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Laying the Foundations for the Proper Statistical Analysis of Data without Hypothesis Tests for Reliability Data

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Link via Gmeet: https://meet.google.com/iex-xpgg-twh?authuser=0&hs=122

Abstract

The origins of the design and analysis of experiments required the analyst to evaluate the effects of treatments applied to properly defined experimental units. Fisher's fundamental principles underlying the proper design of an experiment required: randomization, replication, and local control of error. Randomization assured that each experimental unit available for the experiment has exactly the same probability for being selected for each of the possible treatments. Replication allowed for the analyst to evaluate the effects of the treatments by comparing treatment means. Local control of error represented the attempt to minimize the impact of other possible sources of variation. The fact that Fisher could not directly observe the effect of the "chance causes" of the variation forced the focus on comparing treatment means within his overall framework.

Modern sensor technology allows the experimenter to observe the effects of many of the chance causes that Fisher could not. However, incorporating this information requires the analyst to model the data through proper linear or non-linear models, not by comparing treatment means. The resulting implications for the proper analysis taking into account the available ancillary variables are fascinating with far-reaching implications for the future of the proper design and analysis of research studies, including designed experiments.

This talk begins with a review of Walter Shewhart's actual thoughts about the proper analysis of data and contrasts Shewhart's thought with the Neyman-Pearson approach to data analysis. It then lays the theoretical foundation for a modern approach to the analysis of the experiment taking full advantage of standard linear and non-linear model theory.

The talk uses real data from two studies. Both studies focus on the degradation over time of critical quality characteristics. The ability to predict the degradation provides a basis for improving the maintenance protocols, which in turn improves the overall reliability of the system.

The first study is a process monitoring example on the degradation of a critical temperature for the operation of a jet turbine. More precise modeling of this characteristics has the potential to save millions of Euros per year for the client in terms of maintenance contracts. The second study involves the degradation in performance of batteries used in trains. The study uses a split-plot experiment. The goal is to identify the critical factors that control the degradation in performance. Both examples involve ancillary data when properly used greatly removes the background noise, making inferences easier and cleaner. In the process, it becomes quite clear why many people have recently noted serious issues with hypothesis tests in general.