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Title: *The Power of Potential Outcomes in Experimental Design: From the Neyman-Fisher Controversy to 3D Printing*

Abstract:

Potential outcomes provide a powerful framework for addressing problems in causal inference. Although used extensively in observational studies, their power has not been fully appreciated in experimental design since the time of Neyman and Kempthorne. The key aspect of my research is the application of potential outcomes for a wide range of theoretical and applied problems involving experimental design. This is illustrated by means of two problems, one classical and the other involving a cutting-edge application in engineering.

The first part of this talk will address the Neyman-Fisher controversy, which originated with the 1935 presentation of Jerzy Neyman's “Statistical Problems in Agricultural Experimentation” to the Royal Statistical Society. Neyman asserted that the standard ANOVA F-test for randomized complete block designs is valid, whereas the analogous test for Latin squares is invalid in the sense of detecting differentiation among the treatments, when none existed on average, more often than desired (i.e., having a higher Type I error than advertised). However, Neyman's expressions for the expected mean residual sum of squares, for both designs, are generally incorrect. Furthermore, Neyman's belief that the Type I error (when testing the null hypothesis of zero average treatment effects) is higher than desired whenever the expected mean treatment sum of squares is greater than the expected mean residual sum of squares, is generally incorrect. It is shown that without further assumptions on the potential outcomes, one cannot determine the Type I error of the F-test from expected sums of squares.

The second part will present a novel application of potential outcomes for quality control in 3D printing, a promising manufacturing technique marred by product deformation. Control of printed product deformation can be achieved by a compensation plan. However, little attention has been paid to interference in compensation, which is thought to result from the inevitable discretization of a compensation plan. We investigate interference with an experiment involving the application of discretized compensation plans to cylinders. Our treatment illustrates how the potential outcomes framework improves our ability to understand interference by means of graphical posterior predictive checks. Properly defining experimental units and understanding interference are critical for quality control in complex manufacturing processes. The potential outcomes framework ultimately provides a step in that direction for 3D printing.