

## WISE Confidence Interval Overlap Applet

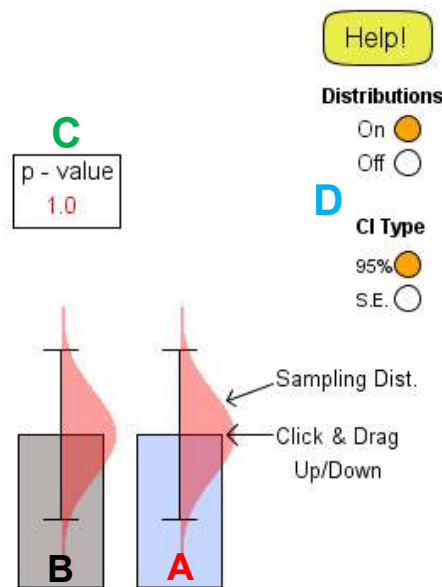
### Purpose of the Confidence Interval Applet

Researchers and students alike often mistake any overlap among 95% confidence intervals as indicating a statistically non-significant  $p$  value. However, two 95% confidence intervals can overlap and still correspond to a statistically significant  $p$  value for an independent samples  $t$  test. The confidence interval (CI) applet is designed to help learners understand the relationship between confidence interval overlap and statistical significance.

### How to use the Applet

The CI applet is comprised of several elements as referenced in the figure below. Two bars represent sample means independently sampled from two populations (**A**, **B**). Overlaid on the means are 95% CIs (default) or standard error bars. By default, these bars are accompanied by normal curves representing the sampling distributions of the mean for the variables of interest. The distributions can be turned on/off and the type of CI can be changed by clicking the corresponding radio buttons (**D**). The  $p$  value textbox (**C**) displays the  $p$  value associated with an independent sample  $t$  test ( $\alpha = .05$ , two-tailed,  $n = 200$ ). The CI applet can be manipulated by clicking and dragging the rightmost mean up or down (**A**). Alternatively, you can use the Up/Down keys on your keyboard to adjust the mean. The change in the mean and the  $p$  value can be observed immediately. The mean of the leftmost bar (**B**) remains unchanged when manipulating the applet.

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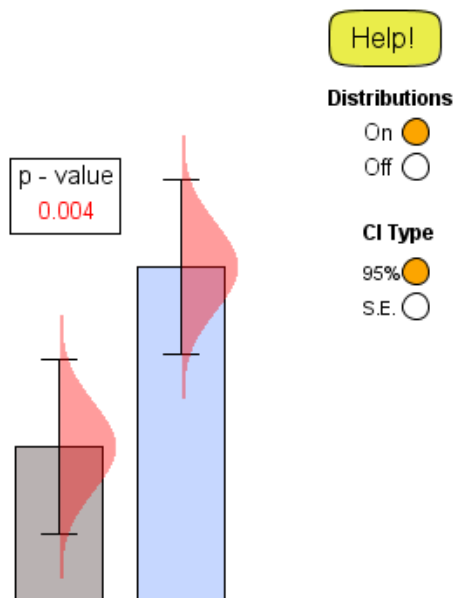
## Instructor's Guide for Using the WISE CI Applet in a Demonstration

### Demonstrating the overlap fallacy

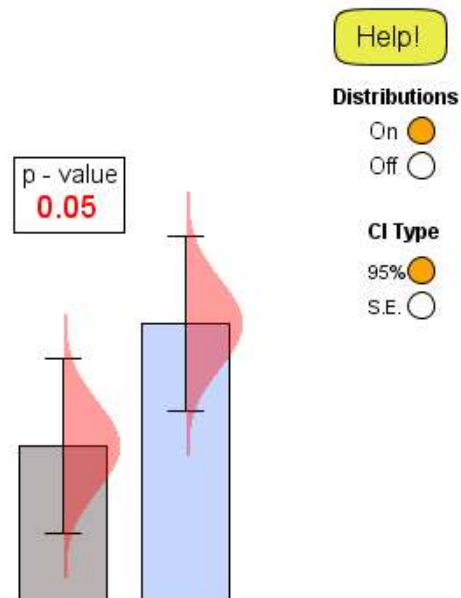
Example: A researcher is interested in comparing two rival training programs that both claim to increase a person's verbal fluency. The researcher conducts a study where participants are randomly assigned to one of the two methods. How much overlap between the 95% CIs would you expect when the two-tailed  $p$  value associated with an independent sample  $t$  test is equal to .05? Adjust the applet using the interactive slider and note the amount of overlap between the CIs. Are you surprised by how much the CIs overlap?

