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Optimal designs for hypothesis testing in the presence of heterogeneous experimental groups

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Comparing the means of several experimental groups is an old and well known problem in the statistical literature which arises in many application areas. In the past decades, a large body of literature about the design of experiments for treatment comparisons has flourished. However, the attention has been almost exclusively devoted to estimation precision, and not to optimal testing. This paper develops a unified approach for deriving optimal designs for testing the efficacy of several heterogeneous treatments. Adopting the general framework of heteroscedastic treatment groups, which also encompasses the general ANOVA set-up with heteroscedastic errors, the design maximizing the power of the multivariateWald test of homogeneity is derived. Specifically, this optimal design is a generalized Neyman allocation involving only two experimental groups. Moreover, in order to account for the ordering among the treatments, which can be of particular interest in many applications, we obtained the constrained optimal design where the allocation proportions reflects the effectiveness of the treatments. Although, in general, the treatments ordering is a-priori unknown, the proposed allocations are locally optimal designs that can be implemented via response-adaptive randomization procedures after suitable smoothing techniques. The advantages of the proposed designs are illustrated both theoretically and through several numerical examples including normal, binary, Poisson and exponential data (with and without censoring). The comparisons with other allocations suggested in the literature confirm that our proposals provide good performance in terms of both statistical power and ethical demands.

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