Title: Post-Fisherian Experimentation: from Physical to Virtual

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Abstract: Experimental design has been a scientific discipline since the founding work of Fisher. During the 80-year history, its development has been largely dominated by work in physical experiments. With advances in high-performance computing and numerical modeling, virtual experiments on a computer have become viable. This talk will highlight some major developments (physical and virtual) in this long period. Fisher's principles (replication, randomization, blocking) will be reviewed, together with principles (effect hierarchy, sparsity, heredity) for factorial experiments. A fresh look at interactions and effect aliasing will be provided, with some surprisingly new insights on an age-old problem. Robust parameter design, another significant development which focuses on variation modeling and reduction, will be mentioned. Turning to computer experiments, the key differences with physical experiments will be highlighted. These include the lack of replication errors which entails new governing principles other than Fisher's and the use of space-filling designs instead of fractional factorials. There are two strategies for modeling and analysis: based on Gaussian processes or on function approximations. These seemingly conflicting approaches can be better linked by bringing a stochastic structure to the numerical errors. Throughout the talk, real experiments/data, ranging from manufacturing to nano technology, will be used for illustration. (This talk is based on the Fisher Lecture the speaker delivered during the 2011 Joint Stat Meetings in Miami.)

Key words: computer experiments, experimental design, kriging, factorial experiments, robust parameter design