**Explanation:** An explanation for these findings can be facilitated by referring to the sampling distributions overlaid on the 95% CIs. Even though the 95% CIs overlap to a large extent when the  $p$  value is near .05, the sampling distributions do not overlap to a large extent because the sampling distributions are very thin in their tails. Given that the sampling distributions overlap only slightly, it is unlikely that a sample drawn from one population will be mistaken for a sample drawn from the other population. Put another way, if the null hypothesis is true so the two population means are the same, the probability of obtaining sample means that are as far apart, or further apart than the ones observed is highly unlikely, even when the CIs for the two samples overlap substantially as they do when  $p = .05$ . This example can be extended by adjusting the applet to the point at which the CIs just touch (see the leftmost figure below). In this case, only the thin tails of the two sampling distributions overlap and the probability of this much overlap or less is only  $p = .004$  if the null hypothesis is true. The two distributions can overlap quite a bit more and still have a  $p$  value less than .05 (see the rightmost figure). These exercises with the applet show that 95% CIs need to be interpreted carefully with regard to statistical inference and that two means can be statistically significantly different even though the two 95% CIs overlap to a considerable extent. This tutorial can be extended to standard error bars by clicking on the radio button labeled "S.E." After supplementing your lecture with the WISE CI Overlap, consider assigning students to interact with the [WISE Confidence Interval Game](#), where they can explore the relationship between CI overlap and statistical significance with this fun game.

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## Confidence Interval Overlap References

Articles 1 - 3 demonstrate the confidence interval overlap fallacy. Article 1 outlines the problem, article 2 demonstrates how ubiquitous the problem is in academia, and article 3 describes some of the issues related to interpreting CI overlap with respect to statistical significance.

- 1 ) Austin, P.C., & Hux, J.E. (2002). A brief note on overlapping confidence intervals. *Journal of Vascular Surgery*, 36, 194-195. Retrieved from [http://www.jvascsurg.org/issues?issue\\_key=S0741-5214%2805%29X7126-9](http://www.jvascsurg.org/issues?issue_key=S0741-5214%2805%29X7126-9)
- 2) Belia, S., Fidler, F., Williams, J., & Cumming, G. (2005). Researchers misunderstand confidence intervals and standard error bars. *Psychological Methods*, 10, 389-396. doi:10.1037/1082-989X.10.4.389. Retrieved from <http://irt.com.ne.kr/data/researchers%20misunderstand%20ci%20and%20error%20bars.pdf>
- 3) Schenker, N., & Gentleman, J.F. (2001) On judging the significance of differences by examining the overlap between confidence intervals. *The American Statistician*, 55, 182-186. doi: 10.1198/000313001317097960. Retrieved from <http://www.mendeley.com/research/on-judging-the-significance-of-differences-by-examining-the-overlap-between-confidence-intervals/>

Articles 4 -7 are teaching papers for those interested in lecturing on CIs.

- 4) Mary, J.C., Berger, D.E., Pentoney, C., & Johnson, J. WISE CI overlap game and support guide. Retrieved from: <http://wise.cgu.edu>.
- 5) Cumming, G. (2007). Inference by eye: Pictures of confidence intervals and thinking about levels of confidence. *Teaching Statistics*, 29, 89-93. doi: 10.1111/j.1467-9639.2007.00267.x. Retrieved from [http://psychweb.psy.umt.edu/denis/datadecision/front/stat\\_II\\_2011/error\\_bars.pdf](http://psychweb.psy.umt.edu/denis/datadecision/front/stat_II_2011/error_bars.pdf)
- 6) Hagtvedt, R., Jones, T.G., & Jones, K. (2008). Teaching confidence intervals using simulation. *Teaching Statistics*, 30, 53-56. doi: 10.1111/j.1467-9639.2008.00308.x
- 7) Bertie, A., & Farington, P. (2003). Teaching confidence intervals with java applets. *Teaching Statistics*, 25, 70-75. doi: 10.1111/1467-9639.00134. Retrieved from <http://www.jsc.nildram.co.uk/articles/CIapplets.p>