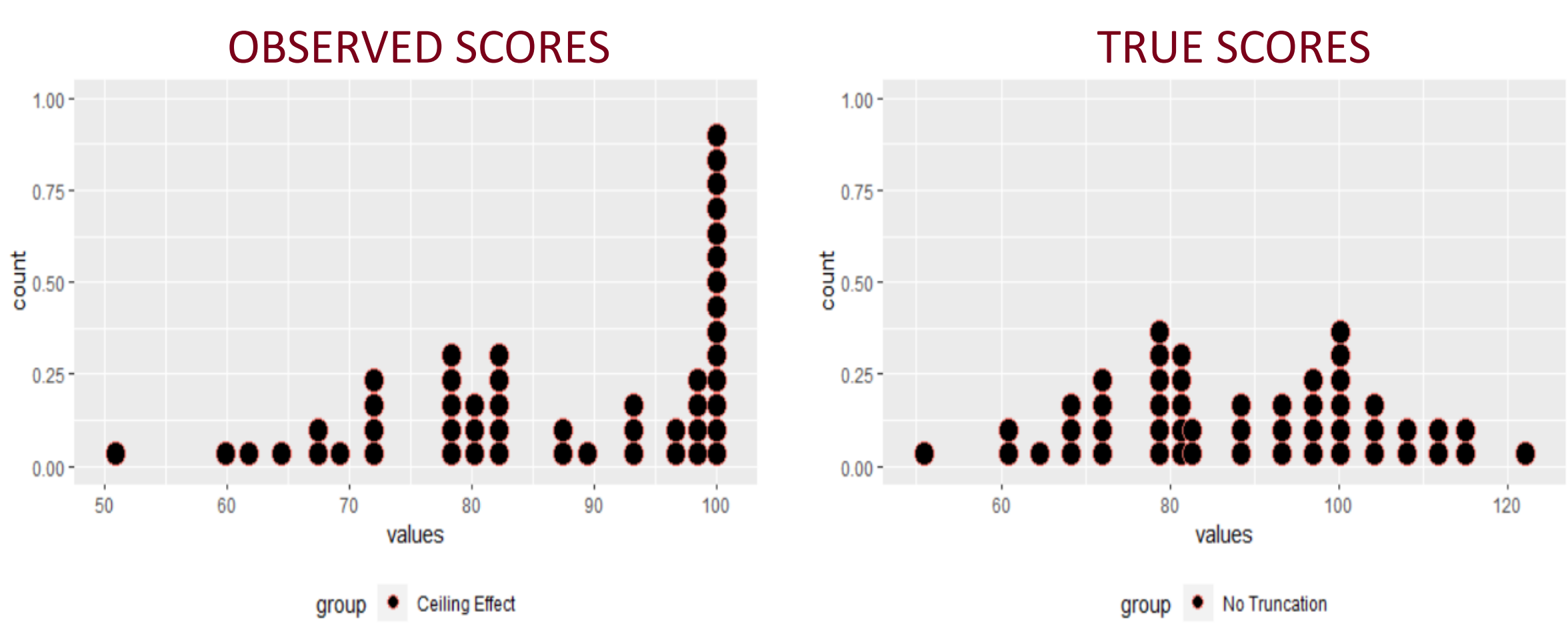


WHEN ANOVA IS NO LONGER USEFUL

ANOVA models assume that data are normally distributed. While true scores may indeed be normally distributed, the presence of a ceiling or floor effect causes the observed scores to appear heavily skewed, as seen below.

