   60   98
Group 2   45  102

Proportion of success
Group 1   .61224
Group 2   .44118

=====

Difference in proportions of success (absolute value of p1-p2)

z and sig.values
      z    1-sided    2-sided
2.42182  .00772    .01544

Difference
|p1-p2|    se
 .17107    .06957

Confidence interval (AC = Agresti-Caffo)
          LB      UB
Wald    .03470   .30743
Yates   .04471   .31744
AC      .03258   .30280

Confidence level (%)
95
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