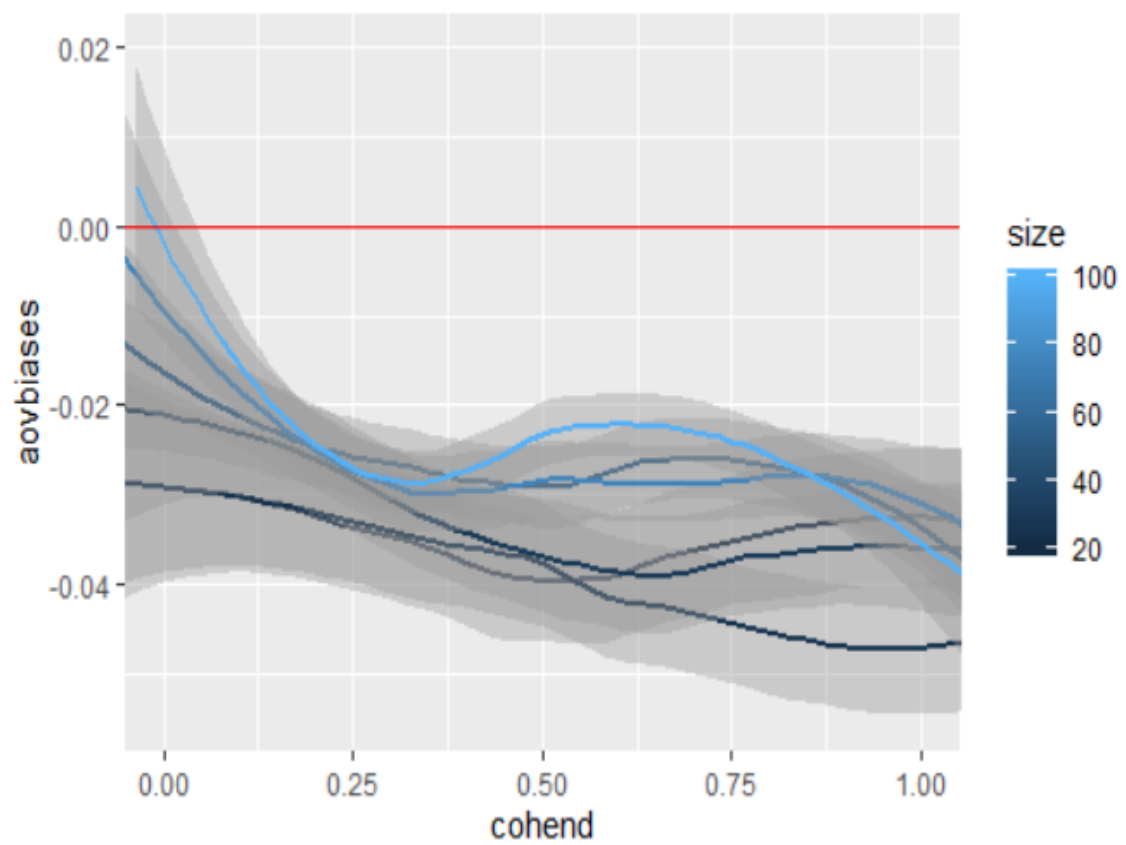


With a ceiling effect, observed scores at the ceiling are less than their true values, causing an underestimate of group means. With a floor effect, the opposite is true, with observed scores causing an overestimate of group means.

These errors inhibit the ANOVA model from accurately estimating differences between group means. This bias poses problems for researchers analyzing experimental data designed to compare the efficacy of different conditions. Check whether an ANOVA model may still be appropriate for your data, regardless of your sample size, by checking the 30-20 rule against your data.

The 30-20 Rule

- (1) All groups must have less than 30% of their observations at the ceiling or floor, and
- (2) The difference in the proportion of observations at a ceiling or floor between groups should be no more than 20%.



When the “30-20” rule is met, ANOVA models will underestimate effect sizes by no more than 0.05. Thus, it may still be appropriate and useful to use ANOVA. However, when the “30-20” rule is violated, ANOVA models will severely underestimate effect sizes, and are no longer useful in estimated differences.

One alternative to ANOVA is a Tobit model. Tobit models explicitly aim to account for observed scores truncated at a floor or ceiling. It estimates differences in means through cumulative frequency distributions within the range of observed scores. Tobit models have a “70%” rule: All groups must have less than 70% of their observations at the ceiling or the floor. If so, Tobit models can estimate differences in group means with a bias less than 0.02 effect sizes.

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“Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.”  
(Box & Draper, 1987, p. 74)

When faced with ceiling and floor effects, ANOVA models severely underestimate group differences.

One alternative is the Tobit model.

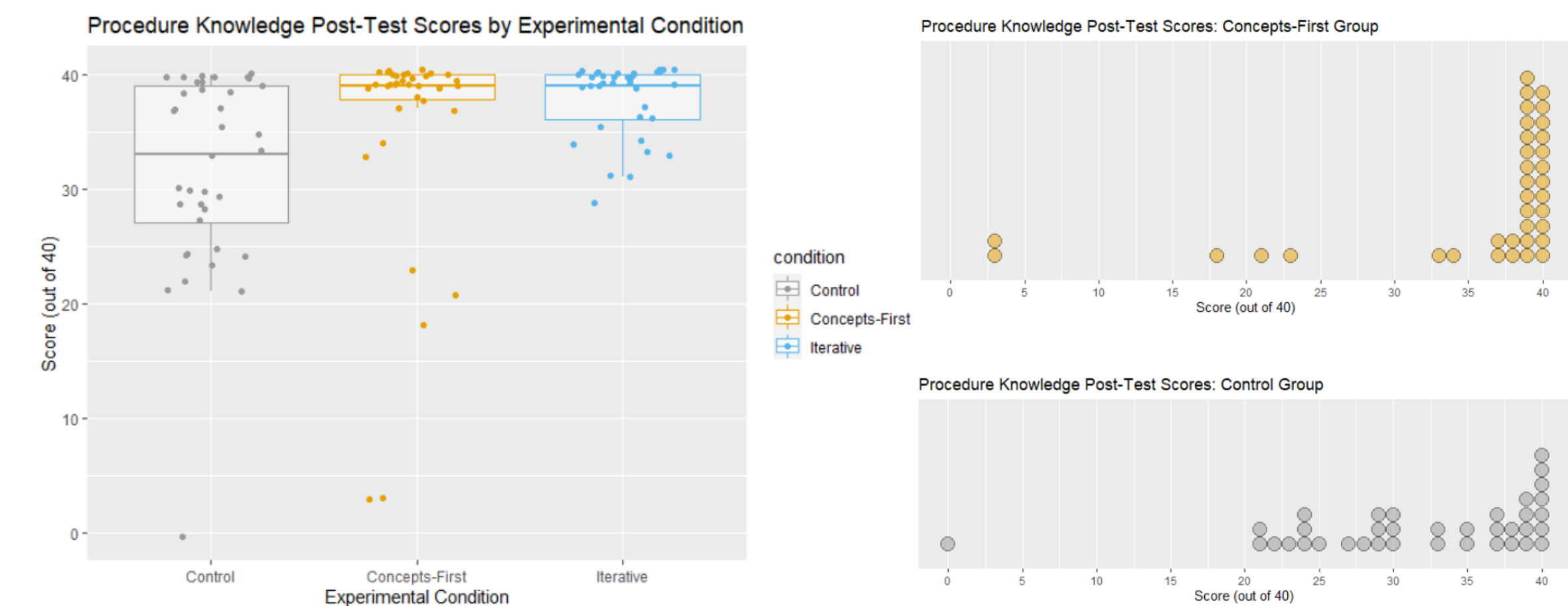
This poster details when and how to use a Tobit model instead of ANOVA.

Choosing a statistical model amidst ceiling and floor effects

V.N. Vimal Rao, Kristin Running, and Robin Coddling

HOW TO FIT A TOBIT MODEL USING R

**NOTICING AND ACKNOWLEDGING** The first step in any analysis and in reasoning about variability is to first notice and acknowledge variability in the data. Create boxplots and dotplots to visualize variability in a response variable.



**FITTING A MODEL** While our design matches that of an ANVOCA model, our data violate the 30-20 rule, as 48.6% of observations in the Iterative group are at the ceiling. Thus, we instead must use a Tobit model. We’ve done so in R.

ANCOVA R SYNTAX

```
ancova.mdl <- aov(
  data = fraction_knowledge,
  procedures_post ~ condition + procedures_pre
)
```

TOBIT R SYNTAX

```
tb.mdl <- vglm(
  data = fraction_knowledge,
  procedures_post ~ condition + procedures_pre,
  family=tobit(Lower=0, Upper=40)
)
```

Estimated Group Differences by Fitted Model		
Comparison Groups	ANCOVA	Tobit
Concepts-First minus Control	2.338	3.579
Iterative minus Control	4.174	6.579
Iterative minus Concepts-First	1.836	3.000

**INTERPRETING RESULTS** The R syntax for fitting an ANOVA model and Tobit model are very similar, as are the outputs from each model. Given Tobit models are easy to fit, and their benefits in accurately estimating group differences despite ceiling or floor effects, we highly recommend researchers consider using Tobit regression models when the 30-20 CFE rule is violated.

Our Methods

The “30-20 rule” and “70% rule” are supported by a simulation study examining the bias in ANOVA and Tobit models. Simulation parameters varied were the proportion of observations at the ceiling in each group and the between group effect size. See Running et al. (2021) for more information on the experiment that this data was collected from.

Supplementary Material

For an Instruction Guide to fitting a Tobit Model using R, our R code, our dataset, a copy of this poster, our final abstract, our reference list, and more, please visit:

